University of Stuttgart
Germany

Program

7th GACM Colloquium on Computational Mechanics

for Young Scientists from Academia and Industry

11 – 13 October 2017
Stuttgart, Germany

7^{th} GACM
Colloquium on Computational Mechanics
for Young Scientists from Academia and Industry

Program

A conference under the auspice of the

German Association for Computational Mechanics (GACM)

11 – 13 October 2017, Stuttgart, Germany

Preface

On behalf of the German Association for Computational Mechanics (GACM) it is our great pleasure to welcome you in Stuttgart at the 7th GACM Colloquium on Computational Mechanics for Young Scientists from Academia and Industry (GACM 2017). The conference is jointly organized by the Institute for Structural Mechanics and the Institute of Applied Mechanics of the University of Stuttgart and the DYNAmore GmbH.

The GACM Colloquium on Computational Mechanics intends to bring together young scientists who are engaged in academic and industrial research on Computational Mechanics and Computer Methods in Applied Sciences. It provides a platform to present and discuss recent results from research efforts and industrial applications.

In more than 200 presentations by young scientists in 18 mini-symposia devoted to a specific scientific area and thematically arranged contributed sessions recent advances in research and applications in the broad field of Computational Engineering Sciences and related subjects are presented and discussed.

We would like to heartily thank the organizers of the 18 mini-symposia, the plenary speakers, the GACM Best PhD Award winners and the chairpersons for their valuable efforts and contributions to the conference.

We hope this conference will meet your expectations, both scientifically and socially, and we are very proud to be able to welcome you in Stuttgart.

Stuttgart, October 2017

Malte von Scheven
Marc-André Keip
Nils Karajan

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Part I.

General Information

Acknowledgements

The conference chairmen gratefully acknowledge the support from the following organizations:

Gold Sponsors

Ed. Züblin AG

DYNAmore GmbH

We would also like to thank the plenary lecturers Paul Steinmann, Kurt Maute and Ralph Lohner, the GACM Best PhD Award winners, the organizers of the mini-symposia as well as the chairpersons for their contribution to the conference.

Conference Organization

Conference Chairmen

- **Malte von Scheven**, Institute for Structural Mechanics, University of Stuttgart
- **Marc-André Keip**, Institute of Applied Mechanics (CE), University of Stuttgart
- **Nils Karajan**, DYNAmore GmbH

Conference Secretariat

Institute for Structural Mechanics
University of Stuttgart

Pfaffenwaldring 7
70569 Stuttgart, Germany

Phone: +49 (711) 685 66121
Fax: +49 (711) 685 56121
Email: info@gacm2017.uni-stuttgart.de

Local Advisory Board

- **Frank Allgöwer**, Institute for Systems Theory and Automatic Control
- **Manfred Bischoff**, Institute for Structural Mechanics
- **Peter Eberhard**, Institute of Engineering and Computational Mechanics
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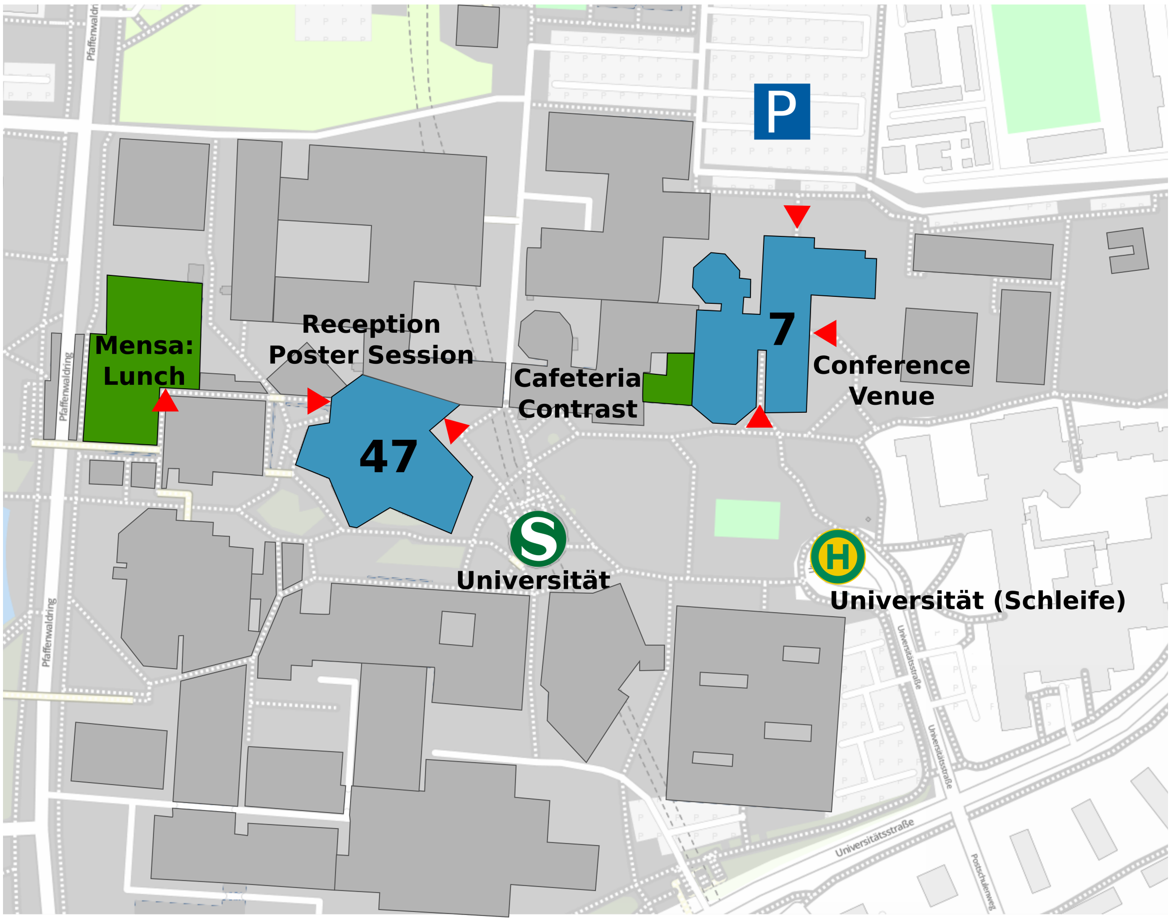
- **Christian Rohde**, Institute of Applied Analysis and Numerical Simulation
- **Siegfried Schmauder**, Institute for Materials Testing, Materials Science and Strength of Materials
- **Holger Steeb**, Institute of Applied Mechanics (CE)

Conference Venue

Address:

University of Stuttgart
Pfaffenwaldring 7
70569 Stuttgart



How to get there:

From Stuttgart Airport ("Flughafen")

Local train (S-Bahn): Please follow the sign S in the arrival hall. For the ride to the conference venue you require a ticket for two zones (single ride € 2.90) which can be bought at the ticket machines at the entrance of the train station (see "How to buy a ticket" on page 14).

Please take lines S2 (direction "Schorndorf") or S3 (direction "Backnang"). The ride will take 16 minutes to the station "Universität". Leave the train station via the exit in the direction of travel (direction "Universitätszentrum") and follow the conference signs.

Taxi: Taxis are located in front of the arrival hall. The taxi ride to the conference venue takes about 15–20 minutes (approx. € 25–30).

From Stuttgart Main Station ("Hauptbahnhof")

Local train (S-Bahn): Please follow the sign S in the arrival hall. For the ride to the conference venue you require a ticket for two zones (single ride € 2.90) which can be bought at the ticket machines in the train station (see "How to buy a ticket" on page 14).

Please take lines S1, S2 or S3 from platform 101 (underground). The ride takes 11 minutes to the station "Universität". Leave the train station via the exit opposite to the direction of travel (direction "Universitätszentrum") and follow the conference signs.

Taxi: Taxis are located in front of the arrival hall. The taxi ride takes about 15–20 minutes to the conference venue (approx. € 20–25).

By Car

There are free parking lots next to the conference venue. From the street Pfaffenwaldring follow the signs Pfaffenwaldring 11+13+15. You will find parking lots to the left of the road. The conference venue is located at the far end of the parking lots.

Social Program

Reception

Wednesday, 11 October 2017; 18:30

Address:

Universität Stuttgart
Pfaffenwaldring 47
70569 Stuttgart

The reception is sponsored by the Ed. Züblin AG. The conference organizers are very grateful for the generous support.

Conference Banquet

Thursday, 12 October 2017; 19:30

Address:

Kursaal Cannstatt
Königsplatz 1
70372 Stuttgart

How to get there:

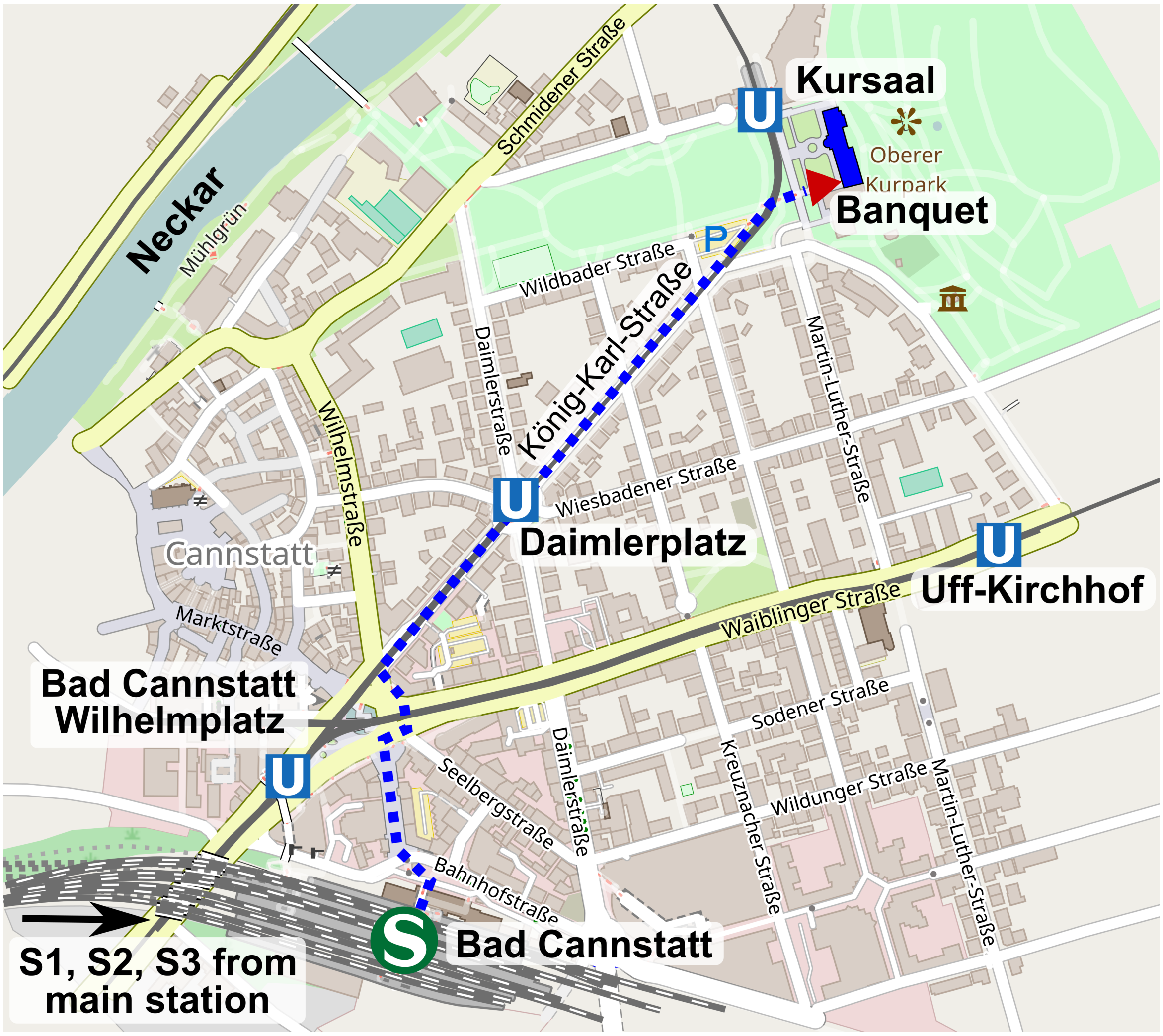
For the ride from the conference venue to the banquet with any of the two public transport connections below you require a ticket for two zones (single ride € 2.90). See "How to buy a ticket" on page 14.

By local train and walking (S-Bahn): From the conference venue take the local train S1, S2 or S3 from platform 2 in the direction "Stuttgart Hbf". The ride takes 15 minutes to the station "Bad Cannstatt". Leave the platform via the underpass to the left from the direction of travel (towards main building, "Wilhelmsplatz"). Now you can walk to the banquet location in approx. 15 minutes (see map on the next page).

Cross the square in front of the train station and take the pedestrian street (Bahnhofstraße), which is slightly on the left. At the end of the pedestrian street cross Waiblingerstraße and turn right into König-Karl-Straße. Follow the König-Karl-Straße till Königsplatz. The banquet venue is on the right hand side of the Königsplatz.

By local train and subway (S-Bahn + U-Bahn): From the conference venue take the local train S1, S2 or S3 from platform 2 in the direction "Stuttgart Hbf". The ride takes 11 minutes to the station "Hauptbahnhof" (main station). Follow the signs U to the "Klett Passage" and the subway platforms . From subway platform 2 (directions "Fellbach", "Neuger.", "Killesberg") take line U2 in the direction of "Neugereut". The ride takes 12 minutes. Leave the subway train at the station "Kursaal".

By car: A public underground car park (subject to charge) is located underneath the Kursaal.



How to return to the hotels/city center:

For the ride from the conference banquet to the city center or Campus Vaihingen you require a ticket for two zones (single ride € 2.90). See "How to buy a ticket" on page 14.

To the city center (U-Bahn:) From the subway station "Kursaal" take the subway U2 in the direction "Botnang". The ride takes 12 minutes to the main station ("Hauptbahnhof").

To the campus Vaihingen (U-Bahn + S-Bahn): Follow the above instructions to go to "Hauptbahnhof" and change there to the local train lines S1, S2 or S3 from platform 101. The ride takes 11 minutes to the station "Universität".

Note that the latest connection by U-Bahn to the city center and to Vaihingen (U-Bahn + local train) is at 00:26 from the station "Kursaal". The latest connection to the city center and Vaihingen by local train only is at 01:01 from the station "Bad Cannstatt" (approx. 15 minutes walking distance from the banquet).

Local Information

Baggage Room

On Wednesday and Friday baggage can be stored in the Institute for Structural Mechanics which is located on Level 1. Outside the opening hours please contact the conference secretariat to use the baggage room.

Opening hours:

Wednesday, 11 October 2017:	07:30 – 09:00
	18:00 – 18:30
	20:00 – 21:00
Friday, 13 October 2017:	08:00 – 09:00
	12:30 – 13:30

Coffee Breaks

During the coffee breaks coffee, tea, soft drinks, snacks and fresh fruits will be served on Level -1 and Level 0. The locations of the coffee break areas are indicated on the floor maps ☕.

Conference Secretariat

If you need assistance or have any questions, please contact the conference secretariat located in the main hall on Level 0. There you get information about the technical and social program of the conference as well as public transport and places of interest in Stuttgart.

Conference Staff

Members of the conference team are present at the conference secretariat and in all lecture rooms. You will recognize them by the orange lanyard.

Internet Access

The University of Stuttgart provides free wireless internet access to all participants. You can choose between two kinds of authentication:

Eduroam

The University of Stuttgart is part of the Eduroam initiative. The Eduroam network is available in most parts of the building and can be accessed with the account of your home institution, if your home institution also takes part in Eduroam.

Conference Network

The conference network (SSID: konferenz) can be used with WPA2 encryption. The passwords change from day to day:

Tuesday,	10 October 2017:	114-657-805-289
Wednesday,	11 October 2017:	878-907-041-060
Thursday,	12 October 2017:	562-302-972-593
Friday,	13 October 2017:	674-855-974-684

Using this internet access you agree with the terms of use for digital data processing and communication technology at the University of Stuttgart.

Lunch

Lunch will be served from 11:15 to 14:15 at the "Mensa" of the University of Stuttgart. The lunch includes a starter or a dessert, a main course including side dishes and one drink. Make sure you have your lunch ticket with you. You can also use your lunch ticket in the Cafeteria "Contrast" next to lecture hall 7.01.

Public Transport in Stuttgart

The public transportation network in Stuttgart is safe, well-developed and reliable. Prices and electronic timetable information can be found at `http://en.vvs.de/`. You can also download the Smartphone App "VVS Mobil" (Android, Mac OS, Windows, Blackberry) for electronic timetable information.

The conference venue is located on the University Campus Vaihingen. It is in the south-west of Stuttgart and can be reached via bus (station "Universität Schleife") and local train (station "Universität"). The station "Universität Hohenheim" is not located close to the conference venue.

You can reach the conference venue with the following public transport services:

Local train (S-Bahn): S1, S2, S3
Bus (H): 82, 84, 91, 92, 746, 747, 748, X60

How to buy a ticket

For the local train, the subway and busses you can use the same tickets of the "Verkehrs- und Tarifverbund Stuttgart" (VVS) vvs.

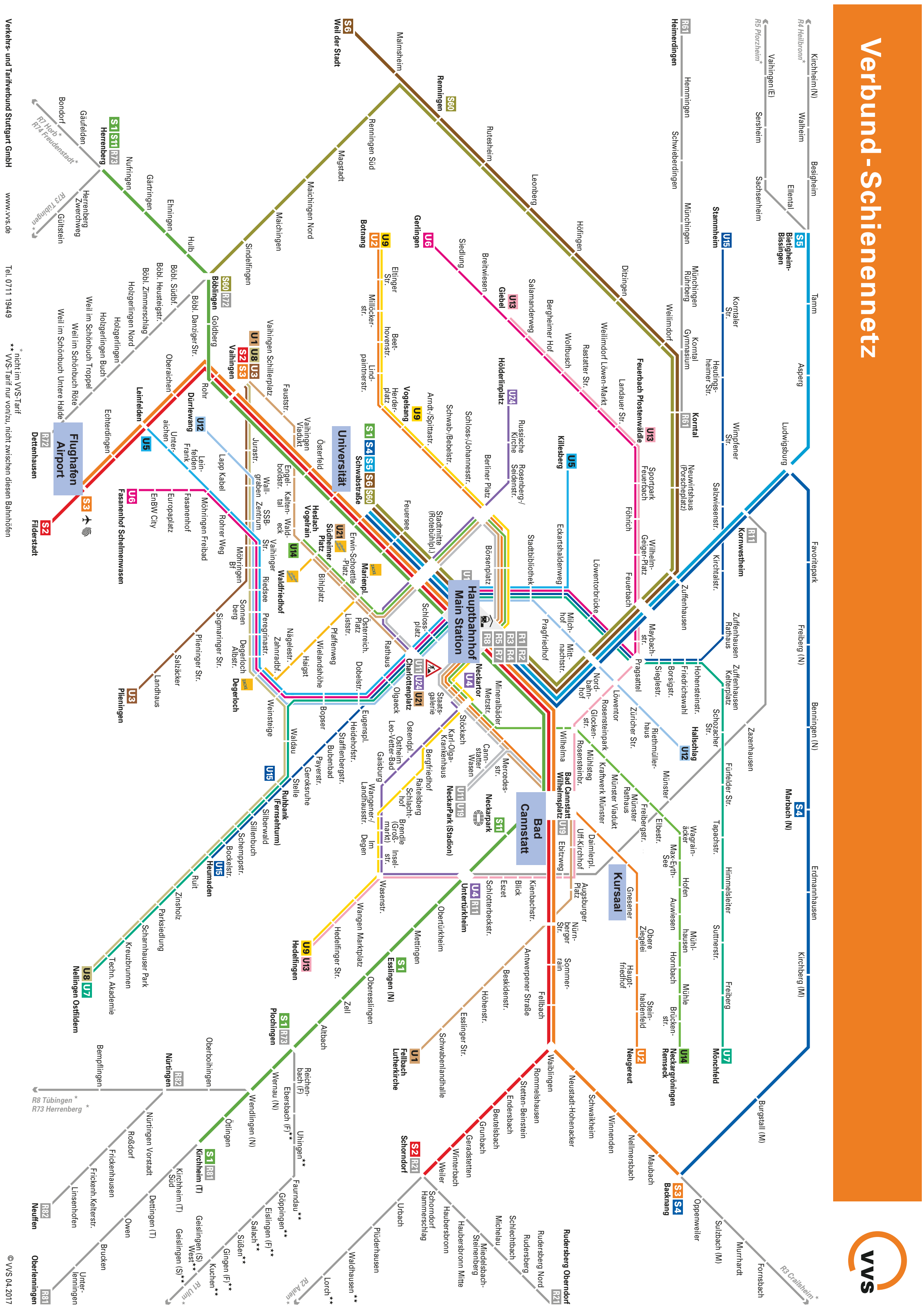
At the local train station you will find red ticket machines:
Push the English flag → "Verkehrs- und Tarifverbund Stuttgart" (VVS) vvs → 1 or 2 zones → pay.

At the subway station you will find orange ticket machines:
To choose English language push the round button at the right upper corner of the machine beneath the German/English/French flags. Then enter the 3 digit code of your destination from the list on the left side of the machine. The stations are ordered alphabetically. Automatically, a single ride ticket will be suggested.

If you know the number of zones of your connection you can directly enter "001" for a ticket for one zone or "002" for two zones.

Taxi

Taxi can be ordered at the conference secretariat or directly at Taxi-Auto-Zentrale (phone: +49 (711) 5510 000).


Verbund-Schienennetz
Hauptbahnhof
Main Station
Flughafen
Airport
Bad Cannstatt
Universität
Kursaal
Verkehrs- und Tarifverbund Stuttgart GmbH
www.vvs.de
Tel. 0711 19449
* nicht im VVS-Tarif
** VVS-Tarif nur von/zu, nicht zwischen diesen Bahnhöfen
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Tourist Information

General Information

Tourist information can be obtained at:

Address:

Tourist-Information i-Punkt Stuttgart
Königstraße 1A
70173 Stuttgart
`https://www.stuttgart-tourist.de/en`

The tourist information is located next to the main station in the Königstraße, which is the main shopping street in Stuttgart. From the tourist information a five minutes walk over the Königstraße leads to the Schloßplatz, where the New Castle, the Old Castle and the Art Museum are located. In the surroundings of the Schloßplatz there are various coffee bars.

Our recommendations for the main attractions in Stuttgart are:

Schloßplatz Stuttgart (Palace Square)

Address:

Schlossplatz Stuttgart
Schlossplatz
70173 Stuttgart

Arriving by public transport:

U5, U6, U7, U12, U15 Schlossplatz

Stuttgart's Palace Square is the vibrant heart of the city, but at the same time it's a place to linger, within easy walking distance of many of the city's attractions. Palace Square is therefore Stuttgart's hub and an integral part of any stroll through town. In 2006 pictures of Palace Square went round the world, when 60,000 fans turned it into a sea of black, red and gold flags at the public screenings during the football World

Cup. Stuttgart's Palace Square is a place both to celebrate and relax. Open-air concerts are held here at regular intervals against the backdrop of the New Palace and at the beginning of August Stuttgart's Summer Festival transforms Palace Square and the Upper Palace Gardens into a gaily lit, elegant promenade.

Originally part of the ducal pleasure garden, the square served as a military drill and parade ground from 1746 onwards. It was not until the middle of the 19th century that it became a Baroque park that could also be used by the townspeople. In the middle of Palace Square towers the Jubilee Column (1841), surmounted by Condordia, goddess of harmony. Behind her is the New Palace, whose architecture, thanks to its lengthy construction period from 1746 to 1807, is a mixture of Baroque, Classicism, Rococo and Empire. Up until the second half of the 19th century, this was the royal residence of the kings of Württemberg. Today, the palace contains ministries of the Baden-Württemberg state government and state reception rooms.

The Old Palace was originally the seat of the first counts and dukes of Württemberg. It is now home to the Württemberg State Museum. Each year its inner courtyard is the setting for the official opening of the Stuttgart Wine Village and the Christmas Market. The Museum of Art, a 27-m-high glass cube, is no less of an eye-catcher at night, when it sets the concrete core of its interior aglow, radiating light into Palace Square. The museum's collection comprises over 15,000 works of art from the late 18th century up to the present day.

Diagonally opposite is the Kunstgebäude gallery, its cupola surmounted by a golden stag, where regular exhibitions of contemporary art are staged by the Württemberg Art Association. The original building was destroyed in WW II and rebuilt to plans by the architect Paul Bonatz, who also designed the main railway station. Between the Kunstgebäude and the New Palace are the Upper Palace Gardens. Here, a sombre structure with a steel skeleton frame catches the eye: the Landtag, seat of Baden-Württemberg's parliament. Built in the 1950s, it was purposely designed in a style that would not detract from the classical architecture of the Opera House and State Theatre.

If you prefer shopping to culture, you'll be in your element in Königstraße, Germany's longest shopping precinct, which takes you past Palace Square and also the Königsbau, Stuttgart's oldest shopping arcade.
[`https://www.stuttgart-tourist.de/en/a-schlossplatz-stuttgart-palace-square`]

Art Museum Stuttgart

Address:

Kunstmuseum Stuttgart
Kleiner Schlossplatz 1
70173 Stuttgart
http://www.kunstmuseum-stuttgart.de/index.php?site=&lang=en

Opening hours:

Tue – Sun: 10:00 – 18:00
Fri: 10:00 – 21:00

Arriving by public transport:

U U5, U6, U7, U12, U15 Schlossplatz
S S1, S2, S3, S4, S5, S6, S60 Stadtmitte (5 minutes walk)

In the heart of the city: the Art Museum Stuttgart

The spectacular glass cubicle – build by the Berlin architecture office Hascher and Jehle – is inspiring with its sleek elegance. During the day glass galleries invite you to enjoy a magnificent view of the city and the surrounding slopes, at night the cube floats as a fascinating light sculpture above the Kleinem Schloßplatz. With a museum shop, book shop, bar and restaurant as well as rooms for events, the glass cube is a unique attraction – for the friends of art as well as for the people passing by.

The collection

The top-class city art collection entices on around 5,000 square meters. The basic inventory was donated by Count Silvio della Valle di Casanova in 1924 through the gift of his private collection of paintings to his adopted home town of Stuttgart. After 1945, Eugen Keuerleber took over the direction of the city art collection and defined four points of emphasis: The Swabian Impressionists, Adolf Hölzel and his followers, Otto Dix as well as the contemporary art of the region. The world's most important Otto Dix collection has formed the core of the city art collection until today. Today the city art collection includes around 15,000 pieces.
[https://www.stuttgart-tourist.de/en/a-art-museum-stuttgart]

State Gallery Stuttgart

Address:

Staatsgalerie Stuttgart
Konrad-Adenauer-Straße 30–32
70173 Stuttgart
`https://www.staatsgalerie.de/en.html`

Opening hours:

Tue, Wed, Fri – Sun: 10:00 – 18:00
Thu: 10:00 – 20:00

Arriving by public transport:

U U1, U2, U9, U14 Staatsgalerie (6 minutes walk)
U U5, U6, U7, U12, U15 Charlottenplatz (8 minutes walk)

Old State Gallery

The State Gallery of Stuttgart, built in the years 1838 – 1843 under King Wilhelm I of Württemberg, has been one of the most visited German museums, especially since the opening of the world famous expansion from the British star architect James Stirling in the year 1984.

The classicist building from the 19th century, the Old State Gallery, is home to the works from the 14th to the 19th century as well as the graphic collection with its extensive inventory of drawings, water paintings, collages, printed graphics, illustrated books, posters and photographs. Originating from the collection of the Württemberg ducal house, excellent paintings, for example by Jerg Ratgeb, Canaletto, Memling and Rembrandt, today are the center pieces in the individual departments of the old masters.

The department of the 19th century contains in addition to the special collection field "Swabian Classicism" exemplary works of the most important artistic movements of the time from the pre-Pre-Raphaelites up to Symbolism, from Romanticism to Impressionism.

New State Gallery

Connected to the old museum on the gallery level, the expansion by James Stirling, The New State Gallery, is dedicated to the art of the 20th century. Since the end of the Second World War the emphasis of the collection of the State Gallery is in the classical modernism and the contemporary painting and sculpture.

The concentration on important groups of works of the differing stylistic movements ("Fauves", "Brücke", "blauer Reiter", "Cubism") as well as the excellent works complexes of individual artists (Picasso, Beckmann, Schlemmer, Beuys, Kiefer) establish the international reputation of the house.
[https://www.stuttgart-tourist.de/en/a-state-gallery]

Mercedes-Benz Museum

Address:

Mercedes-Benz Museum
Mercedesstraße 100
70372 Stuttgart
http://www.mercedes-benz-classic.com/museum

Opening hours:

Tue-Sun: 9:00 – 18:00, last admission: 17:00

Arriving by public transport:

S S1 Neckarpark (Mercedes-Benz)

Take a journey through 125 years of fascinating automotive history – and on into the future.

Visit the Mercedes-Benz Museum in Stuttgart and you will be entering the only place in the world capable of documenting the unbroken 125-year history of the automobile from its very beginning. Transporting you to a height of 34 meters, the museum lift will take you on a journey back in time – to the year 1886. For this is where the legend begins, with the pioneering invention of Gottlieb Daimler and Carl Benz – the automobile. Few inventions have made such an impact on the human world.

Two interlinked museum tours guide the visitor through the spectacular architecture of the building and the eventful history of the Mercedes-Benz brand – combining the key moments in contemporary world history with super sports cars, Silver Arrows and Gullwings. The two tours lead to the same end point: the innovations of the present. Here in the Fascination of Technology exhibition you will gain an insight into the latest topics from the worlds of research, design, development and production.

Over an area covering 16,500 square meters on nine levels, the exhibition presents 160 vehicles and over 1,500 exhibits, divided into Legend rooms and Collection rooms. The Legend rooms document the history of the Mercedes-Benz brand and are subdivided into themes and epochs. The Collection rooms offer a thematic presentation of the wealth and diversity of vehicles made by the brand.

Relive the history – and at the same time you will be afforded an informative glimpse into the future. Where do we go from here? To mark the anniversary of the automobile in 2011, an all-new exhibition room will present a range of different drive variants of the present and future – including the optimized internal combustion engine, electric and hybrid drives and the fuel cell.
[https://www.stuttgart-tourist.de/en/a-mercedes-benz-museum]

Porsche Museum

Address:

Porsche Museum
Porscheplatz 1
70435 Stuttgart
http://www.porsche.com/museum/en/

Opening hours:

Tue – Sun: 9:00 – 18:00, last admission: 17:30

Arriving by public transport:

S S6, S60 Neuwirtshaus/Porscheplatz

One of the greatest and most spectacular building projects in the history of Dr. Ing. h.c. F. Porsche AG: the Porsche Museum in Stuttgart-Zuffenhausen. Located directly in the very heart of this unique sports car company so rich in tradition, the Museum serves to present the fascinating thrill and diversity of the Porsche brand to visitors from all over the world. More than 80 cars are on display in the 5,600 square metre (60,250 square feet) Exhibition Area styled and designed futuristically by the Viennese architects Delugan Meissl, ranging from the legendary wheel hub motor of the Lohner-Porsche, the world's first hybrid automobile built as far back as in 1900, all the way to the latest generation of the Porsche 911.

Apart from the exhibition itself, the historical archives and the "transparent" workshop for historical cars, the Museum offers a wide range of catering services complete with a coffee bar, a bistro and an exclusive restaurant, as well as generous conference areas finished mainly in white, the fundamental colour of the Museum.

The new Porsche Museum is also available as an event location for other purposes, for example for conferences, film screenings or concerts, quite independently of the usual exhibition activities.

The new building at Porscheplatz is located at a very important place in the history of German automobile production, since this is where the Porsche Design Office moved to from downtown Stuttgart to Plant 1 in Zuffenhausen back in 1938. In the same year the forerunners of the VW Beetle saw the light of day precisely here at this location, followed by the Type 64 Porsche as the ancestor of all Porsche sports cars, the legendary Berlin-Rome car, in 1939. Sports cars proudly bearing the now world-famous Porsche logo have been built here in Zuffenhausen ever since 1950.

The exhibition concept

The actual Exhibition Area is made up of a daring steel structure resting on just three concrete cores and appearing to hover in space, covering a span of up to 60 metres or almost 200 feet. Inside the Museum Porsche's historical cars and some 200 additional exhibits are grouped together in a carefully planned and highly attractive arrangement. The visitor is guided through the Museum by the history of Porsche products, conveying the Porsche Idea through characteristic features such as "fast", "light", "clever", "powerful", "intense" and "consistent".
[https://www.stuttgart-tourist.de/en/a-porsche-museum]

Television Tower

Address:

Television Tower
Jahnstraße 120
70597 Stuttgart
https://www.fernsehturm-stuttgart.de/en/

Opening hours:

Mon – Thu: 10:00 – 23:00
Fri – Sun: 09:00 – 23:00

Arriving by public transport:

U U15 Ruhbank
U U7, U8 Waldau

After a construction time of 20 months, operation of the Stuttgart television tower was started on 5 February 1956. With its impressive height of 217 m, it is the original model for the television towers from around the world.

Originally what was then the Süddeutsche Rundfunk wanted to set up its antennas for the transmission of television and VHF radio broadcasts at a height of 200 meters on an iron grid pole which was secured by steel wire rope, as it was common at the time.

For this monstrous project, the Stuttgart engineer Prof. Fritz Leonhardt, who had become famous as a builder of bridges and a structural engineer, was called in. It was his idea to have an elegant concrete needle grow out of the forests of Degerloch instead of an ugly

grated pole and to provide this with a tower construction with a viewing platform which could be used for tourists and gastronomy.
[https://www.stuttgart-tourist.de/en/a-television-tower]

Weissenhofmuseum

Address:

Weissenhofmuseum
Rathenaustraße 1–3
70191 Stuttgart
http://www.stuttgart.de/weissenhof/index.php?p=menu&language=en

Opening hours:

Tue – Fri: 11:00 – 18:00
Sat – Sun: 10:00 – 18:00

Arriving by public transport:

U U5 Killesberg

The Weissenhofsiedlung is one of the most significant landmarks left by the movement known as "Neues Bauen". The development was erected in 1927 as a residential building exhibition arranged by the City of Stuttgart and the Deutscher Werkbund. Working under the artistic direction of Ludwig Mies van der Rohe, seventeen architects created an exemplary residential scheme for modern urban residents.

The semi-detached homes designed by Le Corbusier, one of the most influential architects of the Twentieth Century, show the aesthetic, social and technical upheavals of the Moderne. Following extensive restoration of the interiors, the façades and the grounds, the structure is now open to visitors. The tour takes the visitor through the two halves of the building, where differing aspects are emphasized. The houses of Le Corbusier are part of the UNESCO WORLD HERITAGE.

In the left half of the building, the floor plan of which was profoundly modified since the 1930s, there is an exhibition explaining the genesis and history of the Weissenhofsiedlung. The museum's fittings echo the original floor plan without blurring the traces of structural changes undertaken in the meantime.

The right half of the structure is oriented on the year 1927, when the Werkbund Exhibition was opened at the Weissenhof. It was possible to restore Le Corbusier's arrangement of spaces, the coloration and a part of the furnishings. Thus the visitor encounters a "snapshot" from the exhibition at that time.
[https://www.stuttgart-tourist.de/en/a-weissenhofmuseum]

Wilhelma (Zoological-Botanical Garden)

Address:

Zoologisch-botanischer Garten Wilhelma
Wilhelma 13
70376 Stuttgart
http://www.wilhelma.de/nc/en/home.html

Opening hours:

Mon – Sun: 8:15 – 18:00

Arriving by public transport:

U U14 Wilhelma
S S1, S2, S3 Bad Canstatt (15 minutes walk)

Stuttgart's unique zoological-botanical garden Wilhelma is one of the most beautiful of its kind in Europe. It was built from 1842 – 1853 for King Wilhelm I of Württemberg as a Moorish garden. With around 9,000 animals of almost 1,000 species, important collections of orchids, an aquarium with crocodile hall and famous coral fish collection, bear facilities and much more, the Wilhelma is THE place to see for visitors of all ages. No wonder, that with ca. 1.8 million visitors a year, it is one of the most visited sights in Baden-Württemberg.
[https://www.stuttgart-tourist.de/en/a-wilhelma-stuttgart]

Part II.

Technical Program

Proceedings

The proceedings of the 7th GACM Colloquium on Computational Mechanics containing the extended abstracts are available as a pdf file at the following location:

https://www.gacm2017.uni-stuttgart.de/program/GACM2017_proceedings.pdf

After the conference the proceedings will receive a Digital Object Identifier (DOI) and will be permanently available on the open access document server of the University of Stuttgart (https://elib.uni-stuttgart.de/).

Information for Lecturers

- Please check your presentation time and lecture room daily for possible changes.
- All presentation rooms are equipped with a notebook (Windows 10, Microsoft PowerPoint 2016, Acrobat Reader) and a video projector.
- You are asked to upload your presentation on the notebook as soon as possible, but at the latest in the break before your session. Technical staff wearing a orange lanyard will be present in the lecture rooms during the breaks.
- If you prefer to use your own notebook, a VGA and an hdmi connector are available in all lecture rooms. Please make sure to bring necessary adapters.
- Please be present at least 10 minutes prior to the start of your session and let the chairperson know you are there.
- The time allotted for presentations is
  - 20 min. (incl. discussion) for presentations in mini-symposia and contributed sessions
  - 40 min. (incl. discussion) for keynote lectures in mini-symposia
  - 30 min. for GACM Best PhD Award winner lectures
  - 45 min. for plenary lectures.

  The chairpersons are requested to stop presentations after the allotted time has passed.

Plenary Lectures

Paul Steinmann (Friedrich-Alexander University of Erlangen-Nürnberg, Germany):
Modelling and simulation of SBM processes in computational additive manufacturing
Wednesday, 11 October 2017; 09:15 – 10:00 in room 7.02 (Session PL01)

Ralph Lohner (Hilti AG, Liechtenstein):
71'573 various challenges – Computational Engineering @ HILTI
Thursday, 12 October 2017; 08:30 – 09:15 in room 7.02 (Session PL04)

Kurt Maute (University of Colorado Boulder, United States of America):
Topology Optimization of Nonlinear Problems in Solid and Fluid Mechanics
Friday, 13 October 2017; 11:30 – 12:15 in room 7.02 (Session PL05)

GACM Best PhD Award Winner Lectures

Tobias Gleim (University of Colorado Boulder, United States of America):
High-order accurate time integration methods for electromagnetic-thermal analysis
Wednesday, 11 October 2017; 13:30 – 14:00 in room 7.02 (Session PL02)

Vladimir Statnikov (RWTH Aachen University, Germany):
Zonal Turbulence Modeling and Reduced-Order Methods for Space Launcher Wake Flows Analyses
Wednesday, 11 October 2017; 14:00 – 14:30 in room 7.02 (Session PL02)

Ursula Rasthofer:
Computational multiscale methods for turbulent single- and two-phase flows
Thursday, 12 October 2017; 09:15 – 09:45 in room 7.02 (Session PL04)

Richard Ostwald (TU Dortmund University, Germany):
Modeling and simulation of phase transformations in elasto-plastic polycrystals
Friday, 13 October 2017; 11:00 – 11:30 in room 7.02 (Session PL05)

Mini-Symposia

MS01: 3D Imaging and Segmentation Methods for Computational Modeling of Heterogeneous Materials

Organizers:
Pietro Carrara (Institute of Applied Mechanics, Technical University of Braunschweig)
Michele Griffa (Concrete/Construction Chemistry Laboratory, Swiss Federal Laboratories for Materials Science and Technology, EMPA)

Sessions:
MS01-1: Wednesday, 11 October 2017; 10:30 – 12:30 in room 7.12
MS01-2: Wednesday, 11 October 2017; 16:00 – 18:00 in room 7.12

MS02: Adaptive Structures: Theory, Modelling, Simulation and Evaluation

Organizers:
Florian Geiger (Institute for Structural Mechanics, University of Stuttgart)
Christian Kelleter (Institute for Lightweight Structures and Conceptual Design (ILEK), University of Stuttgart)

Sessions:
MS02-1: Wednesday, 11 October 2017; 10:30 – 12:30 in room 7.22
MS02-2: Wednesday, 11 October 2017; 16:00 – 18:00 in room 7.22

MS03: Challenges of Current and Emerging Applications for High Performance Computing

Organizer:
Ralf Schneider (Numerical Methods & Libraries, High Performance Computing Center Stuttgart)

Session:
MS03-1: Thursday, 12 October 2017; 10:30 – 12:30 in room 7.12

MS04: Computational Analysis and Modeling of Experimental Dynamic Loading Tests

Organizers:
Mohammad Reza Khosravani (Institute of Solid Mechanics, University of Siegen)
Carola Bilgen (Institute of Solid Mechanics, University of Siegen)

Session:
MS04-1: Thursday, 12 October 2017; 13:30 – 15:30 in room 7.12

MS05: Computational Contact Mechanics

Organizers:
Alexander Popp (Institute for Computational Mechanics, Technical University of Munich)
Christian Hesch (Chair of Computational Mechanics, University of Siegen)
Anton Tkachuk (Institute for Structural Mechanics, University of Stuttgart)
Christoph Wilking (Institute for Structural Mechanics, University of Stuttgart)

Sessions:
MS05-1: Thursday, 12 October 2017; 13:30 – 15:30 in room 7.04
MS05-2: Thursday, 12 October 2017; 16:00 – 18:00 in room 7.04
MS05-3: Friday, 13 October 2017; 08:30 – 10:30 in room 7.04

MS06: Computational FSI and Aero-elasticity

Organizers:
Roland Wüchner (Chair of Structural Analysis, Technical University of Munich)
Thorsten Lutz (Institute for Aerodynamics and Gas Dynamics, University of Stuttgart)
Andreas Apostolatos (Chair of Structural Analysis, Technical University of Munich)

Sessions:
MS06-1: Wednesday, 11 October 2017; 10:30 – 12:30 in room 7.04
MS06-2: Wednesday, 11 October 2017; 16:00 – 18:00 in room 7.04

MS07: Computational Mechanics and Biomimetics

Organizers:
Annette Birkhold (Advanced Therapies - Innovation, Siemens Healthineers)
Renate Sachse (Institute for Structural Mechanics, University of Stuttgart)

Session:
MS07-1: Friday, 13 October 2017; 08:30 – 10:30 in room 7.22

MS08: Coupled Multi-field Problems in Porous-media Mechanics

Organizers:
Said Jamei (Institute of Applied Mechanics (CE), University of Stuttgart)
Arndt Wagner (Institute of Applied Mechanics (CE), University of Stuttgart)
Yousef Heider (Institute of General Mechanics, RWTH Aachen University)

Sessions:
MS08-1: Thursday, 12 October 2017; 10:30 – 12:30 in room 7.02
MS08-2: Thursday, 12 October 2017; 13:30 – 15:30 in room 7.02

MS09: Damage Mechanics and Numerical Applications

Organizers:
Jaan-Willem Simon (Institute of Applied Mechanics, RWTH Aachen University)
Katrin Schulz (Institute for Applied Materials - Computational Materials Science, Karlsruhe Institute of Technology)
Stephan Wulfinghoff (Institute of Applied Mechanics, RWTH Aachen University)

Sessions:
MS09-1: Wednesday, 11 October 2017; 10:30 – 12:30 in room 7.11
MS09-2: Wednesday, 11 October 2017; 16:00 – 18:00 in room 7.11

MS10: Mechanics of Dissipative Solids: Plasticity, Fracture and Damage

Organizers:
Fadi Aldakheel (Institute of Continuum Mechanics, Leibniz Universität Hannover)
Charlotte Kuhn (Computational Mechanics, University of Kaiserslautern)
Stephan Teichtmeister (Institute of Applied Mechanics (CE), University of Stuttgart)

Sessions:
MS10-1: Thursday, 12 October 2017; 16:00 – 18:00 in room 7.11
MS10-2: Friday, 13 October 2017; 08:30 – 10:30 in room 7.11

MS11: Modeling, Simulation, Control and Optimization of Multi-physical Phenomena

Organizers:
Thorsten Schindler (ABB Corporate Research Center Germany)
Oliver Hofmann (Chair of Applied Mechanics, Technical University of Munich)

Session:
MS11-1: Thursday, 12 October 2017; 16:00 – 18:00 in room 7.02

MS12: Multidisciplinary and Structural Design Optimization

Organizer:
Erich Wehrle (Industrial Engineering and Automation, Free University of Bozen-Bolzano)

Sessions:
MS12-1: Thursday, 12 October 2017; 16:00 – 18:00 in room 7.12
MS12-2: Friday, 13 October 2017; 08:30 – 10:30 in room 7.12

MS13: Multiscale Methods for Complex Materials

Organizers:
Stefan Löhnert (Institute of Continuum Mechanics, Leibniz Universität Hannover)
Bernhard Eidel (Mechanical Engineering, University of Siegen)
Jörg F. Unger (Safety of Structures, Federal Institute for Materials Research and Testing)

Sessions:
MS13-1: Wednesday, 11 October 2017; 10:30 – 12:30 in room 7.31
MS13-2: Wednesday, 11 October 2017; 16:00 – 18:00 in room 7.31

MS14: Multiscale Modeling of Transport Processes and Fracture in Concrete

Organizers:
Tao Wu (Institute of Applied Mechanics, Technical University of Braunschweig)
Jithender Jaswant Timothy (Institute for Structural Mechanics, Ruhr University Bochum)

Session:
MS14-1: Thursday, 12 October 2017; 10:30 – 12:30 in room 7.11

MS15: Non-standard Formulations and Discretization Methods for Thin-walled Structures

Organizers:
Bastian Oesterle (Institute for Structural Mechanics, University of Stuttgart)
Wolfgang Dornisch (Chair of Applied Mechanics, University of Kaiserslautern)
Michael Breitenberger (Chair of Structural Analysis, Technical University of Munich)
Josef Kiendl (Department of Marine Technology, Norwegian University of Science and Technology)

Sessions:
MS15-1: Wednesday, 11 October 2017; 10:30 – 12:30 in room 7.01
MS15-2: Wednesday, 11 October 2017; 16:00 – 18:00 in room 7.01
MS15-3: Thursday, 12 October 2017; 10:30 – 12:30 in room 7.01

MS16: Reduced Order Models for Multiscale and Multiphysics Problems

Organizers:
Felix Fritzen (EMMA - Efficient Methods for Mechanical Analysis, Institute of Applied Mechanics (CE), University of Stuttgart)
Ralf Jänicke (Department of Industrial and Materials Science, Chalmers University of Technology)

Sessions:
MS16-1: Wednesday, 11 October 2017; 10:30 – 12:30 in room 7.02
MS16-2: Wednesday, 11 October 2017; 16:00 – 18:00 in room 7.02

MS17: Smart and Active Materials: Experiments, Modelling, and Simulation

Organizers:
Mokarram Hossain (Swansea University)
Krishnendu Haldar (Laboratory of Solid Mechanics (LMS), Ecole Polytechnique)

Sessions:
MS17-1: Thursday, 12 October 2017; 10:30 – 12:30 in room 7.22
MS17-2: Thursday, 12 October 2017; 13:30 – 15:30 in room 7.22
MS17-3: Thursday, 12 October 2017; 16:00 – 18:00 in room 7.22

MS18: Virtual Analysis and Design of New Materials

Organizers:
Martin Hohberg (Institute of Vehicle System Technology - Lightweight Technology, Karlsruhe Institute of Technology)
Loredana Kehrer (Institute of Engineering Mechanics, Chair for Continuum Mechanics, Karlsruhe Institute of Technology)
Christian Weißenfels (Institute of Continuum Mechanics, Leibniz Universität Hannover)

Sessions:
MS18-1: Thursday, 12 October 2017; 10:30 – 12:30 in room 7.31
MS18-2: Thursday, 12 October 2017; 13:30 – 15:30 in room 7.31
MS18-3: Thursday, 12 October 2017; 16:00 – 18:00 in room 7.31

Contributed Sessions

CS01: Advanced Modelling and Discretization Schemes

Session:
Thursday, 12 October 2017; 13:30 – 15:30 in room 7.01

CS02: Fluid Mechanics

Session:
Thursday, 12 October 2017; 16:00 – 18:00 in room 7.01

CS03: Multiphysics

Session:
Friday, 13 October 2017; 08:30 – 10:30 in room 7.02

CS04: Fracture

Session:
Thursday, 12 October 2017; 13:30 – 15:30 in room 7.11

CS05: Damage and Plasticity

Session:
Friday, 13 October 2017; 08:30 – 10:30 in room 7.31

CS06: Interface Models and Homogenization

Session:
Thursday, 12 October 2017; 10:30 – 12:30 in room 7.04

CS07: Crystal Mechanics

Session:
Friday, 13 October 2017; 08:30 – 10:30 in room 7.01

Program Overview

	Wed. 11 Oct.	Thu 12 Oct.	Fri. 13 Oct.
08:00	Registration		
08:30	**W1: Opening & Plenary** P. Steinmann	**T1: Plenary** R. Lohner U. Rasthofer	**F1** CS07 Crystal Mechanics CS03 Multiphysics MS05-3 Contact Mechanics MS10-2 Dissipative Solids MS12-2 Optimization MS07-1 Biomimetics CS05 Damage/Plasticity
09:00			
09:30			
10:00	Coffee Break	Coffee Break	
10:30	**W2** MS15-1 Thin-walled Structures MS16-1 Reduced Order Models MS06-1 FSI MS09-1 Damage Mechanics MS01-1 Heterogeneous Material MS02-1 Adaptive Structures MS13-1 Multiscale Methods	**T2** MS15-3 Thin-walled Structures MS08-1 Porous Media CS06 Interfaces/Homogen. MS14-1 Transport+Fracture MS03-1 HPC MS17-1 Smart Materials MS18-1 New Materials	Coffee Break
11:00			**F2: Plenary & Closing** R. Ostwald K. Maute
11:30			
12:00			
12:30	Lunch	Lunch	
13:00			
13:30	**W3: Plenary** T. Gleim V. Statnikov **Poster Track & Poster Session**	**T3** CS01 Modelling+Discretiz. MS08-2 Porous Media MS05-1 Contact Mechanics CS04 Fracture MS04-1 Dynamic Loading Tests MS17-2 Smart Materials MS18-2 New Materials	
14:00			
14:30			
15:00			
15:30	Coffee Break	Coffee Break	
16:00	**W4** MS15-2 Thin-walled Structures MS16-2 Reduced Order Models MS06-2 FSI MS09-2 Damage Mechanics MS01-2 Heterogeneous Material MS02-2 Adaptive Structures MS13-2 Multiscale Methods	**T4** CS02 Fluid Mechanics MS11-1 Multi-phys. Phenom. MS05-2 Contact Mechanics MS10-1 Dissipative Solids MS12-1 Optimization MS17-3 Smart Materials MS18-3 New Materials	
16:30			
17:00			
17:30			
18:00			
18:30	**Reception** GACM Best Poster Award Ceremony		
19:00			
19:30		**Conference Banquet**	
20:00			

Wednesday, 11 October 2017

08:00 – 13:00
Registration

W1: 08:30 – 10:00
Opening & Plenary Lecture

PL01	Chairperson: Malte von Scheven	**7.02**
08:30	Opening	
09:15	Modelling and simulation of SBM processes in computational additive manufacturing *Paul Steinmann, Julia Mergheim*	

10:00 – 10:30
Coffee Break

MS15-1	**Non-standard Formulations and Discretization Methods for Thin-walled Structures** Chairperson: Bastian Oesterle	**7.01**
10:30	Smooth spline spaces on unstructured quadrilateral meshes for isogeometric analysis (Keynote) *Hendrik Speleers, Deepesh Toshniwal, Thomas J. R. Hughes*	
11:10	Recent advances in isogeometric dual mortar patch coupling *Wolfgang Dornisch, Joachim Stöckler, Ralf Müller*	
11:30	Strain gradient elasticity theories in lattice structure modelling *Jarkko Niiranen, Sergei Khakalo, Viacheslav Balobanov*	
11:50	A homogenization approach for beam-like structures with arbitrarily shaped and deformable cross-sections *Simon Klarmann, Friedrich Gruttmann*	
12:10	Shell models in the framework of generalized continuum theories: isogeometric implementation and applications *Viacheslav Balobanov, Sergei Khakalo, Josef Kiendl, Jarkko Niiranen*	
MS16-1	**Reduced Order Models for Multiscale and Multiphysics Problems** Chairperson: Ralf Jänicke	**7.02**
10:30	Partial mechanics of far fields in elastoplastic structures (Keynote) *David Ryckelynck*	
11:10	Viscoplastic reduced order homogenization using mixed formulations *Federica Covezzi, Stefano de Miranda, Felix Fritzen, Sonia Marfia, Elio Sacco*	
11:30	High-performance model order reduction techniques in non-linear multiscale fracture problems *Manuel Alejandro Caicedo Silva, Javier Oliver, Alfredo E. Huespe, Oriol Lloberas-Valls*	
11:50	Two-scale Reduced Basis Homogenization under Large Deformations *Oliver Kunc, Felix Fritzen*	
12:10	Two-Phase Model-Reduction for Two-Scale Simulations of Components *Matthias Kabel*	
MS06-1	**Computational FSI and Aero-elasticity** Chairperson: Thorsten Lutz	**7.04**
10:30	Aeroelasticity of Large Horizontal Axis Wind Turbines: Simulation Approaches and Modeling Challenges (Keynote) *Mohamed Sayed, Thorsten Lutz, Shahrokh Shayegan, Roland Wüchner*	
11:10	Transient aeroelastic simulations of wind turbines with composite blades *Gilberto Santo, Mathijs Peeters, Wim Van Paepegem, Joris Degroote*	
11:30	Aspects of FSI with aeroacoustics in turbulent flow *Thorsten Reimann, Awais Ali*	
11:50	Official preCICE Adapters for Standard Open-Source Solvers *Benjamin Uekermann, Hans-Joachim Bungartz, Lucia Cheung Yau, Gerasimos Chourdakis, Alexander Rusch*	
MS09-1	**Damage Mechanics and Numerical Applications** Chairperson: Jaan-Willem Simon	**7.11**
10:30	Phase Field Modeling of Fracture in Anisotropic Brittle Solids (Keynote) *Stephan Teichtmeister, Daniel Kienle, Fadi Aldakheel, Marc-André Keip*	
11:10	Adaptive Isogeometric Phase-Field Modeling of Ductile Fracture *Paul Hennig, Markus Kästner, Marreddy Ambati, Laura De Lorenzis*	
11:30	Data-driven crack assessment *Katrin Schulz, Valentin Verrier, Stephan Kreis*	
11:50	Discussion of crack initiation in metal matrix composites *Markus Sudmanns, Katrin Schulz*	

MS01-1	**3D Imaging and Segmentation Methods for Computational Modeling of Heterogeneous Materials** Chairperson: Pietro Carrara	**7.12**
10:30	Modelling of microcracking in image-based models of highly heterogeneous materials using the phase field method (Keynote) *Julien Yvonnet, Than Tung Nguyen, Michel Bornert, Camille Chateau, Liang Xia*	
11:10	Numerical validation framework for micromechanical simulations based on 3D imaging *Francois Hild, Group Cominside*	
11:30	Diffraction and Attenuation X-ray Imaging of Ductile Damage Combine with Crystal Plasticity Finite Element Modelling *Christophe Le Bourlot, Sylvain Dancette, Eric Maire, Wolfgang Ludwig*	
11:50	2D-Surface and 3D-Volume Digital Image Correlation (DIC) for materials characterization at different scales *Roberto Fedele*	
MS02-1	**Adaptive Structures: Theory, Modelling, Simulation and Evaluation** Chairperson: Florian Geiger	**7.22**
10:30	Gramian-Based Actuator Placement for Static Load Compensation in Adaptive Structures (Keynote) *Julia Wagner, Michael Heidingsfeld, Michael Böhm, Oliver Sawodny*	
11:10	The implementation of an adaptive high-rise building *Stefanie Weidner, Paula-Lie Sternberg, Werner Sobek*	
11:30	Realization of Adaptive Prestressing *Daniel Steiner, Martina Schnellenbach-Held*	
11:50	Variable filter radii for Vertex Morphing based design of adaptive structures *Armin Geiser, Roland Wüchner, Kai-Uwe Bletzinger*	
MS13-1	**Multiscale Methods for Complex Materials** Chairperson: Stefan Löhnert	**7.31**
10:30	Mesoscale influence on the macroscopic material behavior of concrete *Volker Hirthammer, Jörg F. Unger, Josko Ozbolt*	
10:50	Obtaining macroscopic properties from a mesoscale thermomechanical model of concrete *Christoph Pohl, Jörg F. Unger*	
11:10	Validation of a synthetic model of hot mix asphalt *Johannes Neumann, Jaan-Willem Simon, Stefanie Reese*	
11:30	The Heterogeneous Multiscale Finite Element Method (FE-HMM) for nonlinear problems in solid mechanics *Andreas Fischer, Ajinkya Gote, Bernhard Eidel*	
11:50	A two-scale homogenization scheme for the simulation of micro-heterogeneous magneto-electric composites *Matthias Labusch, Jörg Schröder*	

W3: 13:30 – 15:30
Plenary Lectures & Poster Session

PL02 Chairperson: Nils Karajan **7.02**

13:30 High-order accurate time integration methods for electromagnetic-thermal analysis
Tobias Gleim

14:00 Zonal Turbulence Modeling and Reduced-Order Methods for Space Launcher Wake Flows Analyses
Vladimir Statnikov, Matthias Meinke, Wolfgang Schröder

PL03 **Poster Track** Chairperson: Nils Karajan **7.02**

14:30 Application of X-ray computed tomography on fracture behaviour study of cement paste at micro-scale (Poster)
Hongzhi Zhang, Branko Šavija, Erik Schlangen

14:31 A scaled boundary NURBS approach for nonlinear solid analysis (Poster)
Markus Klassen, Margarita Chasapi, Bernd Simeon, Sven Klinkel

14:32 The Particle Finite Element Method in Solid Mechanics Applications (Poster)
Markus Manuel Schewe, Andreas Menzel

14:33 Two-scale Reduced Basis Homogenization under Large Deformations (Poster)
Oliver Kunc, Felix Fritzen

14:34 Computation of multiphysics processes in deformable media (Poster)
Bilen Emek Abali

14:35 Regenerating CAD Models with OpenCASCADE and pythonOCC from Numerical Models with Application to Shape Optimization (Poster)
Altug Emiroglu, Andreas Apostolatos, Roland Wüchner, Kai-Uwe Bletzinger

14:36 The Heterogeneous Multiscale Finite Element Method (FE-HMM) for nonlinear problems in solid mechanics (Poster)
Andreas Fischer, Ajinkya Gote, Bernhard Eidel

14:37 Discussion of crack initiation in metal matrix composites (Poster)
Markus Sudmanns, Katrin Schulz

14:38 A Novel Parameter Identification Toolbox for the Selection of Hyperelastic Constitutive Models from Experimental Data (Poster)
Hüsnü Dal, Yashar Badienia, Kemal Açıkgöz, Funda Aksu Denli

14:39 Virtual tests based on model reduction strategies for fatigue analysis (Poster)
Mainak Bhattacharyya, Amelie Fau, Udo Nackenhorst, David Néron, Pierre Ladevèze

14:40 Parallel Stabilized FEM for the Flow Simulations of Microstructured Fluids (Poster)
Metin Cakircali, Marek Behr

14:41 Comparative study of finite-element-based fatigue analysis concepts for adhesive joints in wind turbine rotor blades (Poster)
Pablo Noever Castelos, Michael Wentingmann, Claudio Balzani

14:42 Data-driven crack assessment (Poster)
Katrin Schulz, Valentin Verrier, Stephan Kreis

14:43 Flexible Wheelset Models in Dynamic Interaction with Track (Poster)
Mustapha Afriad, Mohamed Rachik, Ludovic Cauvin, Olivier Cazier, Guy-Leon Kaza

14:44 Determination of optimal damping for passive control of vibration based on the design of limit cycles (Poster)
Rafael A. Rojas, Erich Wehrle, Renato Vidoni

14:45 A Variational Level Set Approach to Ferroelectrics (Poster)
Robin Schulte, Andreas Menzel, Bob Svendsen

14:46 Virtual simulation of deformation behavior of NiTi stents used in minimally invasive surgery (Poster)
Sharath Chandra Chavalla, Daniel Juhre

14:47 Parameter identification for thermo-mechanically coupled material models (Poster)
Lars Rose, Andreas Menzel

14:48 A method for the elimination of shear locking effects in an isogeometric Reissner-Mindlin shell formulation (Poster)
Georgia Kikis, Wolfgang Dornisch, Sven Klinkel

14:49 Phase-Field Modelling of Crack Propagation in Elasto-Plastic Multilayered Materials (Poster)
Zhengkun Liu, Daniel Juhre

14:50 – 15:30
Poster Session
(Pfaffenwaldring 47)

15:30 – 16:00
Coffee Break
(Pfaffenwaldring 47)

MS15-2 **Non-standard Formulations and Discretization Methods for Thin-walled Structures** **7.01**
Chairperson: Wolfgang Dornisch

16:00 A Discretization Independent Methodology for Mixed Methods
Simon Bieber, Bastian Oesterle, Ekkehard Ramm, Manfred Bischoff

16:20 Hierarchic Isogeometric Large Rotation Shell Elements Including Linearized Transverse Shear Parametrization
Renate Sachse, Bastian Oesterle, Ekkehard Ramm, Manfred Bischoff

16:40 Generalized local B-bar method for locking phenomenon in Reissner-Mindlin shell and skew-symmetric Nitsche method for boundary conditions imposing and patch coupling in IGA
Qingyuan Hu, Franz Chouly, Andreas Zilian, Gengdong Cheng, Stéphane Bordas

17:00 A method for the elimination of shear locking effects in an isogeometric Reissner-Mindlin shell formulation
Georgia Kikis, Wolfgang Dornisch, Sven Klinkel

17:20 Analysis of axisymmetric shells based on the scaled boundary finite element method
Milan Wallner, Carolin Birk, Hauke Gravenkamp

MS16-2 **Reduced Order Models for Multiscale and Multiphysics Problems** **7.02**
Chairperson: Felix Fritzen

16:00 Reduced Order Modelling for the Simulation of Quenches in Superconducting Magnets (Keynote)
Sebastian Schöps, Idoia Cortes Garcia, Michał Maciejewski, Bernhard Auchmann

16:40 Computational homogenization and model order reduction of pressure diffusion in fractured rock
Ralf Jänicke, Fredrik Larsson, Kenneth Runesson

17:00 Numerical Model Reduction in Computational Homogenization of Transient Heat Flow
Fredrik Ekre, Fredrik Larsson, Kenneth Runesson

17:20 Substituting FE analysis of cyclic processes by a space-time reduced order model
Mohammad Reza Hassani, Felix Fritzen

17:40 Reduced order modeling of the viscoelastic properties of asphalt concrete
Dennis Wingender, Felix Fritzen, Ralf Jänicke

MS06-2 **Computational FSI and Aero-elasticity** **7.04**
Chairperson: Andreas Apostolatos

16:00 A Partitioned Approach for Fluid-Structure Interaction using NURBS-Enhanced Finite Elements and Isogeometric Analysis (Keynote)
Norbert Hosters, Michel Make, Stefanie Elgeti, Marek Behr

16:40 An isogeometric mortar surface coupling method for trimmmed multipatch CAD geometries with application to FSI
Andreas Apostolatos, Altug Emiroglu, Fabien Pean, Roland Wüchner, Kai-Uwe Bletzinger

17:00 Deforming-Domain Problems Related to Packaging Machines: Mesh-Update Method and Flow Simulation
Fabian Key, Stefanie Elgeti

17:20 Hybrid Additive/Multiplicative Schwarz Preconditioning for Monolithic Solvers for Surface-Coupled Multi-Physics Problems
Maximilian Noll, Matthias Mayr, Michael W. Gee

MS09-2 **Damage Mechanics and Numerical Applications** **7.11**
Chairperson: Katrin Schulz

16:00 Comparative study of finite-element-based fatigue analysis concepts for adhesive joints in wind turbine rotor blades
Pablo Noever Castelos, Michael Wentingmann, Claudio Balzani

16:20 A gradient-extended elastic isotropic damage model considering crack-closure
Marek Fassin, Stephan Wulfinghoff, Stefanie Reese

16:40 A simplified damage model for unilateral behavior of concrete
Ajmal Hasan Monnamitheen Abdul Gafoor, Dieter Dinkler

17:00 A continuum damage model for delamination and intralaminar damage in composite laminates
Jaan-Willem Simon, Daniel Höwer, Stefanie Reese, Jacob Fish

17:20 A viscoelastic-viscoplastic constitutive model with damage for thermoplastics under creep-type loading
Benjamin Schneider, Patrick Zerbe, Egon Moosbrugger, Michael Kaliske

MS01-2 3D Imaging and Segmentation Methods for Computational Modeling of Heterogeneous Materials **7.12**
Chairperson: Michele Griffa

16:00 Application of X-ray computed tomography on fracture behaviour study of cement paste at micro-scale
Hongzhi Zhang, Branko Šavija, Erik Schlangen

16:20 In situ cement hydration in levitated droplets
Julia Stroh , Franziska Emmerling

16:40 High energy microtomography using synchrotron radiation for materials science application
Felix Beckmann

17:00 X-ray computed tomography: Image processing and applications
Matteo Lunardelli, Patrick Varady, Dennis Köhnke, Sven Lehmberg, Harald Budelmann

17:20 Efficient mesh generation of real concrete mesostructures from CT scan images using contrast enhancers
Pietro Carrara, Roland Kruse, Laura De Lorenzis

17:40 X-ray imaging of water transport in porous materials: New possibilities by phase and dark-field contrast
Michele Griffa, Fei Yang

MS02-2 Adaptive Structures: Theory, Modelling, Simulation and Evaluation **7.22**
Chairperson: Christian Kelleter

16:00 Adaptive Structures: Optimum Design Methodology, Case Study and Prototype (Keynote)
Gennaro Senatore

16:40 Feedback Controller Design and Topology Optimization for Truss Structures Under Uncertain Dynamic Loads
Anja Kuttich, Stefan Ulbrich

17:00 Experimental and Theoretical Analysis of Cable dome
Peter Cauner, Stanislav Kmet, Marek Mojdis

17:20 Simulation and optimal control of dielectric elastomer actuated systems
Tristan Schlögl, Sigrid Leyendecker

MS13-2 Multiscale Methods for Complex Materials **7.31**
Chairperson: Bernhard Eidel

16:00 Stress simulation in lithium-ion batteries
Tobias Hofmann, Heiko Andrä, Ralf Müller, Jochen Zausch

16:20 Macroscopic yield curves based on RVE-based polycrystal simulations
Lisa Scheunemann, Jörg Schröder

16:40 Cycle-by-cycle fatigue damage model for concrete
Thomas Titscher, Jörg F. Unger, Javier Oliver

17:00 Domain decomposition methods for fracture mechanics problems and its application to fiber reinforced concrete
Philip Huschke, Jörg F. Unger

Thursday, 12 October 2017

T1: 08:30 – 10:00

Plenary Lectures

PL04	Chairperson: Manfred Bischoff	**7.02**
08:30	71’573 various challenges – Computational Engineering @ HILTI *Ralph Lohner*	
09:15	Computational multiscale methods for turbulent single- and two-phase flows *Ursula Rasthofer*	

10:00 – 10:30

Coffee Break

MS15-3	**Non-standard Formulations and Discretization Methods for Thin-walled Structures** Chairperson: Bastian Oesterle	**7.01**
10:30	Forming simulations with NURBS shells in LS-DYNA *Stefan Hartmann, Attila P. Nagy, Dave J. Benson*	
10:50	A mixed isogeometric collocation method for rate-independent elastoplasticity *Frederik Fahrendorf, Laura De Lorenzis*	
11:10	A scaled boundary NURBS approach for nonlinear solid analysis *Markus Klassen, Margarita Chasapi, Bernd Simeon, Sven Klinkel*	
11:30	Simulation of brittle fracture in shells using a phase-field approach and LR B-splines *Davide Proserpio, Josef Kiendl, Marreddy Ambati, Laura De Lorenzis, Kjetil André Johannessen, Trond Kvamsdal*	
11:50	A shell element for the analysis of interlaminar stresses and delaminations of layered composites *Gregor Knust, Friedrich Gruttmann*	
MS08-1	**Coupled Multi-field Problems in Porous-media Mechanics** Chairperson: Arndt Wagner, Said Jamei	**7.02**
10:30	Modeling porous medium modification through induced calcite precipitation (Keynote) *Johannes Hommel, Adrienne J. Phillips, Robin Gerlach, Alfred B. Cunningham, Rainer Helmig, Holger Class*	
11:10	Heat transfer in multi-phase porous media for intelligent cancer detection *Angela Niedermeyer, Carlos Alberto Hernandez Padilla, Marcus Stoffel, Bernd Markert*	
11:30	Variation of different growth descriptions in a metastatic proliferation model *Patrick Schröder, Arndt Wagner, Daniela Stöhr, Markus Rehm, Wolfgang Ehlers*	
11:50	The TPM^2-Method: A two-scale homogenization scheme for fluid saturated porous media *Florian Bartel, Tim Ricken, Jörg Schröder, Joachim Bluhm*	
12:10	Using a pore-network model to couple mass, momentum and energy at the interface between free flow and porous media flow *Kilian Weishaupt, Rainer Helmig*	
CS06	**Interface Models and Homogenization** Chairperson: Arne Hansen-Dörr	**7.04**
10:30	General imperfect interface models at finite deformations *Tim Heitbreder, Jörn Mosler*	
10:50	Improvement in the accordance of numerical and experimental analysis of a T-joint automotive structure made of composite *Carlo Boursier Niutta, Giovanni Belingardi*	
11:10	Computational modelling of wear and the effective frictional behaviour of elastoplastic tools *Rolf Berthelsen, Hendrik Wilbuer, Andreas Menzel*	
11:30	A homogenisation method based on the Irving-Kirkwood-Theory *Maximilian Müller, Friedrich Gruttmann*	
MS14-1	**Multiscale Modeling of Transport Processes and Fracture in Concrete** Chairperson: Tao Wu	**7.11**
10:30	A Bayesian approach to parameter identification for phase-field modeling fracture (Keynote) *Tao Wu, Bojana Rosić, Hermann Matthies, Laura De Lorenzis*	
11:10	Transport properties of microcracked porous materials: Micromechanics models and mesoscale simulations *Jithender Jaswant Timothy, Tagir Iskhakov, Günther Meschke*	
11:30	Multiscale model of ASR-induced damage in concrete *Tagir Iskhakov, Jithender Jaswant Timothy, Günther Meschke*	
11:50	A Lattice Boltzmann approach for advection-diffusion problems in porous media including dissolution *Hussein Alihussein, Manfred Krafczyk, Konstantin Kutscher, Martin Geier*	

MS03-1	**Challenges of Current and Emerging Applications for High Performance Computing** Chairperson: Ralf Schneider	**7.12**
10:30	An HPC technology review with respect to large scale engineering applications *Ralf Schneider*	
10:50	Numerical Simulation of Flow with Volume Condensation during Accident in Containment of Nuclear Power Plant *Jing Zhang*	
11:10	Modelling the neuromuscular system using HPC systems *Thomas Klotz, Nehzat Emamy, Thomas Ertl, Dominik Göddeke, Aaron Krämer, Michael Krone, Benjamin Maier, Miriam Mehl, Tobias Rau, Oliver Röhrle*	
11:30	Load-balance strategies for CFD-codes on HPC systems *Philipp Offenhäuser*	
11:50	Eigenmodes for nonlinear operators *Uwe Küster, Ralf Schneider, Andreas Ruopp*	
MS17-1	**Smart and Active Materials: Experiments, Modelling, and Simulation** Chairperson: Mokarram Hossain	**7.22**
10:30	Constitutive modeling of shape memory alloys incorporating transformation-induced plasticity and damage (Keynote) *George Chatzigeorgiou, Long Cheng, Yves Chemisky, Fodil Meraghni*	
11:10	Bilayer Liquid Crystal and Freedericksz Instability *Krishnendu Haldar, Kostas Danas, Nicolas Triantafyllidis*	
11:30	Thermo-magneto-mechanical modeling of magneto-rheological elastomers *Markus Mehnert*	
11:50	Continuum Mechanical Modeling of Strain-Induced Crystallization in Polymers *Serhat Aygün, Sandra Klinge, Sanjay Govindjee*	
MS18-1	**Virtual Analysis and Design of New Materials** Chairperson: Martin Hohberg	**7.31**
10:30	Stochastic modelling of microstructures for virtual material design (Keynote) *Claudia Redenbach*	
11:10	Fiber-Orientation-Evolution Models for Compression Molding of Fiber Reinforced Polymers *Róbert Bertóti, Thomas Böhlke*	
11:30	Effective meso properties for fibre reinforced polymer curing *Christian Dammann, Rolf Mahnken, Peter Lenz*	
11:50	A micro-mechanically motivated approach for modelling the oxidative ageing process of elastomers *Darcy Beurle, Markus André, Udo Nackenhorst*	
12:10	Rheology of Additive Manufacturing Processes for Medical Silicone *Philipp Hartmann, Christian Weißenfels, Peter Wriggers*	

CS01	**Advanced Modelling and Discretization Schemes** Chairperson: Tobias Gleim	**7.01**
13:30	A primal discontinuous Petrov Galerkin Finite Element Method *Tobias Steiner, Peter Wriggers*	
13:50	Virtual simulation of deformation behavior of NiTi stents used in minimally invasive surgery *Sharath Chandra Chavalla, Daniel Juhre*	
14:10	Flexible Wheelset Models in Dynamic Interaction with Track *Mustapha Afriad, Mohamed Rachik, Ludovic Cauvin, Olivier Cazier, Guy-Leon Kaza*	
14:30	Improving Numerical Stability of a Tensor-Based Blood Damage Model using the Log-Conformation Formulation *Stefan Haßler, Lutz Pauli, Marek Behr*	
14:50	Parallel Stabilized FEM for the Flow Simulations of Microstructured Fluids *Metin Cakircali, Marek Behr*	
MS08-2	**Coupled Multi-field Problems in Porous-media Mechanics** Chairperson: Yousef Heider	**7.02**
13:30	Compressible Flows inside Piston Ring Pack Simulated with Space-Time Finite Elements *Max von Danwitz, Norbert Hosters, Marek Behr*	
13:50	Phase-Field Modeling of Multiple Phase Change Materials (PCMs) *Abdel Hassan Sweidan, Heider Yousef, Bernd Markert*	
14:10	Preliminary calibration of a phase-field model for cracks due to shrinkage in cement-based materials *Tuanny Cajuhi, Pietro Lura, Laura De Lorenzis*	
14:30	A study of temperature and strain rate dependent glass fracture behaviour *Ziyuan Li, Yousef Heider, Bernd Markert*	
MS05-1	**Computational Contact Mechanics** Chairperson: Alexander Popp	**7.04**
13:30	Contact along virtual interfaces: coupling the X-FEM with the mortar discretization (Keynote) *Vladislav Yastrebov, Basava Raju Akula, Julien Vignollet*	
14:10	On the shape functions for the contact pressure in mortar methods *Xuan Thang Duong, Laura De Lorenzis, Roger A. Sauer*	
14:30	A Nitsche's method for finite deformation thermo-mechanical contact *Alexander Seitz, Wolfgang A. Wall, Alexander Popp*	
14:50	An exact penalty approach for the finite element solution of frictionless contact problems *Fabian Sewerin, Panayiotis Papadopoulos*	
CS04	**Fracture** Chairperson: Timo Noll	**7.11**
13:30	Phase-Field Modelling of Crack Propagation in Elasto-Plastic Multilayered Materials *Zhengkun Liu, Daniel Juhre*	
13:50	Crack propagation simulation of concrete considering water fracture interaction using SBFEM *Chengbin Du, Peng Zhang, Xinran Tian*	
14:10	Numerical investigation of hydraulic fracturing and borehole interaction under deep reservoir conditions using XFEM *Janis Reinold, Sven Beckhuis, Günther Meschke*	
14:30	A 3D peridynamic model of rock cutting with TBM disc cutters *Sahir Butt, Günther Meschke*	

MS04-1 **Computational Analysis and Modeling of Experimental Dynamic Loading Tests** **7.12**
Chairperson: Mohammad Reza Khosravani

13:30 Numerical fracture studies of ultra-high performance concrete under dynamic loading
Mohammad Reza Khosravani, Carola Bilgen, Kerstin Weinberg

13:50 Modelling of the Mars® 300 armour steel under impact loadings
Teresa Fras, Faderl Norbert, Lach Erhardt

14:10 Numerical and experimental ricochet investigation of a spin-stabilised projectile
Marina Seidl, Thomas Wolf, Rainer Nuesing

14:30 Application of the Phase-field Method for Crack Approximation on a Split-Hopkinson-Pressure-Bar Experiment
Christian Steinke, Michael Kaliske

MS17-2 **Smart and Active Materials: Experiments, Modelling, and Simulation** **7.22**
Chairperson: Krishnendu Haldar

13:30 A variational and computational framework for large strain electromechanics based on convex multi-variable energies (Keynote)
Rogelio Ortigosa, Antonio J. Gil

14:10 Constitutive modeling of eletroelasticity based on the analytical network averaging concept
Vu Ngoc Khiêm, Mikhail Itskov

14:30 An optimal solid-shell finite element for modeling dielectric elastomers
Dana Bishara, Mahmood Jabareen

MS18-2 **Virtual Analysis and Design of New Materials** **7.31**
Chairperson: Loredana Kehrer

13:30 Experimental methods to validate modeling of fiber reinforced materials (Keynote)
Markus Sause

14:10 Influence of the tape number on the optimized structural performance of locally reinforced composite structures
Benedikt Fengler, Luise Kärger, Andrew Hrymak

14:30 Virtual tests based on model reduction strategies for fatigue analysis
Mainak Bhattacharyya, Amelie Fau, Udo Nackenhorst, David Néron, Pierre Ladevèze

14:50 Experimental and Numerical Analysis of Deep Drawing and Failure Characteristics for Sheet Metal/Polymer Hybrid Structure
Henrik Schulze, B.-A. Behrens, A. Bouguecha, Christian Bonk

CS02	**Fluid Mechanics**	Chairperson: Ursula Rasthofer	**7.01**
16:00	Boundary-Conforming Space-Time Finite Elements for Co-Rotating Intermeshing Domains *Jan Helmig, Marek Behr, Stefanie Elgeti*		
16:20	Simulation of Oil Jets for Piston Cooling Applications Using Mesh Deformation and the Level Set Method *Loïc Wendling, Karyofyli Violeta, Markus Frings, Anselm Hopf, Elgeti Stefanie, Marek Behr*		
16:40	Numerical two-phase simulations of the propagation of an evaporating extinguishing agent for optimal fire suppression *Waldemar Stapel, Michael Breuer*		
17:00	Computational modeling of fiber flow during casting of fresh concrete *Vladislav Gudzulic, Thai Son Dang, Günther Meschke*		
17:20	Anisotropic surface and bulk stresses in transition metal oxide nanoparticles and their impact on diffusion *Peter Stein, Ashkan Moradabadi, Manuel Diehm, Bai-Xiang Xu, Karsten Albe*		
MS11-1	**Modeling, Simulation, Control and Optimization of Multi-physical Phenomena**	Chairperson: Thorsten Schindler	**7.02**
16:00	Error estimation approach for controlling the macro step-size for explicit co-simulation methods *Tobias Meyer, Jan Kraft, Pu Li, Daixing Lu, Bernhard Schweizer*		
16:20	Quasi-Newton methods for unstable partitioned fluid-structure interactions *Nadja Wirth, Bettina Landvogt*		
16:40	Design of a Nonlinear Observer for a Very Flexible Parallel Robot *Fatemeh Ansarieshlaghi, Peter Eberhard*		
17:00	Shape optimization of wind turbine blades in a fluid structure interaction simulation *Shahrokh Shayegan, Reza Najian Asl, Roland Wüchner, Kai-Uwe Bletzinger*		
17:20	Co-simulation in the vehicle development process *Stefan Steidel, Michael Burger*		
17:40	Computational challenges and uncertainty in simulation of electrical arcs *Henrik Nordborg, Mario Mürmann, Roman Fuchs*		
MS05-2	**Computational Contact Mechanics**	Chairperson: Christian Hesch	**7.04**
16:00	Adaptive finite elements for contact problems based on efficient and reliable residual-type a posteriori estimators *Mirjam Walloth*		
16:20	A posteriori error estimates for finite elements of higher-order for frictional, elasto-plastic two-body contact problem *Andreas Rademacher, Hannah Frohne*		
16:40	Time-adaptive non-linear finite-element analysis of contact problems *Matthias Grafenhorst, Stefan Hartmann*		
17:00	BFGS quasi-Newton finite element solver for the penalty constrained contact problems *Dusan Gabriel, Ján Kopačka, Petr Parik, Jan Masak, Jiří Plešek*		
17:20	Singular mass matrices for isogeometric finite element analysis of dynamic contact *Anton Tkachuk, Martina Matzen, Radek Kolman, Manfred Bischoff*		
17:40	A robust explicit finite element algorithm with bi-penalty stabilization for contact-impact problems *Radek Kolman, Ján Kopačka, Anton Tkachuk, Dusan Gabriel, José González, Manfred Bischoff*		

MS10-1 **Mechanics of Dissipative Solids: Plasticity, Fracture and Damage** **7.11**
Chairperson: Fadi Aldakheel

16:00 Modeling fatigue phenomena with a variational phase-field approach (Keynote)
Roberto Alessi, Marreddy Ambati, Laura De Lorenzis, Stefano Vidoli

16:40 Phase field modelling of thermo-mechanically driven fracture processes in electronic control units
Fabian Welschinger

17:00 A phase field model for porous plastic solids at ductile fracture
Daniel Kienle, Fadi Aldakheel, Stephan Teichtmeister, Christian Miehe

MS12-1 **Multidisciplinary and Structural Design Optimization** **7.12**
Chairperson: Erich Wehrle

16:00 Industrial Design Optimization: From Research to Industry Application (Keynote)
Markus Schatz

16:40 Regenerating CAD Models with OpenCASCADE and pythonOCC from Numerical Models with Application to Shape Optimization
Altug Emiroglu, Andreas Apostolatos, Roland Wüchner, Kai-Uwe Bletzinger

17:00 Variational sensitivity analysis in the scope of multiscale problems
Wojciech Kijanski, Franz-Joseph Barthold

17:20 Kriging-guided Level Set Method for Crash Topology Optimization
Elena Raponi, Mariusz Bujny, Markus Olhofer, Nikola Aulig, Simonetta Boria, Fabian Duddeck

MS17-3 **Smart and Active Materials: Experiments, Modelling, and Simulation** **7.22**
Chairperson: Krishnendu Haldar

16:00 A Novel Parameter Identification Toolbox for the Selection of Hyperelastic Constitutive Models from Experimental Data
Hüsnü Dal, Yashar Badienia, Kemal Açıkgöz, Funda Aksu Denli

16:20 Modelling electro-active polymers with a dispersion-type anisotropy
Mokarram Hossain

16:40 Micro- and Macrostructural magneto-electric coupling in soft composites
Matthias Rambausek, Marc-André Keip

17:00 Reduced-Order Modelling applied to Computational Homogenisation in Magneto-Mechanics
Benjamin Brands, Julia Mergheim, Paul Steinmann

MS18-3 **Virtual Analysis and Design of New Materials** **7.31**
Chairperson: Christian Weißenfels

16:00 Modeling three-dimensional anisotropic damage in organic sheet composites at large deformation
Dominik Naake, Fabian Welschinger, Luise Kärger, Frank Henning

16:20 Micromechanical Study of Fiber Kinking and Debonding in Fiber Reinforced Composites
Samira Hosseini, Stefan Löhnert

16:40 A Non-Intrusive Global-Local Approach with Application to Phase-Field Modeling of Brittle Fracture
Nima Noii, Tymofiy Gerasimov, Laura De Lorenzis, Olivier Allix

17:00 Two-scale anisotropic damage modeling of SMC
Johannes Görthofer, Malte Schemmann, Thomas Böhlke

17:20 Combined Macro- and Micro-Mechanical Analysis of Instable Crack Propagation in Interlaminar Fracture Toughness Tests
Michael Schober, Jörg Hohe, Takashi Kuboki

Friday, 13 October 2017

CS07	**Crystal Mechanics**	Chairperson: Richard Ostwald	**7.01**
08:30	Geometrically nonlinear single crystal viscoplasticity implemented into a hybrid discontinuous Galerkin framework *Atefeh Alipour, Stephan Wulfinghoff, Bob Svendsen, Stefanie Reese*		
08:50	Multiscale FE-FFT-based thermo-mechanically coupled modeling of viscoplastic polycrystalline materials *Sebastian Felder, Julian Kochmann, Stephan Wulfinghoff, Stefanie Reese*		
09:10	Defect density-based modelling of work hardening and recovery in fully lamellar TiAl alloys *Jan Eike Schnabel, Swantje Bargmann*		
09:30	Molecular dynamic study on the tensile deformation of an aluminium nano single- and polycrystal *Philipp Höfer, Carsten Könke*		
CS03	**Multiphysics**	Chairperson: Maximilian Noll	**7.02**
08:30	Numerical Analysis of Virtualized Heart Models *Baris Cansiz, Michael Kaliske, Krunoslav Sveric, Karim Ibrahim, Ruth Strasser*		
08:50	Simulation of the Change in Mechanical Properties of Degradable Bone Implants *Ann-Kathrin Krüger, Stefan Julmi, Christian Klose, Silke Besdo, Peter Wriggers*		
09:10	Computation of multiphysics processes in deformable media *Bilen Emek Abali*		
09:30	Experimental and Numerical Studies of Thermoelastic Damping *Christin Zacharias, Carsten Könke*		
09:50	Leakage currents in nanogenerator concepts in phase field simulations *Franziska Wöhler, Ingo Münch, Werner Wagner*		
10:10	Optimal control of a slot car racer *Johann Penner, Tristan Schlögl, Sigrid Leyendecker*		
MS05-3	**Computational Contact Mechanics**	Chairperson: Anton Tkachuk	**7.04**
08:30	Contact, Fluid Structure Interaction and Variational Transfer *Patrick Zulian, Maria Nestola, Cyrill von Planta, Rolf Krause*		
08:50	Simulation of fibers in woven composites: a comparison between solid and beam models *Mathias Haverstreng, Stephanie Andress, Ajay Bangalore Harish, Alfredo Gay Neto, Peter Wriggers*		
09:10	Mortar-based contact formulations for non-smooth geometries *Alexander Popp, Philipp Farah, Wolfgang A. Wall*		
09:30	Numerical model for contact with adhesion based on Kalker's variational principle. *Mykola Tkachuk*		
09:50	A symmetry preserving contact treatment in isogeometric analysis *Ján Kopačka, Dusan Gabriel, Radek Kolman, Jiří Plešek*		
MS10-2	**Mechanics of Dissipative Solids: Plasticity, Fracture and Damage**	Chairperson: Stephan Teichtmeister	**7.11**
08:30	Extension of isogeometric Kirchhoff-Love shell formulations towards fracture and plasticity problems *Marreddy Ambati, Josef Kiendl, Laura De Lorenzis*		
08:50	A phase field model for materials with anisotropic fracture resistance *Christoph Schreiber, Charlotte Kuhn, Ralf Müller*		
09:10	Affine Full Network Model for Strain-Induced Crystallization in Rubbery Polymers *Aref Nateghi, Hüsnü Dal, Marc-André Keip, Christian Miehe*		
09:30	On Degradation Functions and Solution Schemes for a Phase Field Model of Elastic-Plastic Fracture *Timo Noll, Charlotte Kuhn, Ralf Müller*		
09:50	Phase Field Model for Interface Failure *Arne Claus Hansen-Dörr, Paul Hennig, Markus Kästner*		

MS12-2	**Multidisciplinary and Structural Design Optimization**	**7.12**
	Chairperson: Erich Wehrle	
08:30	Advanced Optimization Methods for CFRP Components in the Motorcycle Industry *Martin Perterer, Michael Tischer, Mark Hölzl*	
08:50	Optimization of topology and shape, combining phase field modelling and discrete stochastic algorithms *Alexander Keller, Ingo Münch, Werner Wagner*	
09:10	Shape optimization with application to inverse form finding and the use of mesh adaptivity *Michael Caspari, Philipp Landkammer, Paul Steinmann*	
09:30	Determination of optimal damping for passive control of vibration based on the design of limit cycles *Rafael A. Rojas, Erich Wehrle, Renato Vidoni*	
09:50	Sensitivity Analysis for Pedestrian Lower Leg Impact *Stefano Chiapedi, Andreas Koukal, Fabian Duddeck*	
MS07-1	**Computational Mechanics and Biomimetics**	**7.22**
	Chairperson: Annette Birkhold	
08:30	Plant-inspired compliant actuation *Anja Mader, Annette Birkhold, Marco Caliaro, Olga Speck, Oliver Röhrle, Jan Knippers*	
08:50	Modelling functional properties of frost-resistant plant tissues for transfer to construction materials *Lukas Eurich, Arndt Wagner, Wolfgang Ehlers*	
09:10	Upscaling of Self-actuated Wooden Bilayers *Philippe Grönquist, Falk K. Wittel, Markus Rüggeberg*	
09:30	Cellular Solids in sea urchin spines: Numerical analyses and parametric modelling *Immanuel Schäfer, Siegfried Schmauder*	
CS05	**Damage and Plasticity** Chairperson: Frederik Fahrendorf	**7.31**
08:30	Evaluation of a Gradient Enhanced Damage Plasticity Model for Shotcrete *Matthias Neuner, Magdalena Schreter, Günter Hofstetter*	
08:50	Study of the Regularization Scheme of an Advanced Rock Model *Magdalena Schreter, Matthias Neuner, Günter Hofstetter*	
09:10	Variational constitutive updates based on hyper-dual numbers - theory of gradient enhanced thermoplasticity *Volker Fohrmeister, Alexander Bartels, Jörn Mosler*	
09:30	Regularisation of gradient-enhanced damage coupled to finite plasticity *Leon Sprave, Andreas Menzel*	
09:50	On the modelling of evolving material symmetries in finite strain plastic deformations *Tobias Asmanoglo, Jia Lu, Andreas Menzel, Panayiotis Papadopoulos*	
10:10	Eigenerosion Approach for Drucker-Prager Plasticity *Aurel Qinami, Michael Kaliske*	

F2: 11:00 – 12:30
Plenary Lectures & Closing

PL05 Chairperson: Marc-André Keip **7.02**

11:00 Modeling and simulation of phase transformations in polycrystals – a micro-sphere framework
Richard Ostwald, Thorsten Bartel, Andreas Menzel

11:30 Topology Optimization of Nonlinear Problems in Solid and Fluid Mechanics
Kurt Maute

12:15 Closing

Part III.

Micro Abstracts

Wednesday, 11 October 2017

PL01: Plenary Lecture

Modelling and simulation of SBM processes in computational additive manufacturing

Paul Steinmann (Friedrich-Alexander University of Erlangen-Nürnberg), Julia Mergheim (Friedrich-Alexander University of Erlangen-Nürnberg)

The contribution aims in modelling and simulation of SBM additive manufacturing processes to predict transient temperature distributions during the process and to capture residual stresses in the produced part. A multiscale thermomechanical model is developed which accounts for temperature-dependent material behavior, phase-transitions between powder, melt and solid material, energy input by a moving heat source and thermo-viscoplastic material behavior.

MS15-1: Non-standard Formulations and Discretization Methods for Thin-walled Structures

Smooth spline spaces on unstructured quadrilateral meshes for isogeometric analysis (Keynote)

Hendrik Speleers (University of Rome "Tor Vergata"), Deepesh Toshniwal (University of Texas at Austin), Thomas J. R. Hughes (University of Texas at Austin)

We present a framework for isogeometric analysis on unstructured quadrilateral meshes. Acknowledging the differing requirements posed by design and analysis, we propose the construction of a separate, smooth spline space for each, while ensuring isogeometric compatibility. A key ingredient in the approach is the use of singular parameterizations at extraordinary vertices. We demonstrate the versatility of the approach with applications in design and analysis.

Recent advances in isogeometric dual mortar patch coupling

Wolfgang Dornisch (University of Kaiserslautern), Joachim Stöckler (TU Dortmund University), Ralf Müller (University of Kaiserslautern)

Isogeometric analysis fosters the integration of design and analysis by using the geometry description of the CAD system also for the numerical analysis. Hereby, the use of NURBS surfaces is common but entails the need for a coupling of non-conforming patches. The use of mortar methods allows a coupling which requires neither additional variables nor empirical parameters. In this contribution dual basis functions are used in order to obtain an accurate and efficient mortar method.

Strain gradient elasticity theories in lattice structure modelling

Jarkko Niiranen (Aalto University), Sergei Khakalo (Aalto University), Viacheslav Balobanov (Aalto University)

The first and second strain gradient elasticity theories, resulting in higher-order governing equations, are studied in the framework of continualization, or homogenization, of lattice structures such as trusses in plane and space, with auxetic metamaterials as a special application. In particular, the role of length scale parameters and classical dimensions, such as the beam thickness, is addressed by parameter studies. Finite element and isogeometric methods are utilized for discretizations.

A homogenization approach for beam-like structures with arbitrarily shaped and deformable cross-sections

Simon Klarmann (Technical University of Darmstadt), Friedrich Gruttmann (Technical University of Darmstadt)

Beam elements demonstrate an efficient way of modeling large, thin structures if the assumed kinematics are reasonable. Regarding arbitrarily shaped cross-sections and varying material properties, difficulties arise in describing their behavior. A homogenization approach for a simple Timoshenko beam using a representative volume element circumvents this problem. In addition to that cross-sectional deformations can be taken into account.

Shell models in the framework of generalized continuum theories: isogeometric implementation and applications

Viacheslav Balobanov (Aalto University), Sergei Khakalo (Aalto University), Josef Kiendl (Norwegian University of Science and Technology), Jarkko Niiranen (Aalto University)

Physico-mathematical models of shells in the framework of couple stress and strain gradient elasticity theories with variational formulations are developed. The models derived are embedded into a commercial finite element software as user subroutines following the isogeometric paradigm. Practical applications such as modelling of microarchitectured materials and materials with microstructure, or problems of fracture mechanics, illustrate the advantages of the non-classical continuum theories.

MS16-1: Reduced Order Models for Multiscale and Multiphysics Problems

Partial mechanics of far fields in elastoplastic structures (Keynote)

David Ryckelynck (MINES ParisTech)

We propose a reduced-modeling protocol that accounts of topological modifications in elastoplastic structures. We assume that topological modifications and mesh adaptations are restricted to a subdomain termed the zone of interest. This zone of interest is surrounded by an hyper-reduced order model that propagates boundary conditions by using empirical modes.

Viscoplastic reduced order homogenization using mixed formulations

Federica Covezzi (University of Bologna), Stefano de Miranda (University of Bologna), Felix Fritzen (University of Stuttgart), Sonia Marfia (University of Cassino and of Southern Lazio), Elio Sacco (University of Cassino and of Southern Lazio)

The effective response of viscoplastic composites is studied by means of two reduced order models that use a mixed variational formulation developed in the framework of the Transformation Field Analysis : the pRBMOR and the MxTFA. The MxTFA is based on a mixed variational formulation of viscoplasticity involving stress and plastic multiplier as independent variables, while the pRBMOR assumes non uniform inelastic strain and hardening modes. Examples show the capabilities of the two approaches.

High-performance model order reduction techniques in non-linear multiscale fracture problems

Manuel Alejandro Caicedo Silva (Universitat Politècnica de Catalunya (UPC)), Javier Oliver (Universitat Politècnica de Catalunya (UPC)), Alfredo E. Huespe (Universidad del Litoral), Oriol Lloberas-Valls (Universitat Politècnica de Catalunya (UPC))

In this work presents a strategy to diminish the computational cost of a hierarchical (FE2) multi-scale computational homogenization approach for fracture problems is presented. Focusing on concepts as Reduced Order Modeling (ROM) based on the POD and optimal integration quadrature techniques, a hyper-reduced order modeling (HPROM) method is specifically derived. This model departs from the multi-scale framework developed in (Oliver/2015) for the numerical modeling of failure.

Two-scale Reduced Basis Homogenization under Large Deformations

Oliver Kunc (University of Stuttgart), Felix Fritzen (University of Stuttgart)

In this work, the first aim is to solve the task of two-scale homogenization of nonlinear materials for large deformations. We propose a model with a reduced basis for the deformation gradient. The accuracy of the predictions is evaluated online. The main benefit of this approach is the reduction of both CPU time and memory requirements. It also opens opportunities for generalization and further acceleration which are also discussed, e.g. data-driven techniques.

Two-Phase Model-Reduction for Two-Scale Simulations of Components

Matthias Kabel (Fraunhofer Institute for Industrial Mathematics ITWM)

The Nonuniform Transformation Field Analysis (NTFA) has been introduced by Suquet et al. to make two-scale simulations of components feasible for industrial sized problems. To reduce the computational complexity of the "offline" phase of the NTFA, the micro-solver applies the recently introduced composite voxel technique. The predicted effective response will be compared to both the original NTFA method using micro-scale simulations at full resolution and direct simulations.

MS06-1: Computational FSI and Aero-elasticity

Aeroelasticity of Large Horizontal Axis Wind Turbines: Simulation Approaches and Modeling Challenges (Keynote)

Mohamed Sayed (University of Stuttgart), Thorsten Lutz (University of Stuttgart), Shahrokh Shayegan (Technical University of Munich), Roland Wüchner (Technical University of Munich)

Currently, the wind turbine design trend is up-scaling which results in larger slender and flexible wind turbine blades. Therefore, as wind turbine blades become lighter and more flexible, aeroelastic instabilities must be of great concern. Most of the current aeroelasticity tools are based on simplified models of the aerodynamics and the structural dynamics. Therefore, the accuracy level of the engineering models compared to the high-fidelity models were investigated.

Transient aeroelastic simulations of wind turbines with composite blades

Gilberto Santo (Ghent University), Mathijs Peeters (Ghent University), Wim Van Paepegem (Ghent University), Joris Degroote (Ghent University)

A fluid-structure interaction model is employed to numerically investigate the interaction of wind flow and blade structures of a horizontal axis wind turbine. On the fluid side, the atmospheric boundary layer is included and sliding interfaces are adopted to handle the rotation of the rotor. On the structural side, a detailed model of each blade composite structure is used. The two models are coupled in a transient simulation where stresses, loads and deformations of the blades are monitored.

Aspects of FSI with aeroacoustics in turbulent flow

Thorsten Reimann (Technical University of Darmstadt), Awais Ali (Technical University of Darmstadt)

In recent years, reliable resolved simulations of FSI problems containing turbulent flow have become more frequent, and thus opened the possibility to consider aeroacoustics in such setups as well. Noise generation in turbulence can then be considered in designs of flexible structures. In our FSI simulation environment, we incorporate an acoustic splitting approach to account for aeroacoustics in low Mach number flow. We discuss important problems and obstacles that emerge in such a scenario.

Official preCICE Adapters for Standard Open-Source Solvers

Benjamin Uekermann (Technical University of Munich), Hans-Joachim Bungartz (Technical University of Munich), Lucia Cheung Yau (Technical University of Munich), Gerasimos Chourdakis (Technical University of Munich), Alexander Rusch (Technical University of Munich)

To deal with the increasing complexity of today's multiphysics applications, the reuse of existing simulation software often becomes a necessity. Coupling to open-source simulation codes, in particular, is a time-efficient way to tackle new applications. The open-source coupling library preCICE enables such coupling in a minimally-invasive way. In this contribution, we give an overview on ready-to-use preCICE adapters for standard open-source solvers, namely CalculiX, Code_Aster, OpenFOAM, and SU2.

MS09-1: Damage Mechanics and Numerical Applications

Phase Field Modeling of Fracture in Anisotropic Brittle Solids (Keynote)

Stephan Teichtmeister (University of Stuttgart), Daniel Kienle (University of Stuttgart), Fadi Aldakheel (Leibniz Universität Hannover), Marc-André Keip (University of Stuttgart)

A phase field model of fracture that accounts for anisotropic material behavior and crack propagation is presented within the small and large deformation context. Different kinds of material anisotropy are incorporated by (i) enhancing the crack surface density function by appropriate structural tensors stemming from a rigorous application of the theory of tensor invariants and (ii) by a modification of energetic and stress-like fracture criteria.

Adaptive Isogeometric Phase-Field Modeling of Ductile Fracture

Paul Hennig (Technische Universität Dresden), Markus Kästner (Technische Universität Dresden), Marreddy Ambati (Technical University of Braunschweig), Laura De Lorenzis (Technical University of Braunschweig)

To increase the computational efficiency of phase field models of ductile fracture, we have developed an isogeometric framework for adaptive local mesh refinement. This includes appropriate marking criteria to select elements for refinement, the creation of the locally refined basis and a projection of the nodal displacements and internal variables. We provide and analyze marking criteria and projection methods and compare their numerical applicability in several numerical examples.

Data-driven crack assessment

Katrin Schulz (Karlsruhe Institute of Technology (KIT)), Valentin Verrier (Karlsruhe Institute of Technology (KIT)), Stephan Kreis (Karlsruhe Institute of Technology (KIT))

Different methods of selection and feature creation are considered in order to discuss the chances and limits of a data driven assessment of cracks. We apply different methods of data mining to find correlations which yield an unconventional approach for the prediction of critical crack states and material failure. The results of different explorative multivariate analyses will be compared and discussed in the context of applicability in engineering science.

Discussion of crack initiation in metal matrix composites

Markus Sudmanns (Karlsruhe Institute of Technology (KIT)), Katrin Schulz (Karlsruhe Institute of Technology (KIT))

Understanding the mechanisms of micro-crack initiation in metals is of high academic as well as industrial interest. In this contribution, we discuss the role of stress concentrations in metal matrix composite materials as the cause of crack initiation. Using a continuum representation of dislocation microstructures, we compare microscale simulations to experimental studies of crack initiation and discuss the dislocation microstructure around a crack tip.

MS01-1: 3D Imaging and Segmentation Methods for Computational Modeling of Heterogeneous Materials

Modelling of microcracking in image-based models of highly heterogeneous materials using the phase field method (Keynote)

Julien Yvonnet (Université Paris-Est), Than Tung Nguyen (Université Paris-Est), Michel Bornert (Ecole des Ponts ParisTech), Camille Chateau (Ecole des Ponts ParisTech), Liang Xia (Université Paris-Est)

Crack nucleation and propagation in heterogeneous materials models, as obtained by X-Ray micro-CT imagery, is investigated by the phase field method. Several 3D analyses in highly heterogeneous materials are carried out, with application to cementitious materials. Direct comparisons of complex 3D micro cracking in heterogeneous quasi-brittle materials modeled by the phase field numerical method and observed by imaging during in situ mechanical testing are presented.

Numerical validation framework for micromechanical simulations based on 3D imaging

Francois Hild (The National Center for Scientific Research, University Paris-Saclay), Group Cominside (Ecoles des Mines de Paris)

A computational framework is introduced to validate simulations at the microscale. A specimen made of cast iron is imaged via synchrotron laminography during a tensile test. The region of interest is analyzed by Digital Volume Correlation (DVC) to measure kinematic fields. Finite Element simulations, which account for the studied material microstructure, are driven by Dirichlet boundary conditions extracted from DVC measurements. Gray level residuals are assessed for validation purposes.

Diffraction and Attenuation X-ray Imaging of Ductile Damage Combine with Crystal Plasticity Finite Element Modelling

Christophe Le Bourlot (INSA LYON), Sylvain Dancette (INSA LYON), Eric Maire (INSA LYON), Wolfgang Ludwig (INSA LYON)

Recent techniques of 3D synchrotron imaging allow to fill the gap between several fields of experimental damage mechanics. The present work combines local crystallographic characterisation and the related plasticity mechanisms to observations and quantitative measurements of the three stages of ductile fracture, applied on aluminium. Phase and diffraction contrast tomography are used as input for modelling to better understand the local stress and deformation state governing damage.

2D-Surface and 3D-Volume Digital Image Correlation (DIC) for materials characterization at different scales

Roberto Fedele (Politecnico di Milano)

Mechanical response of advanced materials and structures at different scales can be effectively assessed through Digital Image Correlation (DIC) procedures. Displacement fields can be measured over the flat surface of samples or even within the bulk at different instants during non-conventional experiments, and used as highly qualified information for finite element modelling and for the subsequent calibration/validation stages.

MS02-1: Adaptive Structures: Theory, Modelling, Simulation and Evaluation

Gramian-Based Actuator Placement for Static Load Compensation in Adaptive Structures (Keynote)

Julia Wagner (University of Stuttgart), Michael Heidingsfeld (University of Stuttgart), Michael Böhm (University of Stuttgart), Oliver Sawodny (University of Stuttgart)

The compensation of static loads aims at reducing stresses or displacements by applying energy to an adaptive structure. The performance in static adaption significantly depends on the location of the actuators. We present a method for optimal actuator placement regarding static adaption using a Gramian-based cost function. The method is demonstrated by means of a numerical model of an adaptive truss structure. Results indicate the method's effectiveness to promote actuator placement.

The implementation of an adaptive high-rise building

Stefanie Weidner (University of Stuttgart), Paula-Lie Sternberg (University of Stuttgart), Werner Sobek (University of Stuttgart)

High-rises could be one solution for the future of urban planning. However, due to the increase of global population and the limits of available resources, new technologies become necessary. The collaborative research centre at the University of Stuttgart copes with these topics and will realize an adaptive high-rise building within the next few years. This project will be an experimental building with multiple research opportunities in the fields of structural engineering, building physics, system dynamics, architecture and many more.

Realization of Adaptive Prestressing

Daniel Steiner (University of Duisburg-Essen), Martina Schnellenbach-Held (University of Duisburg-Essen)

Adaptive Prestressing is based on the conventional passive design principle of prestressed concrete combined with active self-adjustment of structures. For realization of these systems a closed-loop control is developed utilizing Artificial Intelligence techniques like Fuzzy Logic, expert knowledge and machine learning processes. In the context of a feasibility study experiments on two prototypes – an aluminium truss and a concrete T-beam – are conducted to exhibit applicability and potentials.

Variable filter radii for Vertex Morphing based design of adaptive structures

Armin Geiser (Technical University of Munich), Roland Wüchner (Technical University of Munich), Kai-Uwe Bletzinger (Technical University of Munich)

Most optimization tasks on adaptive structures focus on the optimal actuator/sensor placement. Also, the shape of the controlled structure plays an important role for its efficiency. The initial applications of Vertex Morphing, a node based shape optimization method, made use of a single filter radius. This contribution will assess the effect of varying filter radii towards a better control of the shape, whereas the rich design space given with the Vertex Morphing method shall be maintained.

MS13-1: Multiscale Methods for Complex Materials

Mesoscale influence on the macroscopic material behavior of concrete

Volker Hirthammer (Federal Institute for Materials Research and Testing), Jörg F. Unger (Federal Institute for Materials Research and Testing), Josko Ozbolt (University of Stuttgart)

The heterogeneous mesostructure of concreted causes local stress concentrations. Stress dependent phenomena like damage and creep as well as their interactions are effected by those stress concentrations. Therefore a material model's macroscopic behavior will differ whether the mesoscale structure is considered or not. The differences between the mesoscale approach and an homogeneous approach will be presented. The results are discussed with focus on the true materials behavior.

Obtaining macroscopic properties from a mesoscale thermomechanical model of concrete

Christoph Pohl (Federal Institute for Materials Research and Testing), Jörg F. Unger (Federal Institute for Materials Research and Testing)

A coupled thermomechanical mesoscale model for concrete under heating is presented. When considering the heterogeneous structure under coupled loads, complex macroscopic material properties can be modelled using simple constitutive relations. For instance, damage evolution is directly driven by the incompatibility of thermal strains between matrix and aggregates. Without prescribing $f_c = f(T)$, a decline in compressive strength with rising temperatures will be shown.

Validation of a synthetic model of hot mix asphalt

Johannes Neumann (RWTH Aachen University), Jaan-Willem Simon (RWTH Aachen University), Stefanie Reese (RWTH Aachen University)

We have recently extended a method to obtain 3D synthetic models of hot mix asphalt by capturing the particle size distribution. The model is applied in the context of first-order strain driven homogenisation. The morphological accuracy of the model is compared to XRCT data by means of several common shape measures. Furthermore, the usefulness of the homogenised mechanical properties is assessed by comparing to master-curve data of the mixture scale.

The Heterogeneous Multiscale Finite Element Method (FE-HMM) for nonlinear problems in solid mechanics

Andreas Fischer (University of Siegen), Ajinkya Gote (University of Siegen), Bernhard Eidel (University of Siegen)

The present work proposes a nonlinear extension of the FE-HMM for the homogenization of microheterogeneous solids. The advantage of FE-HMM compared with FE^2 is the existence of a priori convergence estimates, which allow for optimal strategies in mesh refinements. While these estimates were proved for linear problems so far, we assess their validity for geometrical nonlinearity and hyperelastic constitutive laws. Applications to complex microstructures showcase the performance of the method.

A two-scale homogenization scheme for the simulation of micro-heterogeneous magneto-electric composites

Matthias Labusch (University of Duisburg-Essen), Jörg Schröder (University of Duisburg-Essen)

We present the simulation of two-phase composites, consisting of a ferroelectric and a magnetostrictive phase, which generate a magneto-electric coupling. A two-scale finite element homogenization approach is performed. The typical hysteresis loops of the phases are approximated by considering the switching behavior of the spontaneous polarizations and the implementation of a Preisach operator.

PL02: Plenary Lectures

High-order accurate time integration methods for electromagnetic-thermal analysis

Tobias Gleim (University of Colorado Boulder)

The inductive heating of a metal shaft is influenced by an alternating current inducing a high frequency electromagnetic field, which causes a temperature increase due to the resulting eddy currents. To examine this process, the fully coupled electromagnetic Maxwell equations are combined with heat conduction. Due to the high frequencies of the applied current and the strongly temperature dependent material parameters, high-order accurate numerical methods in space and time are investigated.

Zonal Turbulence Modeling and Reduced-Order Methods for Space Launcher Wake Flows Analyses

Vladimir Statnikov (RWTH Aachen University), Matthias Meinke (RWTH Aachen University), Wolfgang Schröder (RWTH Aachen University)

Turbulent wake flows of generic Ariane 5-like space launcher configurations are investigated using zonal turbulence modeling and reduced-order methods. For two selected, dynamically crucial trajectory stages, i.e., $M_\infty = 0.8$ and $M_\infty = 6$, previously unknown coherent three-dimensional modes are extracted and attributed to the single characteristic frequencies and wave lengths which are responsible for critical side loads on the nozzle structure.

Poster Session

Application of X-ray computed tomography on fracture behaviour study of cement paste at micro-scale (Poster)
Hongzhi Zhang (Delft University of Technology), Branko Šavija (Delft University of Technology), Erik Schlangen (Delft University of Technology)

3D microstructure with a cubic dimension of 100 μm^3 was generated by X-ray computed tomography. Its mechanical properties were predicted by the microstructure informed lattice model. Considering the heterogeneous nature of this material, 30 specimens were investigated. Correlation analysis was conducted between the simulated mechanical properties and porosity.

A scaled boundary NURBS approach for nonlinear solid analysis (Poster)
Markus Klassen (RWTH Aachen University), Margarita Chasapi (RWTH Aachen University), Bernd Simeon (University of Kaiserslautern), Sven Klinkel (RWTH Aachen University)

In this contribution, the scaled boundary formulation is proposed as a discretization technique which is based on the isogeometric concept. By this means, the representation of a solid body is given by the boundary surface of the body and a radial scaling parameter which is used to describe the interior. NURBS shape functions are employed to define the geometry as well as to approximate the solution field. The numerical examples are given for elasto-plastic material behavior at small strains.

The Particle Finite Element Method in Solid Mechanics Applications (Poster)
Markus Manuel Schewe (TU Dortmund University), Andreas Menzel (TU Dortmund University)

In manufacturing processes, the separation of material occurs either on purpose or as undesired wear of tools and work-pieces. The PFEM offers a framework to deal with configurational changes through repeated remeshing and shape detection of a point-cloud, representing the body. A standard Finite-Element-Analysis can be performed with suitable transformations of variables between meshes. The method is presented along with representative results in the field of solid mechanics.

Two-scale Reduced Basis Homogenization under Large Deformations (Poster)

Oliver Kunc (University of Stuttgart), Felix Fritzen (University of Stuttgart)

In this work, the first aim is to solve the task of two-scale homogenization of nonlinear materials for large deformations. We propose a model with a reduced basis for the deformation gradient. The accuracy of the predictions is evaluated online. The main benefit of this approach is the reduction of both CPU time and memory requirements. It also opens opportunities for generalization and further acceleration which are also discussed, e.g. data-driven techniques.

Computation of multiphysics processes in deformable media (Poster)

Bilen Emek Abali (Technische Universität Berlin)

Micro electro-mechanical systems (MEMS) exploit the coupling between mechanics and electromagnetism. For an accurate simulation of this coupling we need a strategy to calculate deformation, temperature, and electromagnetic fields in solids, at once. By using open-source packages, we present an approach to simulate MEMS by solving nonlinear and coupled equations at once by using finite difference method in time and finite element method in space.

Regenerating CAD Models with OpenCASCADE and pythonOCC from Numerical Models with Application to Shape Optimization (Poster)

Altug Emiroglu (Technical University of Munich), Andreas Apostolatos (Technical University of Munich), Roland Wüchner (Technical University of Munich), Kai-Uwe Bletzinger (Technical University of Munich)

Sensitivity filtering methods are unavoidable when numerical shape optimization is considered. A mortar based sensitivity filtering method which incorporates underlying CAD parametrization of the numerical models is proposed. The method is combined with a software environment which utilizes the capabilities of the opensource library OpenCASCADE and pythonOCC module respectively for the regeneration of the CAD models directly from the optimized numerical models as a result of the procedure.

The Heterogeneous Multiscale Finite Element Method (FE-HMM) for nonlinear problems in solid mechanics (Poster)

Andreas Fischer (University of Siegen), Ajinkya Gote (University of Siegen), Bernhard Eidel (University of Siegen)

The present work proposes a nonlinear extension of the FE-HMM for the homogenization of microheterogeneous solids. The advantage of FE-HMM compared with FE^2 is the existence of a priori convergence estimates, which allow for optimal strategies in mesh refinements. While these estimates were proved for linear problems so far, we assess their validity for geometrical nonlinearity and hyperelastic constitutive laws. Applications to complex microstructures showcase the performance of the method.

Discussion of crack initiation in metal matrix composites (Poster)

Markus Sudmanns (Karlsruhe Institute of Technology (KIT)), Katrin Schulz (Karlsruhe Institute of Technology (KIT))

Understanding the mechanisms of micro-crack initiation in metals is of high academic as well as industrial interest. In this contribution, we discuss the role of stress concentrations in metal matrix composite materials as the cause of crack initiation. Using a continuum representation of dislocation microstructures, we compare microscale simulations to experimental studies of crack initiation and discuss the dislocation microstructure around a crack tip.

A Novel Parameter Identification Toolbox for the Selection of Hyperelastic Constitutive Models from Experimental Data (Poster)

Hüsnü Dal (Middle East Technical University), Yashar Badienia (Middle East Technical University), Kemal Açıkgöz (Middle East Technical University), Funda Aksu Denli (Middle East Technical University)

This paper presents a novel parameter identification toolbox based on various multi-objective optimization strategies for the selection of the best constitutive models from a given set of homogeneous experiments. The toolbox aims at providing an objective model selection procedure along with the material parameters for the rubber compound at hand. To this end, we utilize the multi-objective optimization using genetic algorithm of MATLAB. For the validation purposes, we use 24 constitutive laws.

Virtual tests based on model reduction strategies for fatigue analysis (Poster)

Mainak Bhattacharyya (Leibniz Universität Hannover), Amelie Fau (Leibniz Universität Hannover), Udo Nackenhorst (Leibniz Universität Hannover), David Néron (Ecole Normale Supérieure Paris-Saclay, Université Paris-Saclay), Pierre Ladevèze (Ecole Normale Supérieure Paris-Saclay, Université Paris-Saclay)

Virtual tests for fatigue considering a large number of cycles in perspective of continuum damage mechanics are generally avoided due to numerical expense. To tackle this problem, a Proper Generalised Decomposition model reduction technique in time and space, and a multi-time scale approach are proposed. These innovations used in a non-incremental LATIN framework, reduce the computational cost drastically and can be contemplated to perform virtual analysis of high-cycle fatigue tests.

Parallel Stabilized FEM for the Flow Simulations of Microstructured Fluids (Poster)

Metin Cakircali (Forschungszentrum Jülich GmbH), Marek Behr (RWTH Aachen University)

The Single-Walled Carbon Nanotubes (SWNT) have unique properties that make them ideal for nano-materials. We use efficient numerical methods to improve our understanding of the macroscale assembly processes (e.g., fiber spinning). The Galerkin/Least-Squares formulation is derived for the fully coupled transient equation systems. Space-time elements with equal order velocity-pressure-order parameter are used for several relevant test cases. The results are compared with available literature data.

Comparative study of finite-element-based fatigue analysis concepts for adhesive joints in wind turbine rotor blades (Poster)

Pablo Noever Castelos (Leibniz Universität Hannover), Michael Wentingmann (Leibniz Universität Hannover), Claudio Balzani (Leibniz Universität Hannover)

This contribution aims to clarify the need for considering non-proportionality in the fatigue analysis of adhesive joints of wind turbine rotor blades. The comparison covers three different blade configurations (Length: 20 m, 40 m and 80 m) in order to derive generalized conclusions by extracting a correlation between non-proportionality, radial position and blade size. The results further indicate which type of fatigue analysis has to be performed for reliable life estimations.

Data-driven crack assessment (Poster)

Katrin Schulz (Karlsruhe Institute of Technology (KIT)), Valentin Verrier (Karlsruhe Institute of Technology (KIT)), Stephan Kreis (Karlsruhe Institute of Technology (KIT))

Different methods of selection and feature creation are considered in order to discuss the chances and limits of a data driven assessment of cracks. We apply different methods of data mining to find correlations which yield an unconventional approach for the prediction of critical crack states and material failure. The results of different explorative multivariate analyses will be compared and discussed in the context of applicability in engineering science.

Flexible Wheelset Models in Dynamic Interaction with Track (Poster)

Mustapha Afriad (Sorbonne Universités, Université de technologie de Compiègne), Mohamed Rachik (Sorbonne Universités, Université de technologie de Compiègne), Ludovic Cauvin (Sorbonne Universités, Université de technologie de Compiègne), Olivier Cazier (French National Railways Company (SNCF)), Guy-Leon Kaza (Sorbonne Universités, Université de technologie de Compiègne)

Until now, multibody models of vehicle-track interaction consider rigid components. In order to improve these models, it seems necessary to consider flexible components by coupling finite element analysis with multibody dynamics simulations. The main objective of this study is to present the methodology used to integrate wheelset flexibility in a multibody model of train. Wheel-rail contact forces and vehicle stability obtained with rigid wheelset and flexible wheelset will be compared.

Determination of optimal damping for passive control of vibration based on the design of limit cycles (Poster)

Rafael A. Rojas (Free University of Bozen-Bolzano), Erich Wehrle (Free University of Bozen-Bolzano), Renato Vidoni (Free University of Bozen-Bolzano)

The optimal design of passive vibration control is a challenge for both application and research. These design methods are based on structure optimization and models are typically solved in frequency domain. This work explores the benefits of introducing state-space methods on passive control. We propose an optimization approach based on the design of the limit cycles of mechanical systems under periodic forces. The method is applied to an example of damping optimization.

A Variational Level Set Approach to Ferroelectrics (Poster)

Robin Schulte (TU Dortmund University), Andreas Menzel (TU Dortmund University), Bob Svendsen (RWTH Aachen University)

The level set formulation, in contrast to a laminate approach, provides more information considering domain wall kinetics in ferroelectrics since the microstructure is simulated with a spatial resolution. The level set function is defined as a signed distance function to the domain wall. In the variational approach, an internal energy penalises the deviation from the signed distance function due to numerical errors which is computationally more efficient than the commonly used reinitialization.

Virtual simulation of deformation behavior of NiTi stents used in minimally invasive surgery (Poster)

Sharath Chandra Chavalla (Otto von Guericke University Magdeburg), Daniel Juhre (Otto von Guericke University Magdeburg)

Finite element method is a popular computation tool which has its own drawbacks. In recent years, a numerical method called isogeometric analysis (IGA) has been developed which bridges gap between CAD and FEM. Unlike FEM, IGA uses high-order and high-regular basis functions (nonuniform rational B-splines-NURBS). The aim of this project is efficient simulation of the deformation behavior of carotid NiTi stents using IGA which makes a step closer in realising realtime simulation of stents.

Parameter identification for thermo-mechanically coupled material models (Poster)

Lars Rose (TU Dortmund University), Andreas Menzel (TU Dortmund University)

For material models which are based on a phenomenological set of material parameters, the identification of such a set for a certain material model and a related material is the foundation of predictive simulations. The current work focuses on the performance of a parameter identification including the algorithmic structure, as well as the realisation of suitable experiments under inhomogeneous states of deformation and the influence of weighting parameters within the objective function.

A method for the elimination of shear locking effects in an isogeometric Reissner-Mindlin shell formulation (Poster)

Georgia Kikis (RWTH Aachen University), Wolfgang Dornisch (University of Kaiserslautern), Sven Klinkel (RWTH Aachen University)

Shell elements for slender structures based on a Reissner-Mindlin approach struggle in pure bending problems. The stiffness of such structures is overestimated due to the transversal shear locking effect. Here, an isogeometric Reissner-Mindlin shell element is presented, which uses adjusted control meshes for the displacements and rotations in order to create a conforming interpolation of the pure bending compatibility requirement. The method is tested for standard numerical examples.

Phase-Field Modelling of Crack Propagation in Elasto-Plastic Multilayered Materials (Poster)

Zhengkun Liu (Otto von Guericke University Magdeburg), Daniel Juhre (Otto von Guericke University Magdeburg)

The phase-field method has emerged as an extremely powerful technique to simulate crack propagation with significant success. Phase-field simulation of crack propagation in elasto-plastic multilayered materials is discussed in this work. Three fundamental cases are studied i.e. (i) crack propagation in a brittle material, (ii) in a ductile material and (iii) in a brittle-ductile composite. The numerical results demonstrate the mechanical performance of such a multilayered composite design.

MS15-2: Non-standard Formulations and Discretization Methods for Thin-walled Structures

A Discretization Independent Methodology for Mixed Methods

Simon Bieber (University of Stuttgart), Bastian Oesterle (University of Stuttgart), Ekkehard Ramm (University of Stuttgart), Manfred Bischoff (University of Stuttgart)

Nowadays a broad range of different discretization methods, such as (isogeometric) spline based finite element approaches, collocation or meshless methods are available to compute approximate solutions for boundary value problems. Locking is a common issue for primal formulations in all these schemes and formulations based on mixed methods may be favorable. A general methodology will be presented to construct necessary strain/stress ansatz spaces, independent of the discretization method.

Hierarchic Isogeometric Large Rotation Shell Elements Including Linearized Transverse Shear Parametrization

Renate Sachse (University of Stuttgart), Bastian Oesterle (University of Stuttgart), Ekkehard Ramm (University of Stuttgart), Manfred Bischoff (University of Stuttgart)

Two novel hierarchic isogeometric formulations for geometrically nonlinear shell analysis including transverse shear effects are presented. Both concepts combine a fully nonlinear rotation-free Kirchhoff-Love shell model with hierarchically added linearized transverse shear components. An additive split of Green-Lagrange strains dramatically facilitates representing large rotations in shell analysis while the proposed hierarchic concepts are intrinsically free from transverse shear locking.

Generalized local B-bar method for locking phenomenon in Reissner-Mindlin shell and skew-symmetric Nitsche method for boundary conditions imposing and patch coupling in IGA

Qingyuan Hu (University of Luxembourg), Franz Chouly (Université Bourgogne Franche-Comté), Andreas Zilian (University of Luxembourg), Gengdong Cheng (Dalian University of Technology), Stéphane Bordas (University of Luxembourg)

We adopt the generalized local B-bar method to deal with the locking phenomenon in Reissner-Mindlin shell. The local element-wise projection saves computational effort, and projected basis functions of different orders are used to achieve good accuracy. The skew-symmetric Nitsche method is introduced for boundary conditions imposing and patch coupling. It has an advantage of unconditional stability wrt the stable parameter, i.e. parameter-free.

A method for the elimination of shear locking effects in an isogeometric Reissner-Mindlin shell formulation

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Analysis of axisymmetric shells based on the scaled boundary finite element method

Milan Wallner (University of Duisburg-Essen), Carolin Birk (University of Duisburg-Essen), Hauke Gravenkamp (University of Duisburg-Essen)

In this contribution the SBFEM is used to analyse axisymmetric shell structures. A simplified plane strain arch formulation to approximate a cylindrical shell will be presented. This approximation already shows a high correlation with the membrane theory of shells. Furthermore, first results obtained for a 3D shell formulation used to analyse an axisymmetric spherical shell will illustrate the potential of the SBFEM to minimize locking effects when modelling shell structures.

MS16-2: Reduced Order Models for Multiscale and Multiphysics Problems

Reduced Order Modelling for the Simulation of Quenches in Superconducting Magnets (Keynote)

Sebastian Schöps (Technical University of Darmstadt), Idoia Cortes Garcia (Technical University of Darmstadt), Michał Maciejewski (CERN), Bernhard Auchmann (Paul Scherrer Institut)

This contributions discusses the simulation of magnetothermal effects in superconducting magnets as used in particle accelerators. An iterative coupling scheme using reduced order models between a magnetothermal partial differential model and an electrical lumped-element circuit is demonstrated. The multiphysics, multirate and multiscale problem requires a consistent formulation and framework to tackle the challenging transient effects occurring at both system and device level.

Computational homogenization and model order reduction of pressure diffusion in fractured rock

Ralf Jänicke (Chalmers University of Technology), Fredrik Larsson (Chalmers University of Technology), Kenneth Runesson (Chalmers University of Technology)

Pressure diffusion in fracture networks is the dominating physical process that causes attenuation of elastic waves traveling trough fluid-saturated rock. We simulate this process in a multi-scale approach where pressure diffusion occurs on the sub-scale and the related seismic attenuation is observed on the macro-scale. We introduce a computational homogenization scheme and develop a NTFA-type model order reduction technique which allows to derive the macroscopic properties of fractured rock.

Numerical Model Reduction in Computational Homogenization of Transient Heat Flow

Fredrik Ekre (Chalmers University of Technology), Fredrik Larsson (Chalmers University of Technology), Kenneth Runesson (Chalmers University of Technology)

We present a two-scale finite element (FE^2) formulation for transient linear heat flow. For the sub-scale problem, we use spectral decomposition in order to to establish a reduced basis. We discuss a few methods to estimate the error introduced by the reduction, and in particular we aim for explicit bounds on the error in (i) energy norm and (ii) an arbitrary "quantity of interest". Numerical results confirm the validity of the computed error bounds.

Substituting FE analysis of cyclic processes by a space-time reduced order model

Mohammad Reza Hassani (University of Stuttgart), Felix Fritzen (University of Stuttgart)

The huge computational costs make classical Finite Element (FE) simulations of nonlinear structural problems subjected to long-term or e.g. cyclic loading a challenging task. One approach to tackle this is through Model Order Reduction (MOR). Space-time MOR leads to a low-dimensional nonlinear system of equations which is solved in coarse time intervals, e.g. for each load cycle. Thus, remarkable computational saving in terms of CPU time and memory space are attained.

Reduced order modeling of the viscoelastic properties of asphalt concrete

Dennis Wingender (Ruhr University Bochum), Felix Fritzen (University of Stuttgart), Ralf Jänicke (Chalmers University of Technology)

Mastic asphalt is a highly heterogeneous mixture consisting of elastic mineral aggregates and of an viscoelastic bituminous binding agent. To obtain the mixture's overall material behavior, we apply computational homogenization and order reduction. We computationally generate statistical volume elements based on real-data from X-Ray Computed Tomography. The resulting macroscopic material model is used to verify the method in comparison to laboratory experiments.

MS06-2: Computational FSI and Aero-elasticity

A Partitioned Approach for Fluid-Structure Interaction using NURBS-Enhanced Finite Elements and Isogeometric Analysis (Keynote)

Norbert Hosters (RWTH Aachen University), Michel Make (RWTH Aachen University), Stefanie Elgeti (RWTH Aachen University), Marek Behr (RWTH Aachen University)

In the presented work the Deforming Spatial Domain/Stabilized Space-Time method extended with NEFEM is coupled with a semi-discrete IGA solver. IGA exploits the geometric properties of NURBS for numerical analysis. However, parametrizing the 3D-domains typically needed for fluid dynamics is still challenging. Instead, NEFEM suggests the use of standard finite elements in the interior domain and special elements along the boundaries. A simplified data transfer and an error reduction is achieved.

An isogeometric mortar surface coupling method for trimmmed multipatch CAD geometries with application to FSI

Andreas Apostolatos (Technical University of Munich), Altug Emiroglu (Technical University of Munich), Fabien Pean (ETH Zürich), Roland Wüchner (Technical University of Munich), Kai-Uwe Bletzinger (Technical University of Munich)

In this work the isogeometric analysis concept is extended to the mortar-based method for coupling of non-matching discretizations at common interfaces with application to FSI. In particular, focus is put on transferring data between real world engineering geometries modeled in CAD and low order surface discretizations. Moreover, the continuity enforcement between the trimmed multipatches is discussed.

Deforming-Domain Problems Related to Packaging Machines: Mesh-Update Method and Flow Simulation

Fabian Key (RWTH Aachen University), Stefanie Elgeti (RWTH Aachen University)

We will present an efficient and accurate interface-tracking method that describes computational domains composed of a fixed and a moving component in relative translational motion. The periodic character of the motion is reflected in the method via a closed virtual ring. We will conclude with validation results as well as a simulation of the flow and temperature field inside a generic geometry of a packaging machine.

Hybrid Additive/Multiplicative Schwarz Preconditioning for Monolithic Solvers for Surface-Coupled Multi-Physics Problems

Maximilian Noll (Technical University of Munich), Matthias Mayr (Sandia National Laboratories), Michael W. Gee (Technical University of Munich)

We propose a hybrid additive/multiplicative Schwarz preconditioner for the monolithic solution of surface-coupled problems. Existing physics-based block preconditioners have proven to be very powerful but accumulate the error at the coupling surface. We address this issue by combining them with an additional additive Schwarz preconditioner, whose subdomains span across the interface on purpose. By performing cheap but accurate subdomain solves this error accumulation can be reduced efficiently.

MS09-2: Damage Mechanics and Numerical Applications

Comparative study of finite-element-based fatigue analysis concepts for adhesive joints in wind turbine rotor blades

Pablo Noever Castelos (Leibniz Universität Hannover), Michael Wentingmann (Leibniz Universität Hannover), Claudio Balzani (Leibniz Universität Hannover)

This contribution aims to clarify the need for considering non-proportionality in the fatigue analysis of adhesive joints of wind turbine rotor blades. The comparison covers three different blade configurations (Length: 20 m, 40 m and 80 m) in order to derive generalized conclusions by extracting a correlation between non-proportionality, radial position and blade size. The results further indicate which type of fatigue analysis has to be performed for reliable life estimations.

A gradient-extended elastic isotropic damage model considering crack-closure

Marek Fassin (RWTH Aachen University), Stephan Wulfinghoff (RWTH Aachen University), Stefanie Reese (RWTH Aachen University)

In this work an elastic isotropic damage model considering crack-closure and irreversible strains is discussed. After having introduced the model equations of the local model, results of a simple uniaxial strain controlled test on Gauss-point level are presented. Subsequently, the gradient extension of the model (micromorphic approach) is summarized briefly. Finally, the model's properties and robustness are demonstrated by means of a finite element computation of a single edge-notched plate under shear loading, where an adaptive mesh refinement is utilized.

A simplified damage model for unilateral behavior of concrete

Ajmal Hasan Monnamitheen Abdul Gafoor (Technical University of Braunschweig), Dieter Dinkler (Technical University of Braunschweig)

For complex loadings of concrete structures as earthquakes, cyclic and dynamic conditions must be taken into account. Therefore a simplified damage model which uses an equivalent strain in terms of invariants of elastically predicted stresses is developed. The model is introduced by two history deformation parameters related to the equivalent strain in order to describe unilateral behavior of concrete. Thus the model can simulate the distinct behavior of concrete under monotonic/cyclic loadings.

A continuum damage model for delamination and intralaminar damage in composite laminates

Jaan-Willem Simon (RWTH Aachen University), Daniel Höwer (RWTH Aachen University), Stefanie Reese (RWTH Aachen University), Jacob Fish (Columbia University)

An orthotropic continuum damage model is presented in this paper, which enables accounting for the interaction of damage evolution in different directions. Thereby, uniaxial loading states can lead to different damage progression in directions other than the loading direction. The model is thermodynamically consistent and mesh objective due to use of an energy based regularization scheme. It is shown that the model can be successfully applied on different scales.

A viscoelastic-viscoplastic constitutive model with damage for thermoplastics under creep-type loading

Benjamin Schneider (Robert Bosch GmbH), Patrick Zerbe (Robert Bosch GmbH), Egon Moosbrugger (Robert Bosch GmbH), Michael Kaliske (Technische Universität Dresden)

In this contribution tensile experiments with constant load over time and with cyclically removed load are presented. The dog bone specimens out of polyoxymethylene show time dependent reversible as well as irreversible deformations followed by breakage. To reproduce this, a viscoelastic-viscoplastic constitutive model with damage and recovery is applied. Since the occurring deformations are large, an approximative large strain formulation is used still allowing an additive strain split.

MS01-2: 3D Imaging and Segmentation Methods for Computational Modeling of Heterogeneous Materials

Application of X-ray computed tomography on fracture behaviour study of cement paste at micro-scale

Hongzhi Zhang (Delft University of Technology), Branko Šavija (Delft University of Technology), Erik Schlangen (Delft University of Technology)

3D microstructure with a cubic dimension of 100 μm^3 was generated by X-ray computed tomography. Its mechanical properties were predicted by the microstructure informed lattice model. Considering the heterogeneous nature of this material, 30 specimens were investigated. Correlation analysis was conducted between the simulated mechanical properties and porosity.

In situ cement hydration in levitated droplets

Julia Stroh (Federal Institute for Materials Research and Testing), Franziska Emmerling (Federal Institute for Materials Research and Testing)

Building materials consist of cement, water and chemical admixtures, which adjust cement paste properties. Admixtures can act beyond their aimed functions causing undesirable side effects on the hydration course and the properties of the resulting building material. The mechanisms of these effects are still under investigation. We investigate cement hydration in levitated droplets using an ultrasonic levitator. The hydrate phase formation is followed in situ by synchrotron XRD. The data allows detailed conclusions about the mechanisms of the admixture action in the ongoing hydration reactions.

High energy microtomography using synchrotron radiation for materials science application

Felix Beckmann (Helmholtz-Zentrum Geesthacht)

The Helmholtz-Zentrum Geesthacht, Germany, is operating the user experiments for microtomography at the beamlines P05 and P07 using synchrotron radiation produced in the storage ring PETRA III at DESY, Hamburg, Germany. Attenuation contrast and phase contrast techniques were established to provide an imaging tool for materials science applications. In this talk the current status of the grating-based phase contrast and the concept for the investigation of large samples will be presented.

X-ray computed tomography: Image processing and applications

Matteo Lunardelli (Technical University of Braunschweig), Patrick Varady (Technical University of Braunschweig), Dennis Köhnke (Technical University of Braunschweig), Sven Lehmberg (Technical University of Braunschweig), Harald Budelmann (Technical University of Braunschweig)

Understanding the mechanical behavior and deterioration processes of inhomogeneous cement based materials such as mortar and concrete can be improved with information on their inner structure obtained in non-destructive x-ray CT scans. However, the different concrete components have similar attenuation coefficients, resulting in low contrasts between them. It requires demanding image processing techniques, of which a selection will be presented in relation to their applications.

Efficient mesh generation of real concrete mesostructures from CT scan images using contrast enhancers

Pietro Carrara (Technical University of Braunschweig), Roland Kruse (Technical University of Braunschweig), Laura De Lorenzis (Technical University of Braunschweig)

This work explores the possibility to add contrast enhancers powders into the concrete mixes to allow an easier segmentation and mesh generation. This allows to adopt high fidelity geometries of the concrete mesostructure into numerical simulations. Characterization tests are performed in order to ensure that the concrete mix is not appreciably affected by the presence of the enhancers. The results of both normal and modified concretes are compared to demonstrate the validity of the method.

X-ray imaging of water transport in porous materials: New possibilities by phase and dark-field contrast

Michele Griffa (Swiss Federal Laboratories for Materials Science and Technology, EMPA), Fei Yang (ETH Zürich)

In this contribution, we show examples of X-ray phase and dark-field contrast X-ray imaging, based on refraction and ultra-small angle scattering of the transmitted X-ray photons, respectively, as applied to cement-based materials during changes in their water content due to distinct processes. We overview what can be gained by using such imaging methods compared with what achievable with standard, attenuation contrast ones.

MS02-2: Adaptive Structures: Theory, Modelling, Simulation and Evaluation

Adaptive Structures: Optimum Design Methodology, Case Study and Prototype (Keynote)

Gennaro Senatore (Swiss Federal Institute of Technology (EPFL))

This paper presents an overview of a new methodology to design optimum adaptive structures with minimum whole-life energy comprising an embodied part in the material and an operational part for structural adaptation. Instead of using more material to cope with the effect of rare but strong loading events, a strategically integrated actuation system redirects the internal load path to homogenize the stresses and keep deflections within limits by changing the shape of the structure.

Feedback Controller Design and Topology Optimization for Truss Structures Under Uncertain Dynamic Loads

Anja Kuttich (Technical University of Darmstadt), Stefan Ulbrich (Technical University of Darmstadt)

We consider the problem of topology optimization of truss structures under uncertain dynamic loads and combine the topology optimization problem with a feedback controller design via the H_infty-control problem. With the help of the Bounded Real Lemma the optimization problem can be formulated as nonlinear semidefinite programming problem. We solve the resulting problem using a sequential semidefinite programming approach. The considerations are complemented by numerical results for trusses.

Experimental and Theoretical Analysis of Cable dome

Peter Cauner (Technical University of Košice, Faculty of Civil Engineering), Stanislav Kmet (Technical University of Košice, Faculty of Civil Engineering), Marek Mojdis (Technical University of Košice, Faculty of Civil Engineering)

The paper deals with analysis of newly developed adaptive cable dome which has the ability to change stiffness configuration to adapt its behavior to current loading conditions. Adaptive cable dome was developed and created on the Faculty of Civil Engineering Technical University of Kosice. In the article are presented results of experimental and theoretical analyses which are compared. Tests are aimed to verifying ability of cable dome to adapt its state of stress to changing load cases.

Simulation and optimal control of dielectric elastomer actuated systems

Tristan Schlögl (Friedrich-Alexander University of Erlangen-Nürnberg), Sigrid Leyendecker (Friedrich-Alexander University of Erlangen-Nürnberg)

This contribution introduces different modelling techniques and optimal control approaches for humanoid structures that are actuated by dielectric elastomers. Dielectric elastomers, also known as artificial muscles, belong to the group of smart materials. When excited with an electrical voltage, the elastic material contracts noiselessly, allowing for smooth motion of the actuated system.

MS13-2: Multiscale Methods for Complex Materials

Stress simulation in lithium-ion batteries

Tobias Hofmann (Fraunhofer Institute for Industrial Mathematics ITWM), Heiko Andrä (Fraunhofer Institute for Industrial Mathematics ITWM), Ralf Müller (University of Kaiserslautern), Jochen Zausch (Fraunhofer Institute for Industrial Mathematics ITWM)

Phase separation during the intercalation of lithium ions can lead to degradation effects in some cathode materials. A model describing lithium ion diffusion, electric potentials and small deformations is introduced on the microscale. The Cahn-Hilliard equation is used in an electrochemical model. coupled to linear elasticity of small strains in the electrode material. An immersed boundary method is used with adapative time steps. Charging of porous microstructures is numerically simulated.

Macroscopic yield curves based on RVE-based polycrystal simulations

Lisa Scheunemann (University of Duisburg-Essen), Jörg Schröder (University of Duisburg-Essen)

In multiscale modelling, an appropriate description of microheterogeneous materials is inevitable for realistic simulations. Materials governed by texture require its consideration for an appropriate description of the material's yield behavior. Therefore, macroscopic yield curves resembling the polycrystalline microstructures of the material are constructed using RVE-based polycrystal simulations in the framework of the FE^2-method.

Cycle-by-cycle fatigue damage model for concrete

Thomas Titscher (Federal Institute for Materials Research and Testing), Jörg F. Unger (Federal Institute for Materials Research and Testing), Javier Oliver (Universitat Politècnica de Catalunya (UPC))

Damage caused by stress concentrations in the complex mesoscopic geometry of concrete leads to continuous stress redistribution over the material's life time. The presented fatigue damage model captures this by resolving each load cycle in a cycle-by-cycle time integration. The model extends a static damage model to failure caused by the (time dependent) strain amplitudes and, thus, allows calibrating the majority of the material's parameters in static experiments.

Domain decomposition methods for fracture mechanics problems and its application to fiber reinforced concrete

Philip Huschke (Federal Institute for Materials Research and Testing), Jörg F. Unger (Federal Institute for Materials Research and Testing)

A finite element tearing and interconnecting (FETI) approach for phase-field models and gradient enhanced damage models is presented. These diffusive crack models can solve fracture mechanics problems by integrating a set of partial differential equations and thus avoid the explicit treatment of discontinuities. However, they require a fine discretization in the vicinity of the crack. FETI methods distribute the computational cost among multiple processors and thus speed up the computation.

Thursday, 12 October 2017

PL04: Plenary Lectures

71'573 various challenges – Computational Engineering @ HILTI
Ralph Lohner (Hilti AG)

HILTI is the world market leader in fastening and demolition technology for construction professionals. We offer a highly differentiated product portfolio of over 70'000 different items to our customers in more than 120 countries. Efficient development at HILTI is based on consequent integration of existing and development of progressive simulation methodology. The particular challenge in this is to deal with various physical domains like powder or gas combustion in direct fastening tools, concrete interaction of anchoring products, battery behavior for power tools or the dispensing of high viscous mortars – many of them on the edge or beyond what standard commercial solvers are able to answer. In the lecture some representative examples from industry will be shown to illustrate possible simulation solutions with commercial/ in-house code or adapted open source software packages.

Computational multiscale methods for turbulent single- and two-phase flows
Ursula Rasthofer

Variational multiscale methods for LES of turbulent single- and two-phase flows are presented. To recover the subgrid-scale velocity, multifractal scale similarity in the enstrophy field of turbulent flow is exploited. The extended finite element method allows for sharply representing discontinuities at the interface of two-phase flow on a fixed grid. Various numerical examples, ranging from turbulent flow past a backward-facing step to turbulent bubbly channel flow, illustrate the methods.

MS15-3: Non-standard Formulations and Discretization Methods for Thin-walled Structures

Forming simulations with NURBS shells in LS-DYNA

Stefan Hartmann (DYNAmore GmbH), Attila P. Nagy (Livermore Software Technology Corporation (LSTC)), Dave J. Benson (Livermore Software Technology Corporation (LSTC))

LSTC (Livermore Software Technology Corp.) has started to implement NURBS based finite elements into their widely used commercial simulation package LS-DYNA. This work will give a short overview about the general possibilities of isogeometric shells in LS-DYNA and focus on the recent advances for the analysis of Sheet Metal Forming Applications. A benchmark example from the Numisheet 2005 conference is analyzed and compared with the results achieved with state-of-the-art methods.

A mixed isogeometric collocation method for rate-independent elastoplasticity

Frederik Fahrendorf (Technical University of Braunschweig), Laura De Lorenzis (Technical University of Braunschweig)

We present a mixed isogeometric collocation method for rate-independent elastoplasticity at small strains. In the proposed approach, both stress and displacement fields are approximated as primary variables. An isotropic hardening rule is implemented and the elastoplastic constitutive equations are integrated in time via a classical return-mapping algorithm. Various numerical examples of plane strain elastoplasticity are investigated and compared to reference solutions.

A scaled boundary NURBS approach for nonlinear solid analysis

Markus Klassen (RWTH Aachen University), Margarita Chasapi (RWTH Aachen University), Bernd Simeon (University of Kaiserslautern), Sven Klinkel (RWTH Aachen University)

In this contribution, the scaled boundary formulation is proposed as a discretization technique which is based on the isogeometric concept. By this means, the representation of a solid body is given by the boundary surface of the body and a radial scaling parameter which is used to describe the interior. NURBS shape functions are employed to define the geometry as well as to approximate the solution field. The numerical examples are given for elasto-plastic material behavior at small strains.

Simulation of brittle fracture in shells using a phase-field approach and LR B-splines

Davide Proserpio (Norwegian University of Science and Technology), Josef Kiendl (Norwegian University of Science and Technology), Marreddy Ambati (Technical University of Braunschweig), Laura De Lorenzis (Technical University of Braunschweig), Kjetil André Johannessen (Norwegian University of Science and Technology), Trond Kvamsdal (Norwegian University of Science and Technology)

We present a phase-field approach to model brittle fracture in plates and shells. For structural analysis, the discretization of the geometry is performed using an isogeometric Kirchhoff-Love shell formulation, extended to local refinement with LR B-splines in order to properly resolve the mesh in the cracked regions, improving the accuracy and efficiency of the analysis.

A shell element for the analysis of interlaminar stresses and delaminations of layered composites

Gregor Knust (Technical University of Darmstadt), Friedrich Gruttmann (Technical University of Darmstadt)

In this contribution a mixed hybrid shell element for the calculation of interlaminar shear and normal thickness stresses of layered composite structures is presented. These stresses are decisive factors for delaminations. The element formulation is based on the Reisser-Mindlin kinematics with an inextensible director field. After static condensation the element has the standard shell degrees of freedom. The numerical examples focus on failure caused by delamination.

MS08-1: Coupled Multi-field Problems in Porous-media Mechanics

Modeling porous medium modification through induced calcite precipitation (Keynote)

Johannes Hommel (University of Stuttgart), Adrienne J. Phillips (Montana State University), Robin Gerlach (Montana State University), Alfred B. Cunningham (Montana State University), Rainer Helmig (University of Stuttgart), Holger Class (University of Stuttgart)

Induced calcite precipitation is an emerging technology to alter properties of porous media. It results in a decrease in porosity and permeability as well as an increase in mechanical strength. For a reliable prediction of these changes, numerical modeling is the method of choice, as the involved processes are strongly coupled. Validated to experimental data, such numerical models are useful tools in the upscaling from laboratory to field-scale applications.

Heat transfer in multi-phase porous media for intelligent cancer detection

Angela Niedermeyer (RWTH Aachen University), Carlos Alberto Hernandez Padilla (RWTH Aachen University), Marcus Stoffel (RWTH Aachen University), Bernd Markert (RWTH Aachen University)

The underlying research project aims to improve cancer diagnosis by determining the correlation between the locally increased heat production of hyper-perfused cancerous tissue and the body surface temperature distribution, measurable using thermography. In this work, a preliminary experimental study of the detectability of an embedded heat source in a perfused solid by means of thermography is presented. Furthermore, the suitability of different mathematical modelling approaches is studied.

Variation of different growth descriptions in a metastatic proliferation model

Patrick Schröder (University of Stuttgart), Arndt Wagner (University of Stuttgart), Daniela Stöhr (University of Stuttgart), Markus Rehm (University of Stuttgart), Wolfgang Ehlers (University of Stuttgart)

In biological tissue, the proliferation of metastases is governed by nutrient-driven cell division. In a continuum-mechanical model based on the Theory of Porous Media, the proliferation is described via mass production terms. Therein, the constitutive approach for the growth of the metastases is implemented either by a Monod-type or a logistic growth function. In both cases, the results are compared to cancer cell growth experiments.

The TPM^2-Method: A two-scale homogenization scheme for fluid saturated porous media

Florian Bartel (TU Dortmund University), Tim Ricken (TU Dortmund University), Jörg Schröder (University of Duisburg-Essen), Joachim Bluhm (University of Duisburg-Essen)

This contribution will present a two-scale homogenization (FE^2-Method) approach for fluid saturated porous media with a reduced two-phase material model (TPM), which covers the behaviour of large poro-elastic deformation. The main aspects of theoretical derivation for the weak form, the lower level boundary conditions under consideration of the Hill-Mandel homogeneity condition and the averaged macroscopic tangent moduli will be pointed out and a numerical example will be shown.

Using a pore-network model to couple mass, momentum and energy at the interface between free flow and porous media flow

Kilian Weishaupt (University of Stuttgart), Rainer Helmig (University of Stuttgart)

Coupled systems of a porous medium with an adjacent free flow appear in a wide range of industrial and environmental processes. We propose an efficient coupled model comprising three domains: a bulk porous medium (Darcy's or Forchheimer's law) at the bottom, the free flow domain (Navier-Stokes) on the top and the interface region (dynamic pore-network model) in between. This model can help to provide effective upscaled parameters required for other mechanical modeling approaches.

CS06: Interface Models and Homogenization

General imperfect interface models at finite deformations

Tim Heitbreder (TU Dortmund University), Jörn Mosler (TU Dortmund University)

Considering a geometrically exact description, only isotropic classical cohesive zone models fulfill fundamental principles such as material frame indifference and thermodynamical consistency. The ability to model shear and anisotropy is limited. Within this talk, a novel interface model, which is consistent with the above mentioned fundamental principles, is presented. Besides the simulation of anisotropic hyperelasticity, numerical results for anisotropic material degradation are shown.

Improvement in the accordance of numerical and experimental analysis of a T-joint automotive structure made of composite

Carlo Boursier Niutta (Politecnico di Torino), Giovanni Belingardi (Politecnico di Torino)

Structural behavior of composite material components is particularly influenced by manufacturing processes. A numerical model validation is generally required with respect to experimental analyses, even for complex phenomena as crash impacts. In this work, a T-joint structure of woven fabric carbon/epoxy composite is investigated under transverse bending. The goal is to properly account manufacturing and nonlinearities effects in the finite element study in order to increase its accuracy.

Computational modelling of wear and the effective frictional behaviour of elastoplastic tools

Rolf Berthelsen (TU Dortmund University), Hendrik Wilbuer (TU Dortmund University), Andreas Menzel (TU Dortmund University)

Sheet bulk metal forming tools are often structured, either to favour material flow in desired directions, or to reduce the process forces. During continuous operation, the structures of the tools suffer from material wear which in turn effects the frictional behaviour that is responsible for the favoured flow directions. In order to capture both effects numerically, this contribution presents a framework for the modelling of wear and the effective frictional behaviour of elastoplastic tools.

A homogenisation method based on the Irving-Kirkwood-Theory

Maximilian Müller (Technical University of Darmstadt), Friedrich Gruttmann (Technical University of Darmstadt)

In this contribution a homogenisation method based on the Irving-Kirkwood theory is introduced. The homogenisation formulas for mass and impulse are consistent with the theory and from there homogenisation formulas for the stress tensor and body force vector are derived. A numerical implementation of the theory is shown and examples with various boundary conditions are presented and compared to results obtained with a Hill-Mandel-approach as well as a full scale approach.

MS14-1: Multiscale Modeling of Transport Processes and Fracture in Concrete

A Bayesian approach to parameter identification for phase-field modeling fracture (Keynote)

Tao Wu (Technical University of Braunschweig), Bojana Rosić (Technical University of Braunschweig), Hermann Matthies (Technical University of Braunschweig), Laura De Lorenzis (Technical University of Braunschweig)

Phase-field modeling is capable of simulating complicated fracture processes in a unified framework without the need for ad-hoc criteria and on a fixed mesh. The objective of this work is to apply the probabilistic analysis through a Bayesian approach to provide an efficient and reliable parameter identification for phase-field modeling of fracture.

Transport properties of microcracked porous materials: Micromechanics models and mesoscale simulations

Jithender Jaswant Timothy (Ruhr University Bochum), Tagir Iskhakov (Ruhr University Bochum), Günther Meschke (Ruhr University Bochum)

In the presentation, using a combination of analytical micromechanics models and direct numerical simulations, the effective diffusivity of microcracked porous REVs for various isotropic and anisotropic microcrack configurations are investigated. Furthermore, the level of applied external loading on the effective diffusivity of a fracturing material is simulated by an element-erosion based mesoscale pixel-FE model for fracture coupled with diffusion using selected numerical experiments.

Multiscale model of ASR-induced damage in concrete

Tagir Iskhakov (Ruhr University Bochum), Jithender Jaswant Timothy (Ruhr University Bochum), Günther Meschke (Ruhr University Bochum)

A multiscale micromechanical model for the prediction of the deterioration of concrete caused by Alkali Silica Reaction is presented. The gel pressure results in microcrack growth in the reactive aggregate and the surrounding cement paste. This damage process is formulated in the framework of linear elastic fracture mechanics applied at the scale of the aggregate and the cement paste. The model predictions are compared with selected experimental data.

A Lattice Boltzmann approach for advection-diffusion problems in porous media including dissolution

Hussein Alihussein (Technical University of Braunschweig), Manfred Krafczyk (Technical University of Braunschweig), Konstantin Kutscher (Technical University of Braunschweig), Martin Geier (Technical University of Braunschweig)

A LB model is presented to simulate advection-diffusion processes in porous media. Chemical reactions occurring on the pore surfaces causing dissolution require continuous surface adaptation. The approach utilizes the Cumulant LB model to model advection, a second LBM for the concentration of the chemical species, and an explicit surface dynamics solver governing the transient evolution of the surface geometry.

MS03-1: Challenges of Current and Emerging Applications for High Performance Computing

An HPC technology review with respect to large scale engineering applications

Ralf Schneider (High Performance Computing Center Stuttgart)

An overview about the current state of the art in HPC-systems and technology will be given. Especially the current trends in accelerators, vector and many-core architectures, resulting from the stagnating scalar per core performance of classical CPUs will be addressed. In view of large scale engineering applications from the fields of structural mechanics and fluid dynamics the current and emerging bottlenecks as well as the technological and intellectual challenges will be discussed.

Numerical Simulation of Flow with Volume Condensation during Accident in Containment of Nuclear Power Plant

Jing Zhang (High Performance Computing Center Stuttgart)

One severe accident scenario is a leak in the primary circuit of a Pressurized Water Reactor (PWR), resulting in hydrogen and steam injection into the containment. Because of the influence of steam condensation on the gas mixing, the wall and volume condensation phenomena are of interest for the safety considerations. This presentation shows the simulation results of two-phase flow using the developed volume condensation model in the containment. Simulations were performed on the HPC systems.

Modelling the neuromuscular system using HPC systems

Thomas Klotz (University of Stuttgart), Nehzat Emamy (University of Stuttgart), Thomas Ertl (University of Stuttgart), Dominik Göddeke (University of Stuttgart), Aaron Krämer (University of Stuttgart), Michael Krone (University of Stuttgart), Benjamin Maier (University of Stuttgart), Miriam Mehl (University of Stuttgart), Tobias Rau (University of Stuttgart), Oliver Röhrle (University of Stuttgart)

Modelling the neuromusclular system is challenging due to its high compexlity and variability. Formulating models that account for a realistic biophysical motivated activation process leads to computational expensive multi-scale simulations, which, in turn limits on normal compute environments the model detail and model size due to its computational complexity. We aim to overcome these limitations by using massively parallel HPC clusters.

Load-balance strategies for CFD-codes on HPC systems

Philipp Offenhäuser (High Performance Computing Center Stuttgart)

Today's HPC systems generate their performance by facilitating hundreds of thousands of cores. In order to use this computing power efficiently, the computational effort must be distributed evenly across all cores. Techniques for distributing the simulation initially are well-known. Based on numerical and physical phenomena additional computational effort may occur locally, at run-time. Techniques are presented which recognize these additional loads and redistribute the simulation evenly.

Eigenmodes for nonlinear operators

Uwe Küster (High Performance Computing Center Stuttgart), Ralf Schneider (High Performance Computing Center Stuttgart), Andreas Ruopp (High Performance Computing Center Stuttgart)

Even if spectral analysis seems to be restricted to linear operators, it turns out that it is also applicable to nonlinear operators by turning them linear by embedding these in a much larger space and analyzing the Koopman operator. Spectral analysis will be possible but in an infinite dimensional space. We show a numerical approach, which allows to separate different parts of instationary data in a time vanishing part and a remaining part. We discuss implications for calculation and IO.

MS17-1: Smart and Active Materials: Experiments, Modelling, and Simulation

Constitutive modeling of shape memory alloys incorporating transformation-induced plasticity and damage (Keynote)

George Chatzigeorgiou (Arts et Métiers ParisTech, Metz), Long Cheng (Arts et Métiers ParisTech, Metz), Yves Chemisky (Arts et Métiers ParisTech, Metz), Fodil Meraghni (Arts et Métiers ParisTech, Metz)

Shape memory alloys (SMAs) are exploited in several innovative applications such as biocompatible actuators experiencing up to large number of cyclic loads. However, the description of the SMA cyclic response is still incomplete. The present work is devoted to propose a 3D model based on the thermodynamical coupling of different strain mechanisms such as the forward and reverse phase transformation, the martensitic reorientation, the transformation-introduced plasticity and fatigue damage.

Bilayer Liquid Crystal and Freedericksz Instability

Krishnendu Haldar (Ecole Polytechnique), Kostas Danas (Ecole Polytechnique), Nicolas Triantafyllidis (Ecole Polytechnique)

Liquid crystals are best known for their extensive applications, among many others, in flat display technology. The underlying mechanism is an electro-mechanical coupled phenomenon, followed by an electric field driven instability. This is also known as Freedericksz Transition (FT), where the system evolves with a new stable bifurcated configuration. In this work, through a mixed analytical/numerical study, we present the strong influences of bilayer structure and material constants on the FT.

Thermo-magneto-mechanical modeling of magneto-rheological elastomers

Markus Mehnert (Friedrich-Alexander University of Erlangen-Nürnberg)

A general thermodynamically consistent constitutive framework for thermo-magneto-mechanically coupled phenomena is devised in this contribution. A generalized formulation for the total thermo-magneto-mechanical energy function in an additive form is presented where the magneto-mechanically coupled effect is linearly scaled with the temperature. The framework is verified using a classical non-linear boundary value problem.

Continuum Mechanical Modeling of Strain-Induced Crystallization in Polymers

Serhat Aygün (TU Dortmund University), Sandra Klinge (TU Dortmund University), Sanjay Govindjee (University of California)

The strain-induced crystallization (SIC) in polymers is a phenomenon manifesting itself as the natural reinforcement caused by the high deformation. The current presentation, treats a polymer affected by the SIC as a heterogeneous medium consisting of regions with a different degree of network regularity. Such a concept allows us to simulate the nucleation and the growth of crystalline regions. The model proposed is based on the assumptions for the free energy and dissipation potential.

MS18-1: Virtual Analysis and Design of New Materials

Stochastic modelling of microstructures for virtual material design (Keynote)

Claudia Redenbach (University of Kaiserslautern)

Macroscopic properties of materials, e.g. the permeability of a filter or the mechanical strength of a fiber composite, are highly influenced by the microstructure. Models from stochastic geometry are valuable tools for studying these relations as they allow for the generation of virtual microstructures with controlled characteristics. The talk presents models for different material classes and explains how to fit the models based on geometric characteristics estimated from 3D image data.

Fiber-Orientation-Evolution Models for Compression Molding of Fiber Reinforced Polymers

Róbert Bertóti (Karlsruhe Institute of Technology (KIT)), Thomas Böhlke (Karlsruhe Institute of Technology (KIT))

This presentation gives a short review on the Fiber-Orientation-Evolution models commonly used in commercial softwares. The basis of the considered models is Jeffery's equation from 1922 which describes the motion of a single ellipsoidal particle in a Newtonian fluid. The later models extend Jeffery's equation for many fiber system, with the use of Fiber-Orientation-Tensors. Models are discussed up to the o-iARD-RPR model (Tseng 2016), and compared considering representative flow modes.

Effective meso properties for fibre reinforced polymer curing

Christian Dammann (Paderborn University), Rolf Mahnken (Paderborn University), Peter Lenz (Paderborn University)

Our work presents volumetric effective properties in dependence on the degree of cure. They are obtained by homogenization for a representative unit cell on the heterogeneous microscale. To this end, analytical solutions for (n)- and (n + 1)-layered composite sphere models are derived. In a numerical study it is demonstrated that the effective properties lie within certain bounds. Moreover, application of the effective properties to the curing of fibre reinforced polymers is investigated.

A micro-mechanically motivated approach for modelling the oxidative ageing process of elastomers

Darcy Beurle (Leibniz Universität Hannover), Markus André (University of Applied Sciences and Arts Hannover), Udo Nackenhorst (Leibniz Universität Hannover)

The response of elastomers is strongly influenced by chemical ageing, which changes the polymer network through chain scission and formation of new links. In this work, a micro-mechanical approach based on chain statistics is used to introduce ageing into the constitutive model through a unit-sphere homogenization technique. As a first step, chain scission is handled by a modification of the underlying probabilistic model, and challenges of modelling a secondary network formation are discussed.

Rheology of Additive Manufacturing Processes for Medical Silicone

Philipp Hartmann (Leibniz Universität Hannover), Christian Weißenfels (Leibniz Universität Hannover), Peter Wriggers (Leibniz Universität Hannover)

The objective of this project is to simulate the 3D-printing of medical grade silicone to support patient specific implant development. This requires the formulation of a thermodynamically consistent finite strain curing model, whereby a multiphysics approach for the mechanical, thermal and chemical fields is necessary. Due to the complexities of the manufacturing process, the Optimal Transportation Meshfree method is used to obtain a numerical solution.

CS01: Advanced Modelling and Discretization Schemes

A primal discontinuous Petrov Galerkin Finite Element Method

Tobias Steiner (Leibniz Universität Hannover), Peter Wriggers (Leibniz Universität Hannover)

In this contribution a primal discontinuous Petrov Galerkin Finite Element Method (dPG FEM) with a linear elastic isotropic material model is presented. This novel mixed discretization method was introduced by Demkowicz and Gopalakrishnan in 2010. The behavior of this formulation is studied with benchmark simulations for small deformations in the nearly incompressible case. Furthermore, a possible extension for a nonlinear Finite Element formulation is suggested.

Virtual simulation of deformation behavior of NiTi stents used in minimally invasive surgery

Sharath Chandra Chavalla (Otto von Guericke University Magdeburg), Daniel Juhre (Otto von Guericke University Magdeburg)

Recently isogeometric analysis (IGA) is developed to bridge gap between design and computation analysis. It represents and calculates geometries using non-uniform rational B-splines (NURBS). IGA uses high-order, high-regular basis functions aiding in higher accuracy and minimal computation efforts unlike finite element method. The project aim is efficient simulation of the deformation behavior of carotid NiTi stents in throat arteries which leads to a step closer in realizing real-time simulation.

Flexible Wheelset Models in Dynamic Interaction with Track

Mustapha Afriad (Sorbonne Universités, Université de technologie de Compiègne), Mohamed Rachik (Sorbonne Universités, Université de technologie de Compiègne), Ludovic Cauvin (Sorbonne Universités, Université de technologie de Compiègne), Olivier Cazier (French National Railways Company (SNCF)), Guy-Leon Kaza (Sorbonne Universités, Université de technologie de Compiègne)

Until now, multibody models of vehicle-track interaction consider rigid components. In order to improve these models, it seems necessary to consider flexible components by coupling finite element analysis with multibody dynamics simulations. The main objective of this study is to present the methodology used to integrate wheelset flexibility in a multibody model of train. Wheel/rail contact forces and vehicle stability obtained with rigid wheelset and flexible wheelset will be compared.

Improving Numerical Stability of a Tensor-Based Blood Damage Model using the Log-Conformation Formulation

Stefan Haßler (RWTH Aachen University), Lutz Pauli (RWTH Aachen University), Marek Behr (RWTH Aachen University)

Computational Hemodynamics enables the prediction of hydraulic properties and biocompatibility of new Ventricular Assist Devices (VADs). For hemolysis predictions, we use a tensor-based morphology model that accounts for the physiological behavior of red blood cells in blood flow. It resembles the viscoelastic Oldroyd-B equation and shows similar difficulties in numerical stability. Therefore, we apply the log-conformation formulation to the morphology model and show its enhanced stability.

Parallel Stabilized FEM for the Flow Simulations of Microstructured Fluids

Metin Cakircali (Forschungszentrum Jülich GmbH), Marek Behr (RWTH Aachen University)

The Single-Walled Carbon Nanotubes (SWNT) have unique properties that make them ideal for nano-materials. We use efficient numerical methods to improve our understanding of the macroscale assembly processes (e.g., fiber spinning). The Galerkin/Least-Squares formulation is derived for the fully coupled transient equation systems. Space-time elements with equal order velocity-pressure-order parameter are used for several relevant test cases. The results are compared with available literature data.

MS08-2: Coupled Multi-field Problems in Porous-media Mechanics

Compressible Flows inside Piston Ring Pack Simulated with Space-Time Finite Elements

Max von Danwitz (RWTH Aachen University), Norbert Hosters (RWTH Aachen University), Marek Behr (RWTH Aachen University)

The fuel efficiency of an internal combustion engine is directly related to the performance of the piston ring pack. We present our numerical study of compressible gas flow in the ring pack. Namely, a two-dimensional transient full engine working cycle simulation considering the fluid-rigid-body interaction between piston ring and surrounding fluid, and a three-dimensional simulation of the flow through the ring gap investigating the gap's suction effect.

Phase-Field Modeling of Multiple Phase Change Materials (PCMs)

Abdel Hassan Sweidan (RWTH Aachen University), Heider Yousef (RWTH Aachen University), Bernd Markert (RWTH Aachen University)

A latent heat storage medium with various heat transfer enhancement techniques is being studied. The methods include using multiple immiscible PCM constituents with different melting temperatures and adding highly conductive fins. The system is modeled using the finite element method and the phase-field method is employed as a numerical approach to account for the phase change process. This method relies on specification of free energy density function and employs a phase-field variable that defines the state of the material, and it also allows for realistic simulations of dendritic growth (including anisotropy) and other solidification microstructures.

Preliminary calibration of a phase-field model for cracks due to shrinkage in cement-based materials

Tuanny Cajuhi (Technical University of Braunschweig), Pietro Lura (Swiss Federal Laboratories for Materials Science and Technology, EMPA), Laura De Lorenzis (Technical University of Braunschweig)

Shrinkage in cement-based materials can lead to early microcracking. The phenomenon is related to the change of volume at early states, which can lead to cracking if the medium is either internally or externally restrained. Objective of this work is to describe drying shrinkage and autogenous shrinkage in cementitious materials within the framework of poromechanics and phase-field modeling with special focus on crack initiation and evolution. A preliminary calibration of the material parameters is performed in this paper.

A study of temperature and strain rate dependent glass fracture behaviour

Ziyuan Li (RWTH Aachen University), Yousef Heider (RWTH Aachen University), Bernd Markert (RWTH Aachen University)

In this contribution, the numerical simulation of brittle fracture of glass materials under room temperature is carried out on a continuum-mechanical scale using the theory of linear elasticity and J-integral, extended by a phase-field modeling (PFM) approach. Following this, behaviors such as crack nucleation, propagation, and bulk material fracture can be realized. Moreover, fracture stresses and J-integral values are compared to analyze material toughness.

MS05-1: Computational Contact Mechanics

Contact along virtual interfaces: coupling the X-FEM with the mortar discretization (Keynote)

Vladislav Yastrebov (MINES ParisTech), Basava Raju Akula (MINES ParisTech), Julien Vignollet (Safran)

We suggest a computational framework combining the extended finite element method (X-FEM) with the mortar integration for domain-tying and contact problems. We formulate interface conditions between a finite element surface and a virtual surface, passing at any location of another FE mesh (level set). The integration of the internal work employs the X-FEM. The tying or contact constraints are satisfied in the mortar sense. The aimed applications include a structural zoom and wear simulation.

On the shape functions for the contact pressure in mortar methods

Xuan Thang Duong (RWTH Aachen University), Laura De Lorenzis (Technical University of Braunschweig), Roger A. Sauer (RWTH Aachen University)

Mortar formulations differ on the choice of shape functions for approximation of the contact pressure. The shape functions can be identical to the standard, weighted standard, or the dual shape functions. In this contribution, we will unify all the above choices by starting with a least-squares condition. That is, the shape functions are constructed such that the smoothed contact pressure fits best to the raw contact pressure. Various other choices are also compared and discussed.

A Nitsche's method for finite deformation thermo-mechanical contact

Alexander Seitz (Technical University of Munich), Wolfgang A. Wall (Technical University of Munich), Alexander Popp (Technical University of Munich)

This talk presents an extension of Nitsche's method to finite deformation thermo-mechanical contact problems. Besides the coupling of temperature and stress response in the bulk continuum, special focus is put on the consistent enforcement of all involved interface constraints: normal contact, Coulomb's law of friction, heat conduction across the interface and frictional work converted to heat. A set of numerical examples will be presented demonstrating the accuracy of the presented method.

An exact penalty approach for the finite element solution of frictionless contact problems

Fabian Sewerin (Technical University of Braunschweig), Panayiotis Papadopoulos (University of California)

Considering a discrete formulation of the frictionless two-body contact problem, we adopt an exact penalty approach in order to enforce the kinematic impenetrability constraints. This approach is based on an augmented discrete force equilibrium and a smooth estimation of the Lagrange multipliers in terms of the nodal displacements. A main feature of the resulting formulation is that an exact enforcement of the impenetrability constraints is achieved for a finite value of the penalty parameter.

CS04: Fracture

Phase-Field Modelling of Crack Propagation in Elasto-Plastic Multilayered Materials

Zhengkun Liu (Otto von Guericke University Magdeburg), Daniel Juhre (Otto von Guericke University Magdeburg)

The phase-field method has emerged as an extremely powerful technique to simulate crack propagation with significant success. Phase-field simulation of crack propagation in elasto-plastic multilayered materials is discussed in this work. Three fundamental cases are studied i.e. (i) crack propagation in a brittle material, (ii) in a ductile material and (iii) in a brittle-ductile composite. The numerical results demonstrate the mechanical performance of such a multilayered composite design.

Crack propagation simulation of concrete considering water fracture interaction using SBFEM

Chengbin Du (Hohai University), Peng Zhang (Hohai University), Xinran Tian (Hohai University)

Concrete crack propagation simulations are conducted under both the external force and water pressure using SBFEM, considering the interaction between internal water pressure and crack propagation. Finite Volume Method (FVM) is employed to model the water within the crack considering the interaction between water pressure and the crack opening distance (COD). The results show that the internal water pressure distribution plays an important role in the crack propagation.

Numerical investigation of hydraulic fracturing and borehole interaction under deep reservoir conditions using XFEM

Janis Reinold (Ruhr University Bochum), Sven Beckhuis (Ruhr University Bochum), Günther Meschke (Ruhr University Bochum)

Hydraulic fracturing is a complex process, due to the interaction of the fracturing fluid with the surrounding deformable porous media, while the fracture is propagating. The fracture response is sensitive to in-situ stresses, fracture toughness or initial fracture angles. A hydro-mechanical XFEM model is introduced to simulate the fluid flow and deformation of the rock. Examples with multiple boreholes and initial fractures will investigate the influence of the aforementioned parameters.

A 3D peridynamic model of rock cutting with TBM disc cutters

Sahir Butt (Ruhr University Bochum), Günther Meschke (Ruhr University Bochum)

This study presents computational simulation of rock cutting process using disc cutters, a typical process involved in mechanized rock excavation works. Peridynamics, a nonlocal continuum formulation, is used to model the LCM (linear cutting machine) test of rock cutting with a single TBM (tunnel boring machine) disc cutter. The presented numerical model enables the investigation of different cutting forces as well as of the stress and pressure distribution during the tool-rock interaction.

MS04-1: Computational Analysis and Modeling of Experimental Dynamic Loading Tests

Numerical fracture studies of ultra-high performance concrete under dynamic loading

Mohammad Reza Khosravani (University of Siegen), Carola Bilgen (University of Siegen), Kerstin Weinberg (University of Siegen)

Ultra-high performance concrete (UHPC) is a new class of concrete material. In this contribution, split Hopkinson pressure bar (SHPB) is modified and utilized to conduct series of spalling tests. Dynamic elastic modulus and dynamic tensile strength of the studied UHPC sepcimens are determined. Furthermore, the spalling test is numerically simulated by MATLAB program. Within this context two numerical fracture methods are compared with respect to determination of main parameter like the tensile strength and the specific fracture energy. In order to determine the latter one an inverse analysis is applied. The achieved results showed good agreement between numerical simulations and experimental observations.

Modelling of the Mars® 300 armour steel under impact loadings

Teresa Fras (French-German Research Institute of Saint-Louis (ISL)), Faderl Norbert (French-German Research Institute of Saint-Louis (ISL)), Lach Erhardt (French-German Research Institute of Saint-Louis (ISL))

Material and protective properties of the Mars® 300 steel are analyzed to understand the steel behavior under impact loadings. To validate the flow and fracture model (the Hosford-Coulomb model), a numerical simulation of the impact configuration is performed in which the striker and target are made of the Mars® 300 steel. As targets, plates perforated by an array of holes applied as passive add-on armors in combat vehicles - are considered.

Numerical and experimental ricochet investigation of a spin-stabilised projectile

Marina Seidl (French-German Research Institute of Saint-Louis (ISL)), Thomas Wolf (French-German Research Institute of Saint-Louis (ISL)), Rainer Nuesing (French-German Research Institute of Saint-Louis (ISL))

Numerical simulations in LS-DYNA are used for a qualitative investigation, as measurement precision limits the determination of projectile nutation under oblique impact. The parabolic flight trajectory causes nutation in spin-stabilised projectiles. They rotate at an angle contained between the inertial axis and the relative velocity vector. Especially at the critical angle, where the projectile no longer penetrates but ricochets, influential parameters need to be determined.

Application of the Phase-field Method for Crack Approximation on a Split-Hopkinson-Pressure-Bar Experiment

Christian Steinke (Technische Universität Dresden), Michael Kaliske (Technische Universität Dresden)

The numerical simulation of fracture in brittle material remains a challenging task, both with respect to the suitable approximation technique as well as to the appropriate calibration experiment. The phase-field method – a promising approach under ongoing development – is applied to the simulation of the complex behavior of a concrete specimen in a split-Hopkinson-pressure bar experiment focusing on the capabilities of the method to obtain realistic crack initiation, evolution and arrest.

MS17-2: Smart and Active Materials: Experiments, Modelling, and Simulation

A variational and computational framework for large strain electromechanics based on convex multi-variable energies (Keynote)

Rogelio Ortigosa (Swansea University), Antonio J. Gil (Swansea University)

This paper presents a variational and computational framework for nonlinear electromechanics based on a new convex multi-variable definition of the internal energy. This ensures: a) the material stability of the governing equations (ellipticity) and b) allows to introduce new multi-field variational principles which open up interesting possibilities in terms of using various interpolation spaces for the different fields, leading to enhanced type formulations.

Constitutive modeling of eletroelasticity based on the analytical network averaging concept

Vu Ngoc Khiêm (RWTH Aachen University), Mikhail Itskov (RWTH Aachen University)

In this contribution, we develop a physically-based constitutive model capturing electro-elasticity in electrostrictive elastomers based on an extension of the analytical network-averaging concept. The proposed model includes a few physically motivated material constants and demonstrates good agreement with experimental data of dielectric elastomers.

An optimal solid-shell finite element for modeling dielectric elastomers

Dana Bishara (Technion – Israel Institute of Technology), Mahmood Jabareen (Technion – Israel Institute of Technology)

Dielectric elastomer (DE) based actuators are considered an emerging promising class of thin actuators, which may undergo large deformations and exhibit various modes of activation. For modeling DEs there is a need for a proper finite element technology for the numerical simulations, which captures their realistic response. A model that is calibrated to VHB will be presented, and an efficient low-order finite element that is able to tackle locking pathologies will be introduced.

MS18-2: Virtual Analysis and Design of New Materials

Experimental methods to validate modeling of fiber reinforced materials (Keynote)

Markus Sause (University of Augsburg)

This contribution provides insight to some methods that provide an experimental data basis for modeling of material constituents on microscopic scale and their interaction. This covers the use of versatile full-field methods to improve the cross-validation, to obtain fiber dispersion, topology and orientation, the use of micromechanical techniques and application of in-situ methods to analyze damage progression as function of external load.

Influence of the tape number on the optimized structural performance of locally reinforced composite structures

Benedikt Fengler (Karlsruhe Institute of Technology (KIT)), Luise Kärger (Karlsruhe Institute of Technology (KIT)), Andrew Hrymak (University of Western Ontario)

For lightweight applications, a combination of discontinuous and continuous fiber reinforced polymers is aspired, where position, geometry and orientation of the reinforcing continuous fiber tape needs to be optimized. Therefore, the proposed approach combines an evolutionary algorithm with a structural simulation in the FE software Abaqus. With this method, the influence of different tape numbers on the optimized tape design as well as on the final structural performance is demonstrated.

Virtual tests based on model reduction strategies for fatigue analysis

Mainak Bhattacharyya (Leibniz Universität Hannover), Amelie Fau (Leibniz Universität Hannover), Udo Nackenhorst (Leibniz Universität Hannover), David Néron (Ecole Normale Supérieure Paris-Saclay, Université Paris-Saclay), Pierre Ladevèze (Ecole Normale Supérieure Paris-Saclay, Université Paris-Saclay)

Virtual tests for fatigue considering a large number of cycles in perspective of continuum damage mechanics are generally avoided due to numerical expense. To tackle this problem, a Proper Generalised Decomposition model reduction technique in time and space, and a multi-time scale approach are proposed. These innovations used in a non-incremental LATIN framework, reduce the computational cost drastically and can be contemplated to perform virtual analysis of high-cycle fatigue tests.

Experimental and Numerical Analysis of Deep Drawing and Failure Characteristics for Sheet Metal/Polymer Hybrid Structure

Henrik Schulze (Leibniz Universität Hannover), B.-A. Behrens (Leibniz Universität Hannover), A. Bouguecha (Leibniz Universität Hannover), Christian Bonk (Leibniz Universität Hannover)

Lightweight component design is an everlasting matter in the automotive as well as the aviation industry. To face the challenges concerning lightweight like damping effects or increasing the load-bearing capacity, one approach is the development of new hybrid materials. For these layered structures an extensive material characterization including failure analysis with regard to the influence on the deep drawing process is carried out and the results are used as input for the numerical modelling.

CS02: Fluid Mechanics

Boundary-Conforming Space-Time Finite Elements for Co-Rotating Intermeshing Domains

Jan Helmig (RWTH Aachen University), Marek Behr (RWTH Aachen University), Stefanie Elgeti (RWTH Aachen University)

Using boundary-conforming methods for co-rotating intermeshing domains is a complex task because the mesh has to be updated in every time step. Traditional methods like the elastic mesh update method require constant re-meshing due to mesh failure. We present a new, efficient approach, the Snapping Reference Mesh Update Method (SRMUM). It is based on a background mesh that constantly adapts to the current geometry. We apply the method to flow computations of plastic melt in twin-screw extruders.

Simulation of Oil Jets for Piston Cooling Applications Using Mesh Deformation and the Level Set Method

Loïc Wendling (RWTH Aachen University), Karyofyli Violeta (RWTH Aachen University), Markus Frings (RWTH Aachen University), Anselm Hopf (Ford Motor Company), Elgeti Stefanie (RWTH Aachen University), Marek Behr (RWTH Aachen University)

The level set method is used to understand and design oil jets used to cool pistons of internal combustion engines. Different jet configurations ranging from laminar to atomized are presented and compared with experimental results. Exploiting the flexibility of the space-time finite element method, the reciprocating movement of the piston is modeled by using mesh deformation. The resulting multi-physics simulation realistically represents the main flow features.

Numerical two-phase simulations of the propagation of an evaporating extinguishing agent for optimal fire suppression

Waldemar Stapel (Helmut Schmidt University Hamburg), Michael Breuer (Helmut Schmidt University Hamburg)

Fire suppression systems operate with extinguishing agents released from a reservoir and atomized into droplets. Flow predictions are separated into the release process and the propagation of the extinguishing agent. For the latter an Euler-Lagrange approach is used to model the two-phase flow. Data of the first simulation are used for the droplet initialization. The transformation of parcels into the gaseous state is treated by a evaporation model. The propagation of the agent is investigated.

Computational modeling of fiber flow during casting of fresh concrete

Vladislav Gudzulic (Ruhr University Bochum), Thai Son Dang (Ruhr University Bochum), Günther Meschke (Ruhr University Bochum)

The Folgar-Tucker fiber orientation model coupled with weakly compressible Smoothed Particle Hydrodynamics is used to predict the spatial-temporal evolution of the probability density function of fiber orientation during process of casting of fiber reinforced concrete. The flow-able concrete-fiber mix is modeled as a viscous Bingham-type fluid. The model predictions qualitatively agree with fiber orientations observed in an L-box test with fibers suspended in transparent gel.

Anisotropic surface and bulk stresses in transition metal oxide nanoparticles and their impact on diffusion

Peter Stein (Technical University of Darmstadt), Ashkan Moradabadi (FU Berlin), Manuel Diehm (Technical University of Darmstadt), Bai-Xiang Xu (Technical University of Darmstadt), Karsten Albe (Technical University of Darmstadt)

We analyze the impact of surface stress on the strain distributions within a $LiCoO_2$ nanoparticle. Based on Ref. [1], we incorporate anisotropic surface stress into linear-elastic continuum models. Parameters are determined through ab-initio simulations. We compute the impact of the elastic fields on the formation and migration barriers of Li vacancies and discuss the intercalation behavior of nanostructured $LiCoO_2$.

[1] D. Gross et al., Int. J. Mater. Res. 102(6):743-747 (2011)

MS11-1: Modeling, Simulation, Control and Optimization of Multi-physical Phenomena

Error estimation approach for controlling the macro step-size for explicit co-simulation methods

Tobias Meyer (Technical University of Darmstadt), Jan Kraft (Technical University of Darmstadt), Pu Li (Technical University of Darmstadt), Daixing Lu (Technical University of Darmstadt), Bernhard Schweizer (Technical University of Darmstadt)

An approach for controlling the macro-step size in connection with explicit co-simulation methods is suggested. The method is tailored for applied-force coupling techniques. Each macro-time step is carried out with two different explicit co-simulation methods. By comparing the variables of both results, an error estimator for the local error can be constructed. A step-size controller for the macro step-size can be implemented. Examples are presented demonstrating the applicability and accuracy.

Quasi-Newton methods for unstable partitioned fluid-structure interactions

Nadja Wirth (Fraunhofer Institute for Algorithms and Scientific Computing SCAI), Bettina Landvogt (scapos AG)

The co-simulation software MpCCI offers various coupling algorithms for transient multiphysical applications. For fluid-structure interactions, where the density ratio between fluid and structure is almost 1, instabilities can occur. The presented Quasi-Newton relaxation considers the coupling as a fix point problem, which is solved by the Newton method using approximations of the Jacobian. It stabilizes the co-simulation and reduces the number of iterative coupling steps per time increment.

Design of a Nonlinear Observer for a Very Flexible Parallel Robot

Fatemeh Ansarieshlaghi (University of Stuttgart), Peter Eberhard (University of Stuttgart)

A flexible robot in lambda configuration has been modeled and built in hardware. Since there is no direct feedback of the end-effector, a nonlinear observer to estimate the position of the end-effector is designed and implemented. The nonlinear observer results show that the end-effector position can be estimated with high accuracy. Also, using results from the nonlinear observer, the model of the robot is improved so that the maximum end-effector absolute tracking error is drastically decreased.

Shape optimization of wind turbine blades in a fluid structure interaction simulation

Shahrokh Shayegan (Technical University of Munich), Reza Najian Asl (Technical University of Munich), Roland Wüchner (Technical University of Munich), Kai-Uwe Bletzinger (Technical University of Munich)

This contribution presents the shape optimization of wind turbine blades in the context of a fluid-structure interaction simulation.Vertex Morphing method,which is a node-based shape control technique, is used to find optimal design of the blades.Gradient-based optimization together with continuous adjoint based shape sensitivity analysis is employed to handle the large number of design variables.The fluid-structure interaction problem is solved using a partitioned, strong coupling algorithm.

Co-simulation in the vehicle development process

Stefan Steidel (Fraunhofer Institute for Industrial Mathematics ITWM), Michael Burger (Fraunhofer Institute for Industrial Mathematics ITWM)

Modern vehicles are highly complex systems consisting of many subsystems in various physical domains that dynamically interact. In this context, co-simulation strategies are particularly attractive as each subsystem is solved via tailored simulation tools with appropriate numerical methods. Industrial applications induce enormous numerical challenges regarding efficiency, accuracy and stability. We present co-simulation strategies by means of selected application examples in vehicle engineering.

Computational challenges and uncertainty in simulation of electrical arcs

Henrik Nordborg (HSR Hochschule für Technik), Mario Mürmann (HSR Hochschule für Technik), Roman Fuchs (HSR Hochschule für Technik)

Simulation of electrical arcs is a numerically challenging problem, requiring the coupling of a number of different physical systems: compressible flow, electromagnetism, and radiation. The challenge is to find an efficient and scalable algorithm incorporating all these effects. In addition, the large number of physical processes makes it difficult to handle the uncertainty of the simulations. Progress in this field requires simulations and validation experiments to work hand in hand.

MS05-2: Computational Contact Mechanics

Adaptive finite elements for contact problems based on efficient and reliable residual-type a posteriori estimators

Mirjam Walloth (Technical University of Darmstadt)

The talk deals with the adaptive numerical simulation of contact problems based on residual-type a posteriori estimators. The estimators are easy to compute and provably reliable, efficient and localized. The latter properties enable a good resolution of the free boundary while avoiding over-refinement in the active set of contact. We consider continuous as well as discontinuous finite elements for the numerical simulation of static and time-dependent contact problems.

A posteriori error estimates for finite elements of higher-order for frictional, elasto-plastic two-body contact problem

Andreas Rademacher (TU Dortmund University), Hannah Frohne (TU Dortmund University)

We present a residual a posteriori error estimator for frictional, elasto-plastic two-body contact problems and finite elements of higher order. It is based on a mixed formulation in which the constraints concerning contact, friction and plasticity are captured by Lagrange multipliers. To be able to apply a semi-smooth Newton method we solve a primal-mixed problem and calculate the plastic quantities in a post process. Reliability and suboptimal efficiency of the estimator are shown.

Time-adaptive non-linear finite-element analysis of contact problems

Matthias Grafenhorst (Clausthal University of Technology), Stefan Hartmann (Clausthal University of Technology)

In recent years, mortar finite element methods have been successfully applied as space discretization scheme to a wide range of contact problems. The finite deformation contact formulation taken up is based on a mortar approach using dual Lagrange multipliers. If the constitutive models are of rate-type, the entire system of equations represents a non-smooth DAE-system. This system will be investigated in connection with higher-order time integration methods using DIRK-methods.

BFGS quasi-Newton finite element solver for the penalty constrained contact problems

Dusan Gabriel (Institute of Thermomechanics, Czech Academy of Sciences), Ján Kopačka (Institute of Thermomechanics, Czech Academy of Sciences), Petr Parik (Institute of Thermomechanics, Czech Academy of Sciences), Jan Masak (Institute of Thermomechanics, Czech Academy of Sciences), Jiří Plešek (Institute of Thermomechanics, Czech Academy of Sciences)

A solution scheme for the penalty constrained contact problems is presented. The algorithm employes popular quasi-Newton solver for FE applications-the BFGS (Broyden-Fletcher-Goldfarb-Shanno) method with contact constraints enforced by the penalty method. The effectiveness of proposed solution strategy is tested by means of benchmark examples including bending dominated problems. Finally, the capability of contact solver is demonstrated in creep analysis of high pressure steam turbine casing.

Singular mass matrices for isogeometric finite element analysis of dynamic contact

Anton Tkachuk (University of Stuttgart), Martina Matzen (Bornscheuer Drexler Eisele GmbH), Radek Kolman (Institute of Thermomechanics, Czech Academy of Sciences), Manfred Bischoff (University of Stuttgart)

Usage of standard mass matrices together with implicit time integration leads to temporal oscillations of contact forces and losses/gains of energy at each contact event. Redistribution of the mass from nodes that are potentially coming into contact and removing the term corresponding to contact forces from the predictor of the Newmark method alleviates both problems. In this contribution a mass redistribution for solid isogeometric FE's is presented and results of numerical tests are discussed.

A robust explicit finite element algorithm with bi-penalty stabilization for contact-impact problems

Radek Kolman (Institute of Thermomechanics, Czech Academy of Sciences), Ján Kopačka (Institute of Thermomechanics, Czech Academy of Sciences), Anton Tkachuk (University of Stuttgart), Dusan Gabriel (Institute of Thermomechanics, Czech Academy of Sciences), José González (Universidad de Sevilla), Manfred Bischoff (University of Stuttgart)

We present an explicit time integration scheme for finite element solution of contact-impact problems with stabilization of contact forces using a bi-penalty formulation. The stability limit for an un-penalized system is preserved by a special choice of mass and stiffness penalty parameter ratio. Moreover, the time stepping process produces stable results for a large range of the stiffness penalty parameter. Behavior of the method is shown on impact problems of heterogeneous bars.

MS10-1: Mechanics of Dissipative Solids: Plasticity, Fracture and Damage

Modeling fatigue phenomena with a variational phase-field approach (Keynote)

Roberto Alessi (Sapienza University of Rome), Marreddy Ambati (Technical University of Braunschweig), Laura De Lorenzis (Technical University of Braunschweig), Stefano Vidoli (Sapienza University of Rome)

Fatigue is a key phenomenon in mechanics and is responsible for most of structural failures. Nevertheless, the development of reliable mathematical fatigue models is still an open issue. In this work we present, step-by-step, a new variational phase-field model able to account for fatigue effects. As a strain history variable increases, on which the model relies on, the material fracture toughness is reduced, such to favour cracks where the highest strain variations have occurred.

Phase field modelling of thermo-mechanically driven fracture processes in electronic control units

Fabian Welschinger (Robert Bosch GmbH)

Phase field models for fracture allow shaping the reliability of engineering components in the early stage of the product development process. Epoxy-based molding compounds protect electronic control units from harsh environments. Once this protection fractures, the electronic system fails. Based on a fracture mechanical characterization of the mold material in the full temperature range, computations are performed demonstrating the predictive quality of the phase field model of fracture.

A phase field model for porous plastic solids at ductile fracture

Daniel Kienle (University of Stuttgart), Fadi Aldakheel (Leibniz Universität Hannover), Stephan Teichtmeister (University of Stuttgart), Christian Miehe (University of Stuttgart)

This work outlines a variational framework for the phase field modeling of fracture in porous plastic solids. The phase field regularizes sharp crack surfaces by a specific gradient damage formulation. A model for porous plasticity with a growth law for the evolution of the void fraction is developed and linked to a failure criterion in terms of the elastic-plastic work density. It is shown that this approach is able to model basic phenomena of ductile failure such as cup-cone failure surfaces.

MS12-1: Multidisciplinary and Structural Design Optimization

Industrial Design Optimization: From Research to Industry Application (Keynote)

Markus Schatz (Airbus DS GmbH)

Time effective product development is crucial to success. To obtain viable compromises in aerospace applications, several arrangements with different disciplines have to be made. Those determine the frequency of numerical studies, wherefore time is essential. Starting from a research perspective, general design optimization will be presented. Thereafter, multiple industrial examples will be given, where invested effort returns in performance, robustness and fewer arrangements.

Regenerating CAD Models with OpenCASCADE and pythonOCC from Numerical Models with Application to Shape Optimization

Altug Emiroglu (Technical University of Munich), Andreas Apostolatos (Technical University of Munich), Roland Wüchner (Technical University of Munich), Kai-Uwe Bletzinger (Technical University of Munich)

Sensitivity filtering methods are unavoidable when numerical shape optimization is considered. A mortar based sensitivity filtering method which incorporates underlying CAD parametrization of the numerical models is proposed. The method is combined with a software environment which utilizes the capabilities of the opensource library OpenCASCADE and pythonOCC module respectively for the regeneration of the CAD models directly from the optimized numerical models as a result of the procedure.

Variational sensitivity analysis in the scope of multiscale problems

Wojciech Kijanski (TU Dortmund University), Franz-Joseph Barthold (TU Dortmund University)

The combination of methods for shape optimisation with different established approaches for analysis and simulation of complex heterogeneous materials on multiple scales based on numerical homogenisation techniques opens a remarkable range of applications introducing design variables, objective functions and constraints on different scales. To design micro-structures, the essential steps for sensitivity analysis on multiple scales will be outlined and accentuated by illustrative examples.

Kriging-guided Level Set Method for Crash Topology Optimization

Elena Raponi (University of Camerino), Mariusz Bujny (Technical University of Munich), Markus Olhofer (Honda Research Institute Europe GmbH), Nikola Aulig (Honda Research Institute Europe GmbH), Simonetta Boria (University of Camerino), Fabian Duddeck (Technical University of Munich)

Crashworthiness optimization problems are characterized by strong nonlinearities and discontinuities. Hence, gradient-based methods cannot be used and alternative approaches have to be considered. Here, a novel, kriging-based method for level set topology optimization is proposed and validated on a crash test case. Compared to CMA-ES, this method demonstrates to be efficient in terms of convergence speed and promising in the context of crash topology optimization.

MS17-3: Smart and Active Materials: Experiments, Modelling, and Simulation

A Novel Parameter Identification Toolbox for the Selection of Hyperelastic Constitutive Models from Experimental Data

Hüsnü Dal (Middle East Technical University), Yashar Badienia (Middle East Technical University), Kemal Açıkgöz (Middle East Technical University), Funda Aksu Denli (Middle East Technical University)

This paper presents a novel parameter identification toolbox based on various multi-objective optimization strategies for the selection of the best constitutive models from a given set of homogeneous experiments. The toolbox aims at providing an objective model selection procedure along with the material parameters for the rubber compound at hand. To this end, we utilize the multi-objective optimization using genetic algorithm of MATLAB. For the validation purposes, we use 24 constitutive laws.

Modelling electro-active polymers with a dispersion-type anisotropy

Mokarram Hossain (Swansea University)

In this paper, we propose a novel constitutive framework for electro-active polymers (EAPs) that can take into account anisotropy with a chain dispersion.To demonstrate the performance of the proposed electro-mechanically coupled framework, we analytically solve a widely-used non-homogeneous boundary value problem. The results capture various electro-mechanical couplings with the formulation proposed for EAP composites.

Micro- and Macrostructural magneto-electric coupling in soft composites

Matthias Rambausek (University of Stuttgart), Marc-André Keip (University of Stuttgart)

It was only recently that strong magneto-electric coupling effects in soft-matter-based composites have been described for the first time by Liu and Sharma (2013; Phys. Rev. E 88, 040601). This approach for the realization of magneto-electrical coupling has the potential to outperform existing solutions based ceramic materials. In this contribution we will investigate magneto-electric transducers based on a soft magneto-electric composite with multiscale simulations.

Reduced-Order Modelling applied to Computational Homogenisation in Magneto-Mechanics

Benjamin Brands (Friedrich-Alexander University of Erlangen-Nürnberg), Julia Mergheim (Friedrich-Alexander University of Erlangen-Nürnberg), Paul Steinmann (Friedrich-Alexander University of Erlangen-Nürnberg)

Due to their microstructure the mechanical response of magnetorheological composites is highly affected by applied magnetic fields. The commonly known FE^2 approach is computationally too expensive and therefore the FE problems on the microscale are replaced by reduced-order models. We will present our approach for the construction and computation of these reduced-order models. Through various numerical examples the accuracy and time savings of the reduced models will be discussed.

MS18-3: Virtual Analysis and Design of New Materials

Modeling three-dimensional anisotropic damage in organic sheet composites at large deformation

Dominik Naake (Robert Bosch GmbH), Fabian Welschinger (Robert Bosch GmbH), Luise Kärger (Karlsruhe Institute of Technology (KIT)), Frank Henning (Karlsruhe Institute of Technology (KIT))

Organic sheets consist of embedded interwoven rovings in a thermoplastic matrix. Loading results in a finite change of local reinforcement orientations with reversible and irreversible contributions. A constitutive model taking into account the large strain kinematics and damage evolution is presented. Mechanism-based damage formulations in both the reinforcements and the matrix are employed. Numerical examples demonstrate the features of the suggested material model.

Micromechanical Study of Fiber Kinking and Debonding in Fiber Reinforced Composites

Samira Hosseini (Leibniz Universität Hannover), Stefan Löhnert (Leibniz Universität Hannover)

The objective of this work is to study the fiber kinking and subsequent fiber/matrix debonding in FRP composites under unidirectional compressive loading. In the micro-scale, geometrically nonlinear cohesive elements are used in order to model the shear failure of the matrix material at its interface with the fibers which results in initiation and evolution of local splitting between fiber and matrix and drives the rotation of fibers up to kink band formation.

A Non-Intrusive Global-Local Approach with Application to Phase-Field Modeling of Brittle Fracture

Nima Noii (Technical University of Braunschweig), Tymofiy Gerasimov (Technical University of Braunschweig), Laura De Lorenzis (Technical University of Braunschweig), Olivier Allix (ENS Paris-Saclay)

The variational multiscale (VMS) method by Hughes et al. is a well-established framework for the analysis of nonlinear heterogeneous materials and is capable of tackling strain localization in the multiscale framework. In this contribution, we propose a non-intrusive setting of the VMS approach to be applied to the phase-field formulation of fracture. The proposed two-scale procedure yields results comparable to the single-scale solution, yet they are obtained with much superior efficiency.

Two-scale anisotropic damage modeling of SMC

Johannes Görthofer (Karlsruhe Institute of Technology (KIT)), Malte Schemmann (Karlsruhe Institute of Technology (KIT)), Thomas Böhlke (Karlsruhe Institute of Technology (KIT))

We present a two-scale anisotropic damage model that captures matrix damage and fiber-matrix interface debonding. Based on the fiber orientation distribution and a Weibull probability distribution of the interface strength, the damage evolution on the microscale is determined. Within this work focus lies on the comparison of different matrix damage evolution models. To predict the macroscopic behavior, a mean field homogenization with the Mori-Tanaka method based on orientation tensors of second and fourth order is applied.

Combined Macro- and Micro-Mechanical Analysis of Instable Crack Propagation in Interlaminar Fracture Toughness Tests

Michael Schober (Karlsruhe Institute of Technology (KIT)), Jörg Hohe (Fraunhofer Institute for Mechanics of Materials IWM), Takashi Kuboki (University of Western Ontario)

Fracture toughness experiments with fiber reinforced polymers often show instable growths of the observed cracks. Such discontinuities can occur as a result of the test specimen's microstructure. A combined macromechanical micromechanical simulation approach shall help understanding the occurrence of discontinuities with respect to the specimen's microstructure. Therefore, the fracture toughness test specimen's microstructure is analyzed and modeled for finite element analyses.

Friday, 13 October 2017

CS07: Crystal Mechanics

Geometrically nonlinear single crystal viscoplasticity implemented into a hybrid discontinuous Galerkin framework

Atefeh Alipour (RWTH Aachen University), Stephan Wulfinghoff (RWTH Aachen University), Bob Svendsen (RWTH Aachen University), Stefanie Reese (RWTH Aachen University)

The implementation of geometrically nonlinear crystal plasticity into a hybrid discontinuous Galerkin (DG) framework is presented using a regularization technique for very high strain rate sensitivity exponents. This combination leads to a numerically efficient and locking-free model. The performance of the regularized hybrid DG crystal plasticity is examined on a planar single crystal.

Multiscale FE-FFT-based thermo-mechanically coupled modeling of viscoplastic polycrystalline materials

Sebastian Felder (RWTH Aachen University), Julian Kochmann (RWTH Aachen University), Stephan Wulfinghoff (RWTH Aachen University), Stefanie Reese (RWTH Aachen University)

A two-scale, finite element (FE) and fast Fourier transform (FFT) based thermo-mechanically coupled material model formulation is proposed. The method is developed for the prediction of the structural material behavior and the corresponding local fields of viscoplastic polycrystalline materials. It allows for a qualitative investigation of the microscopic interplay between stress and temperature induced martensitic phase transformation and plasticity.

Defect density-based modelling of work hardening and recovery in fully lamellar TiAl alloys

Jan Eike Schnabel (Helmholtz-Zentrum Geesthacht), Swantje Bargmann (University of Wuppertal)

The dense arrangement of different microstructural interfaces in fully lamellar TiAl alloys necessitates microstructure informed modelling in order to predict the macroscopic mechanical behavior. Microtwinning within the lamellae leads to further interface related strengthening. The presented crystal plasticity model incorporates the evolution of dislocation density and afore mentioned twins during plastic deformation and accounts for thermally activated recovery of said defects.

Molecular dynamic study on the tensile deformation of an aluminium nano single- and polycrystal

Philipp Höfer (Bauhaus-University Weimar), Carsten Könke (Bauhaus-University Weimar)

In our work, we focused on the understanding of the tensile deformation behaviour of a aluminium single- and polycrystal by using molecular dynamics simulations. We considered a fully 3D atomistic model with the embedded-atom method potential for aluminium. A symmetric tilt low energy grain boundary structure was generated and used as an initiation of fracture. Finally, we performed tensile tests investigated the results.

CS03: Multiphysics

Numerical Analysis of Virtualized Heart Models

Baris Cansiz (Technische Universität Dresden), Michael Kaliske (Technische Universität Dresden), Krunoslav Sveric (Technische Universität Dresden), Karim Ibrahim (Technische Universität Dresden), Ruth Strasser (Technische Universität Dresden)

Our novel numerical tools simulating cardiac electromechanics will be introduced. The performance and applicability of the framework will be demonstrated through finite element simulations based on real heart geometries. We will compute left ventricular volume-time curves, pressure-volume curves and electrocardiograms. The results will be compared to real clinical data by means of LV motion. The importance of boundary conditions on LV motion will be discussed.

Simulation of the Change in Mechanical Properties of Degradable Bone Implants

Ann-Kathrin Krüger (Leibniz Universität Hannover), Stefan Julmi (Leibniz Universität Hannover), Christian Klose (Leibniz Universität Hannover), Silke Besdo (Leibniz Universität Hannover), Peter Wriggers (Leibniz Universität Hannover)

To develop and scale degradable bone implants, it is necessary to know the change in mechanical properties of the implant during the degradation process. In this study magnesium sponge structures are being investigated. It is assumed that the magnesium degradation is governed by diffusion of magnesium ions from the surface. To simulate the degradation a numerical model including the diffusion equation was developed. The model was implemented in the commercial finite element code Abaqus/Standard.

Computation of multiphysics processes in deformable media

Bilen Emek Abali (Technische Universität Berlin)

Micro electro-mechanical systems (MEMS) exploit the coupling between mechanics and electromagnetism. For an accurate simulation of this coupling we need a strategy to calculate deformation, temperature, and electromagnetic fields in solids, at once. By using open-source packages, we present an approach to simulate MEMS by solving nonlinear and coupled equations at once by using finite difference method in time and finite element method in space.

Experimental and Numerical Studies of Thermoelastic Damping

Christin Zacharias (Bauhaus-University Weimar), Carsten Könke (Bauhaus-University Weimar)

The use of correct damping parameters is a decisive aspect in the numerical simulation of dynamical problems and indispensable to predict and reduce reliably vibration amplitudes. In this contribution, experimental and numerical studies to identify damping coefficients of simple geometries are presented. In the experiments the focus was set to measure the pure material damping excluding all disturbing environmental influences. In the numerical investigation, the thermoelastic approach was used.

Leakage currents in nanogenerator concepts in phase field simulations

Franziska Wöhler (Karlsruhe Institute of Technology (KIT)), Ingo Münch (Karlsruhe Institute of Technology (KIT)), Werner Wagner (Karlsruhe Institute of Technology (KIT))

Efficient technologies for energy harvesting are in the focus of recent research. Our nanogenerator transforms parasitic mechanical oscillations into usable electric energy. If an electric field exists between electrodes, leakage currents appear if the ferroelectric ceramic is semiconducting. We focus on different formulations of leakage currents for semiconducting ceramics, usually given as scalar equations. We enhance our phase field model to account for these effects in space.

Optimal control of a slot car racer

Johann Penner (Friedrich-Alexander University of Erlangen-Nürnberg), Tristan Schlögl (Friedrich-Alexander University of Erlangen-Nürnberg), Sigrid Leyendecker (Friedrich-Alexander University of Erlangen-Nürnberg)

Within this work, we compute and apply control strategies for the time-minimal path of a slot car racer. Here, the DMOC (Discrete Mechanics and Optimal Control) method is used to generate offline optimal trajectories for the electro-mechanically coupled system, i.e. sequences of discrete configurations and driving voltages. These sequences are embedded to a control architecture with an underling camera tracking system which allows to correct the vehicle towards the desired state via computer.

MS05-3: Computational Contact Mechanics

Contact, Fluid Structure Interaction and Variational Transfer

Patrick Zulian (Università della Svizzera Italiana), Maria Nestola (Università della Svizzera Italiana), Cyrill von Planta (Università della Svizzera Italiana), Rolf Krause (Università della Svizzera Italiana)

We present a new and completely parallel approach for fluid-structure interaction, which includes also contact between the elastic structures. Our approach is inspired by the fictitious domain method and makes intensive use of variational transfer between the solid and the fluid and on the possibly contacting surfaces between solids. We present the discretization, the setup of the variational transfer, and efficient methods for the solution of the arising non-linear problems. We present 2D and 3D benchmarks, and a tricuspid heart valve.

Simulation of fibers in woven composites: a comparison between solid and beam models

Mathias Haverstreng (Leibniz Universität Hannover), Stephanie Andress (Leibniz Universität Hannover), Ajay Bangalore Harish (Leibniz Universität Hannover), Alfredo Gay Neto (University of São Paulo), Peter Wriggers (Leibniz Universität Hannover)

Woven composites find numerous applications in engineering products. Their micromechanical behavior involves complex contact behavior between fibers/matrix, debonding etc and thus warrant micromechanical investigations. Such materials can be geometrically described using computationally intensive solids or reduced structural models like beams/shells etc. This work provides an objective comparison between the two approaches in order to compare pros/cons of each modeling hierarchy.

Mortar-based contact formulations for non-smooth geometries

Alexander Popp (Technical University of Munich), Philipp Farah (Technical University of Munich), Wolfgang A. Wall (Technical University of Munich)

Finite deformation frictional contact is revisited with a special emphasis on non-smooth geometries such as corners and edges. Contact conditions are enforced separately for point-, line- and surface-contact by employing three different sets of Lagrange multipliers and a variationally consistent discretization approach based on mortar FE methods. In particular, no unphysical transition parameters are required, but all contact decisions are taken implicitly by the underlying solution scheme.

Numerical model for contact with adhesion based on Kalker's variational principle.

Mykola Tkachuk (National Technical University, Kharkiv Polytechnical Institute)

Kalker variational principle allows to solve consistently unilateral contact problems in terms of the normal traction as the prime unknown variable. It is particularly useful for the development of boundary elements for Boussinesq problem in half-space approximation. This principle is extended to account for adhesion between solids. The contact pressure may take negative values governed by an adhesive work potential and surface separation energy. The latter is evaluated via level-set.

A symmetry preserving contact treatment in isogeometric analysis

Ján Kopačka (Institute of Thermomechanics, Czech Academy of Sciences), Dusan Gabriel (Institute of Thermomechanics, Czech Academy of Sciences), Radek Kolman (Institute of Thermomechanics, Czech Academy of Sciences), Jiří Plešek (Institute of Thermomechanics, Czech Academy of Sciences)

In this contribution an isogeometric contact treatment by the penalty method is presented. The symmetry preserving formulation, also known as the two-half-pass formulation, is utilized together with the Gauss-point-to-segment discretization. A particular attention is payed to the contact detection, i. e. to the closest point projection of a point onto a NURBS patch. The problem of contact pressure post-processing is also presented in more detail.

MS10-2: Mechanics of Dissipative Solids: Plasticity, Fracture and Damage

Extension of isogeometric Kirchhoff-Love shell formulations towards fracture and plasticity problems

Marreddy Ambati (Technical University of Braunschweig), Josef Kiendl (Norwegian University of Science and Technology), Laura De Lorenzis (Technical University of Braunschweig)

Firstly, the isogeometric Kirchhoff-Love (KL) shell model is combined with phase-field fracture description. Secondly, the KL shell formulation is applied to elasto-plastic models at large deformations. Thirdly, this elasto-plastic KL shell formulation is coupled with phase-field ductile fracture model. A careful investigation on various numerical and benchmark examples and detailed comparisons with 3D solid simulations and with solutions from the literature are carried out.

A phase field model for materials with anisotropic fracture resistance

Christoph Schreiber (University of Kaiserslautern), Charlotte Kuhn (University of Kaiserslautern), Ralf Müller (University of Kaiserslautern)

Directional dependency of the fracture resistance, which is observed for a wide range of materials, requires the integration of anisotropic behavior in approaches for crack growth simulations. The gradient term in the energy functional of a phase field model for isotropic brittle fracture is enhanced accounting for an anisotropic material resistance. Results of crack path simulations for different samples are presented to show the accuracy of the proposed model.

Affine Full Network Model for Strain-Induced Crystallization in Rubbery Polymers

Aref Nateghi (University of Stuttgart), Hüsnü Dal (Middle East Technical University), Marc-André Keip (University of Stuttgart), Christian Miehe (University of Stuttgart)

We propose a micro-mechanically motivated material model for strain-induced crystallization in rubbers. Our point of departure is constructing a micro-mechanical model for a single crystallizing polymer chain. A thermodynamically consistent evolution law describing the kinetics of crystallization in the chain level is then proposed. The chain model is incorporated into the affine full network model. Finally, the numerical performance of the model is compared to the experimental data.

On Degradation Functions and Solution Schemes for a Phase Field Model of Elastic-Plastic Fracture

Timo Noll (University of Kaiserslautern), Charlotte Kuhn (University of Kaiserslautern), Ralf Müller (University of Kaiserslautern)

A phase field model for elastic-plastic fracture is presented, which is based on an energy functional composed of an elastic energy contribution, a plastic dissipation potential and an fracture energy. The coupling of the mechanical fields with the fracture field is modeled by a degradation function. Numerical simulations are presented, where the choice of the degradation function is investigated and a staggered solution scheme is compared to an also possible monolithic iteration scheme.

Phase Field Model for Interface Failure

Arne Claus Hansen-Dörr (Technische Universität Dresden), Paul Hennig (Technische Universität Dresden), Markus Kästner (Technische Universität Dresden)

A phase field model for interface failure between two materials is proposed where the interface is incorporated by a local reduction of the critical fracture energy. Due to the use of a regularised crack model, interaction between the length scales of the crack and the material interface has to be analysed. A local approach is presented, that compensates the influence on the actual numeric fracture toughness at which the crack propagates along the interface.

MS12-2: Multidisciplinary and Structural Design Optimization

Advanced Optimization Methods for CFRP Components in the Motorcycle Industry

Martin Perterer (KTM Technologies), Michael Tischer (KTM Technologies), Mark Hölzl (KTM Technologies)

Carbon fiber reinforced plastics (CFRP) are increasingly used in the motorcycle industry due to their good weight specific mechanical properties. Complex geometries, mechanical requirements as well as cost issues and manufacturing influences are the main design challenges here. Therefore, advanced optimization techniques have been developed for CFRP components in order to find an optimum between costs, weight and manufacturing robustness. This approach is shown using selected case studies.

Optimization of topology and shape, combining phase field modelling and discrete stochastic algorithms

Alexander Keller (Karlsruhe Institute of Technology (KIT)), Ingo Münch (Karlsruhe Institute of Technology (KIT)), Werner Wagner (Karlsruhe Institute of Technology (KIT))

For the design of frame structures in civil engineering we are interested in an approach to combine topology and shape optimization. We use a phase field model to generate topology as design concept first. However, it is not possible to estimate the overall fitness of obtained topologies concerning more complex criteria required in civil engineering. Therefore, as a second step, shape optimization with metaheuristic methods considering the normative constraints is performed.

Shape optimization with application to inverse form finding and the use of mesh adaptivity

Michael Caspari (Friedrich-Alexander University of Erlangen-Nürnberg), Philipp Landkammer (Friedrich-Alexander University of Erlangen-Nürnberg), Paul Steinmann (Friedrich-Alexander University of Erlangen-Nürnberg)

The aim of the novel inverse form finding approach is to determine the optimized workpiece geometry to its given target geometry after a forming process. During the optimization procedure, differences between the computed and the target spatial configuration have to be minimized. Material nodal positions act as design variables. The procedure is applied to a notch stamping process. As a special feature, mesh adaptivity is considered within the iteratively performed forming simulation.

Determination of optimal damping for passive control of vibration based on the design of limit cycles

Rafael A. Rojas (Free University of Bozen-Bolzano), Erich Wehrle (Free University of Bozen-Bolzano), Renato Vidoni (Free University of Bozen-Bolzano)

The optimal design of passive vibration control is a challenge for both application and research. These design methods are based on of structure optimization and models are typically solved in frequency domain. This work explores the benefits of introducing state-space methods on passive control. We propose an optimization approach based on the design of the limit cycles of mechanical systems under periodic forces. The method is applied to an example of damping optimization.

Sensitivity Analysis for Pedestrian Lower Leg Impact

Stefano Chiapedi (Technical University of Munich), Andreas Koukal (AUDI AG), Fabian Duddeck (Technical University of Munich)

Pedestrian safety has gathered a lot of attention in recent years among academic and industrial researchers, promoted by the quick evolution of regulation and consumer test requirements. The current work presents the challenges involved in pedestrian lower leg impact test and attempts to deal with them in the field of structural optimization. A sensitivity analysis of the FlexPLI injury criteria is carried out, as motivation for the development of a parametric simplified vehicle front-end model.

MS07-1: Computational Mechanics and Biomimetics

Plant-inspired compliant actuation

Anja Mader (University of Stuttgart), Annette Birkhold (Siemens Healthineers), Marco Caliaro (University of Freiburg), Olga Speck (University of Freiburg), Oliver Röhrle (University of Stuttgart), Jan Knippers (University of Stuttgart)

Compliant systems with an integrated actuation allow adaption to varying requirements. In this context the cellular structure of plants is a valuable source of inspiration. Plant cells are hydraulic systems that can serve as actuators. Specialized motor cells change volume and shape depending on the internal cell pressure. Besides that the stiffness of parenchymatous plant tissues can change with turgor. Inspired by this a cellular pressure driven actuator capable of varying shape and stiffness can be developed.

Modelling functional properties of frost-resistant plant tissues for transfer to construction materials

Lukas Eurich (University of Stuttgart), Arndt Wagner (University of Stuttgart), Wolfgang Ehlers (University of Stuttgart)

While frost is a common threat for construction materials, plants have developed strategies to cope with freezing processes. In this contribution, a biologically motivated rigorous modelling approach of a multicomponent aggregate is presented using the framework of the Theory of Porous Media. For a selected numerical example, crucial effects of plants with regard to frost resistance, such as the cell dehydration and the water management, are discussed.

Upscaling of Self-actuated Wooden Bilayers

Philippe Grönquist (ETH Zürich), Falk K. Wittel (ETH Zürich), Markus Rüggeberg (ETH Zürich)

The hygroscopic and rotational-orthotropic material wood can be used for generating bending motions of cross-ply structures in response to moisture content variations. We investigate the general behavior and the upscaling of such self-actuated wood bilayer structures by a combined experimental and simulation study using Finite element models, including the mechanical behavior of wood and the adhesive bonding. The aim is the manufacturing of complex curved wood parts by self-actuation.

Cellular Solids in sea urchin spines: Numerical analyses and parametric modelling

Immanuel Schäfer (University of Stuttgart), Siegfried Schmauder (University of Stuttgart)

Sea urchin spines show a complex hierarchical lightweight structure which consists of porous calcium carbonate. They can resist high mechanical loads and when getting compressed, they show a graceful failure behavior. Numerical analysis starts with generating models of sea urchin spine parts based on CT-images. The second approach is based on parametric modelling, to create cellular solids with varied parameters. These are then used in simulations to analyze the influence of the microstructure.

CS05: Damage and Plasticity

Evaluation of a Gradient Enhanced Damage Plasticity Model for Shotcrete

Matthias Neuner (University of Innsbruck), Magdalena Schreter (University of Innsbruck), Günter Hofstetter (University of Innsbruck)

A damage plasticity model representing the time-dependent and nonlinear material behavior of shotcrete is discussed. In order to obtain mesh-insensitive numerical results upon strain softening, an over-nonlocal implicit gradient enhancement is employed. The capabilities of the model are demonstrated by means of finite element simulations, employing meshes of different size and orientations.

Study of the Regularization Scheme of an Advanced Rock Model

Magdalena Schreter (University of Innsbruck), Matthias Neuner (University of Innsbruck), Günter Hofstetter (University of Innsbruck)

Quasi-brittle materials such as rock exhibit strain softening in the post-peak region leading to failure. The application of an advanced constitutive model for rock predicting irreversible deformation, strain hardening and strain softening is discussed. The aim is to the study the regularization scheme of the rock model based on the over-nonlocal implicit gradient enhancement in numerical simulations of a biaxial compression test.

Variational constitutive updates based on hyper-dual numbers - theory of gradient enhanced thermoplasticity

Volker Fohrmeister (TU Dortmund University), Alexander Bartels (TU Dortmund University), Jörn Mosler (TU Dortmund University)

We present a generic framework for thermomechanically coupled gradient-enhanced plasticity theory based on variational constitutive updates, i.e., all relevant equations are fulfilled by minimizing an incremental potential. Within the numerical implementation, the exact derivatives of this potential are computed by means of hyper-dual numbers. By doing so, the laborious task of implementation is highly reduced.

Regularisation of gradient-enhanced damage coupled to finite plasticity

Leon Sprave (TU Dortmund University), Andreas Menzel (TU Dortmund University)

An isotropic gradient-enhanced damage formulation is coupled to finite von Mises plasticity. In the context of finite elements an additional field variable, representing nonlocal damage, is introduced. In a multisurface approach, the evolution of damage and plasticity are governed by their respective criteria. Simulation results are compared to experimental data to verify the model.

On the modelling of evolving material symmetries in finite strain plastic deformations

Tobias Asmanoglo (TU Dortmund University), Jia Lu (University of Iowa), Andreas Menzel (TU Dortmund University), Panayiotis Papadopoulos (University of California)

Motivated by the experimental findings on sheet metal presented in (J. Mech. Phys. Solids 45, 22, 841–851, 1997) we focus on the elaboration of a specific model which allows us to capture the evolution of the plastic anisotropy that is induced by finite strain plastic deformations. We discuss evolution equations for the structural tensor that characterises the material symmetry group and show that the finite element based simulation results are in good agreement with experimental findings.

Eigenerosion Approach for Drucker-Prager Plasticity

Aurel Qinami (Technische Universität Dresden), Michael Kaliske (Technische Universität Dresden)

The eigenfracture scheme is a suitable technique to model brittle fracture. This method faces challenges when dealing with inelasticity. The contribution at hand is focused on an eigenerosion formulation for Drucker-Prager plasticity. Its binary approach, leading to element stiffness degradation, can be implemented in a straightforward manner into a finite element code. Special attention is paid to the distinction of tension and compression. The method is validated by a numerical example.

PL05: Plenary Lectures

Modeling and simulation of phase transformations in polycrystals – a micro-sphere framework

Richard Ostwald (TU Dortmund University), Thorsten Bartel (TU Dortmund University), Andreas Menzel (TU Dortmund University)

A new framework for the simulation of shape memory alloys (SMA) and TRIP steels undergoing martensite-austenite phase transformations is introduced. The goal is the derivation and elaboration of a generalised model which facilitates the reflection of the characteristic macroscopic behaviour of SMA as well as of TRIP steels. The model is implemented in a micro-sphere formulation in order to capture polycrystalline behaviour and to simulate three-dimensional boundary value problems.

Topology Optimization of Nonlinear Problems in Solid and Fluid Mechanics

Kurt Maute (University of Colorado Boulder)

Accurately modeling nonlinear problems in solid and fluid mechanics and, at the same time, allowing for topological changes in the optimization process poses interesting challenges on the formulation of the optimization problem, the physics model, and the discretization method. This talk will provide an overview of topology optimization approaches for nonlinear mechanical problems, focusing on level set methods with immersed boundary discretization techniques. Recent advances for problems in finite strain solid mechanics and fluid mechanics will be presented.

Part IV.

Appendix

Authors Index

In the authors index roman page numbers refer to the technical program (Part II) and *italic* page numbers to the micro abstracts (Part III). For presenting authors the page numbers are printed in **bold** face.

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Floor Maps

Used Symbols

Entrance/Exit	Local Train
Conference Secretariat	Bus Stop
Coffee Break	Parking Lot
Restrooms	Elevator
Baggage Room	

Overview of Lecture Rooms and Conference Facilities

Level -1:

7.01
Coffee Break Area
Exit

Level 0:

7.02, 7.04
Conference Secretariat
Coffee Break Area
Exit

Level 1:

7.11, 7.12
Baggage Room

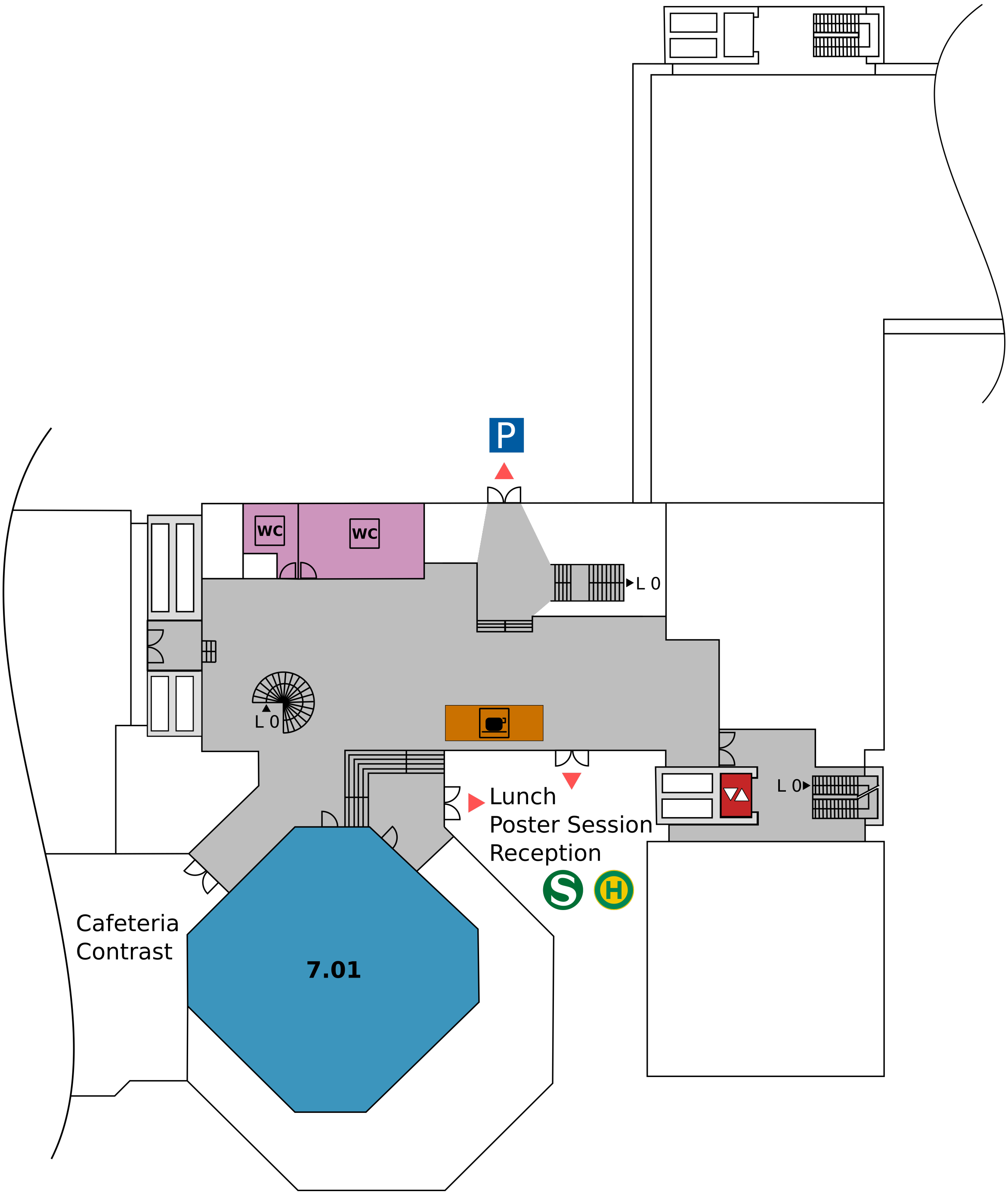
Level 2:

7.22

Level 3:

7.31

Level −1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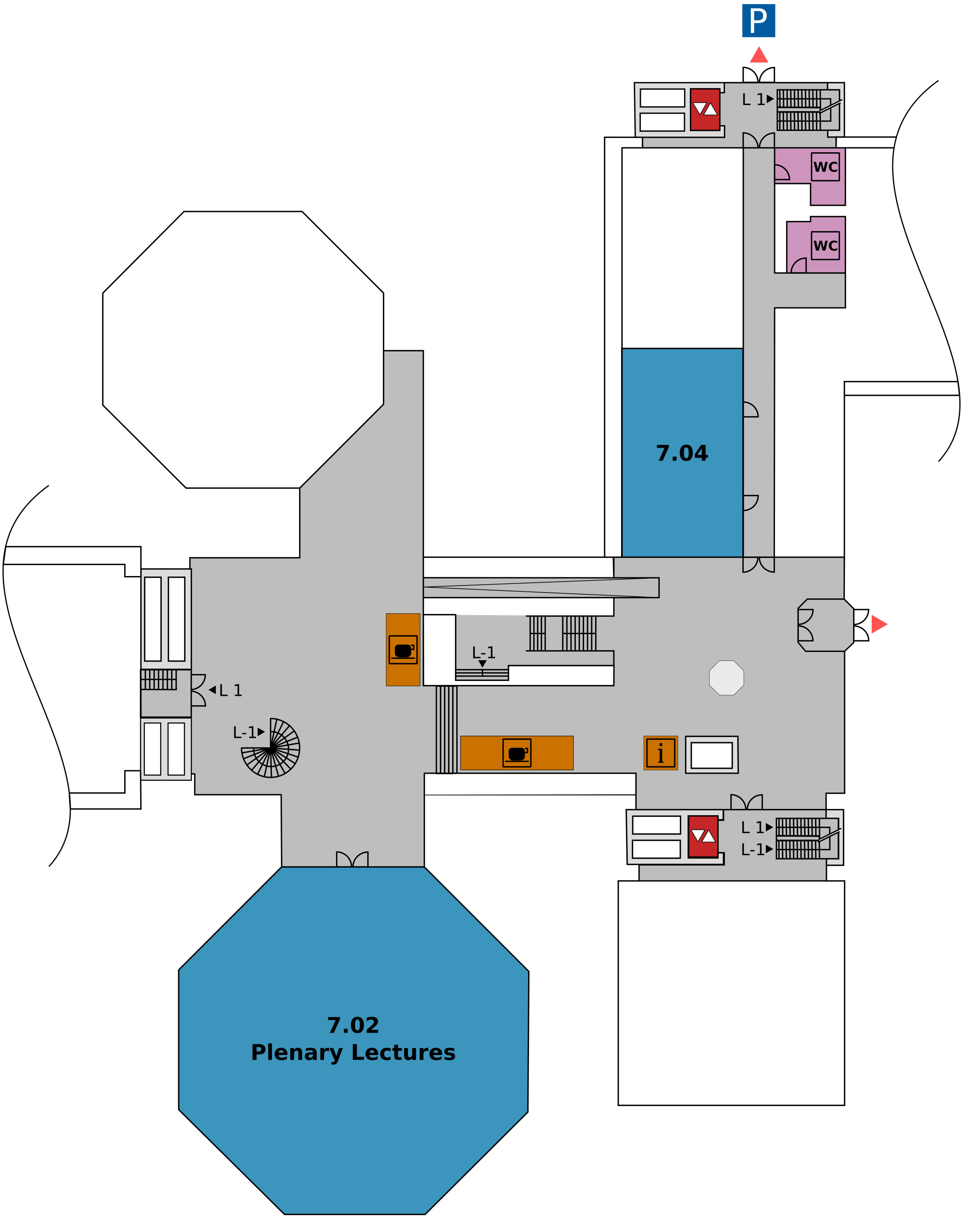
WC
L 0
L 0
L 0
Lunch
Poster Session
Reception
Cafeteria
Contrast
7.01

Level 0



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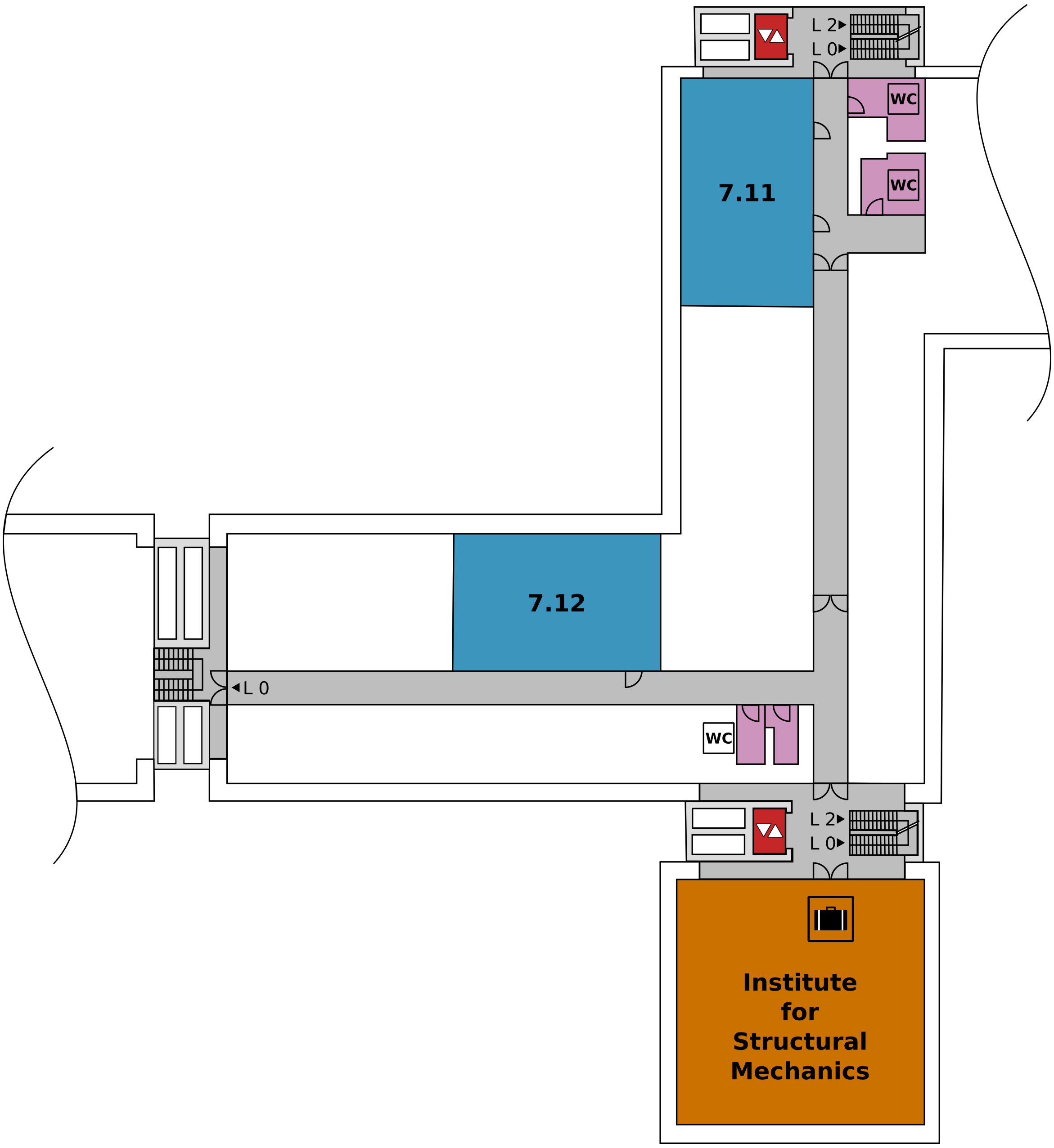
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Institute
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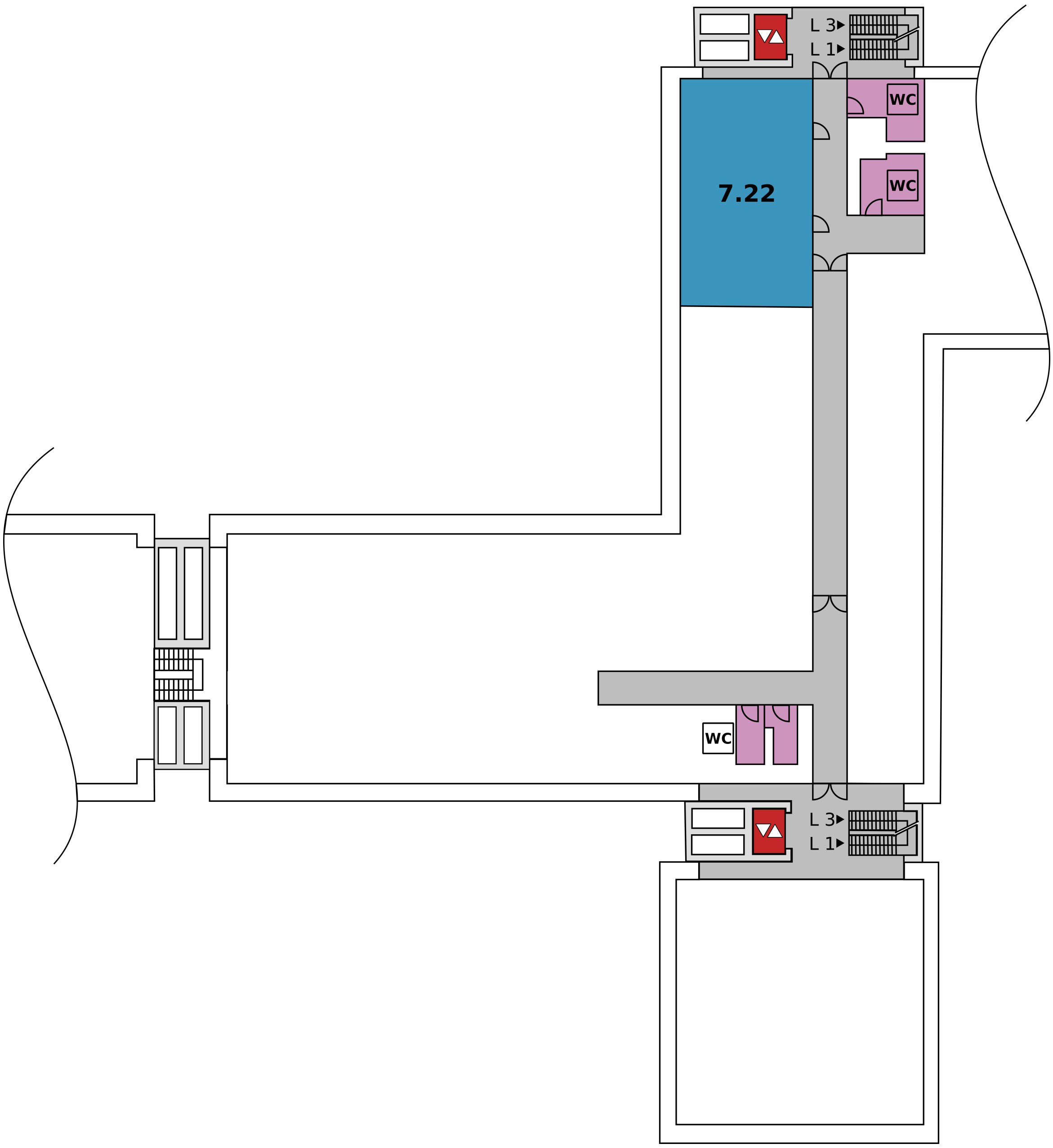
Level 2



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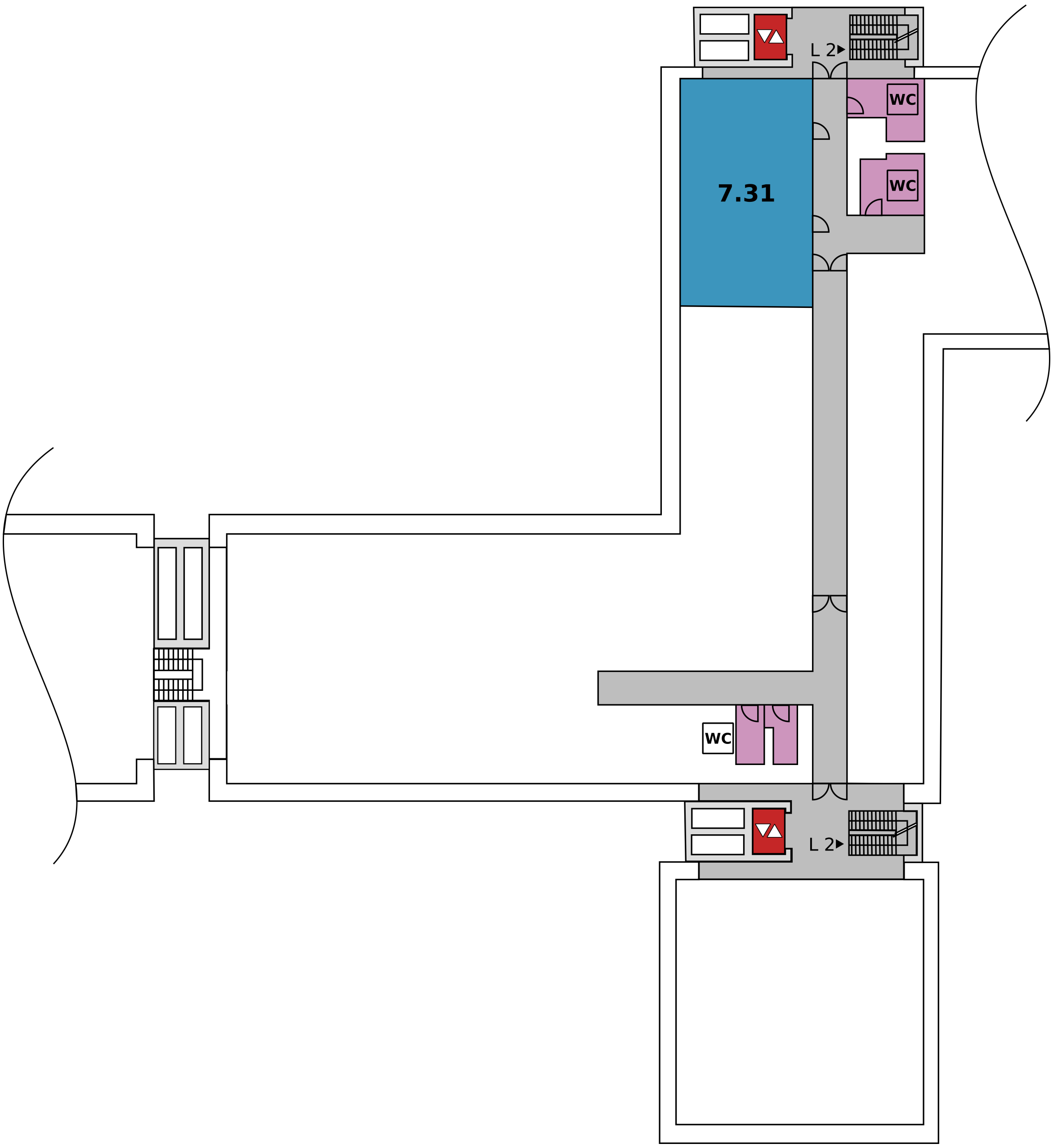

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for Young Scientists from Academia and Industry

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