Course Description and Aims

This short course has the aim to present the current understanding and state-of-the-art of atomization fundamentals, their realization in atomizer systems and their application in a wide variety of engineering branches, including spray drying, spray coating, spray cooling, fuel injection, etc. These aspects are first addressed theoretically in terms of hydrodynamic instabilities of liquid jets and sheets – primary atomization. This is followed by considerations about the break-up of single droplets – secondary atomization. Engineering solutions for realizing the different atomization mechanisms are then presented.

The second day is devoted to experimental descriptors and diagnostics of sprays and droplets. Both non-optical and optical techniques are addressed. Focus is placed on drop size and velocity determination, but an overview is also given about more advanced techniques, allowing temperature and composition to be determined.

The third day presents possibilities for simulating atomization and spray processes. Modelling of primary atomization is discussed, as well as transport processes within sprays and spray/wall interactions.

The final day of the course covers a wide variety of applications and how spray systems have been developed and customized to meet specific requirements and constraints.

The program foresees discussions among the participants and the lecturers. The aim is to address on-going development and application problems suggested by the participants.

Who should attend?

This course is directed towards practicing engineers, researchers involved in R&D and the application of spray systems, and graduate students performing research on the subject of sprays and atomization. For those with little previous background, the course begins with fundamentals of atomization and proceeds through theoretical, experimental, numerical and application topics.

Venue

Lectures will be aired using WebEX, either live or recorded. In either case, the lecturer will be available during the lecture period and questions and discussions with lecturers will be moderated through the chat function.

Course Fees and Registration

- Industry: 200 EUR
- Academia: 100 EUR

Course fees are VAT exempt according to article 132 (i) Council Directive 2006/112/EC. Included is live and download access to all lectures during the week and all accompanying documentation (slides).

Registration for this four-day short course can be made online from December 2020 on the course website:

www.tfi.tu-darmstadt.de/as2021

For further information, please refer to the course website or contact Prof. Cameron Tropea:

ctropea@sla.tu-darmstadt.de
### Lecturers

<table>
<thead>
<tr>
<th>Lecturer</th>
<th>Institution</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof. Dr. Nasser Ashgriz</td>
<td>Department of Mechanical and Industrial Engineering, University of Toronto</td>
<td>Toronto</td>
</tr>
<tr>
<td>Prof. Dr. Dieter Bothe</td>
<td>Institute of Mathematical Modeling and Analysis, TU Darmstadt</td>
<td>Darmstadt</td>
</tr>
<tr>
<td>Prof. Dr.-Ing. Günter Brenn</td>
<td>Institute of Fluid Mechanics and Heat Transfer, TU Graz</td>
<td>Graz</td>
</tr>
<tr>
<td>Prof. Dr. Sanjeev Chandra</td>
<td>Department of Mechanical and Industrial Engineering, University of Toronto</td>
<td>Toronto</td>
</tr>
<tr>
<td>Prof. Dr. -Ing. Udo Fritsching</td>
<td>Department Multiphase Flow, Heat- and Mass-Transfer, Leibniz Institute for Materials Engineering (IWT) Bremen</td>
<td>Bremen</td>
</tr>
<tr>
<td>Prof. Fabrice Lemoine</td>
<td>Laboratoire d'Energétique et de Mécanique Théorique et Appliquée, Université de Lorraine, Nancy</td>
<td>Nancy</td>
</tr>
<tr>
<td>Prof. Dr. Ilia V. Roisman</td>
<td>Institute for Fluid Mechanics and Aerodynamics, TU Darmstadt</td>
<td>Darmstadt</td>
</tr>
<tr>
<td>Prof. Eran Sher</td>
<td>Faculty of Aerospace Engineering, Technion – Israel Institute of Technology</td>
<td>Haifa</td>
</tr>
<tr>
<td>Prof. Dr.-Ing. Peter Stephan</td>
<td>Institute for Technical Thermodynamics, TU Darmstadt</td>
<td>Darmstadt</td>
</tr>
<tr>
<td>Prof. Dr.-Ing. Cameron Tropea</td>
<td>Institute for Fluid Mechanics and Aerodynamics, TU Darmstadt</td>
<td>Darmstadt</td>
</tr>
<tr>
<td>Prof. Dr.-Ing. Bernhard Weigand</td>
<td>Institute of Aerospace Thermodynamics (ITLR), University of Stuttgart</td>
<td>Stuttgart</td>
</tr>
<tr>
<td>Prof. Dr. Alexander L. Yarin</td>
<td>Department of Mechanical and Industrial Engineering, University of Illinois at Chicago</td>
<td>Chicago</td>
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### Schedule

#### Monday 22 February 2021
**Fundamentals**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session/Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:45</td>
<td>Session open for joining</td>
</tr>
<tr>
<td>9:00</td>
<td>Welcome, Introductions, Overview, Use of WebEX and guidelines for discussions (Tropea)</td>
</tr>
<tr>
<td>9:30</td>
<td>Techniques of Atomization: Overview of Atomizers and their Applications (Tropea)</td>
</tr>
<tr>
<td>10:30</td>
<td>Screen break</td>
</tr>
<tr>
<td>10:45</td>
<td>Stability Analysis of Liquid Jets and Sheets (Brenn)</td>
</tr>
<tr>
<td>12:00</td>
<td>Screen break (Lunch)</td>
</tr>
<tr>
<td>12:30</td>
<td>Fundamentals of Atomization (Roisman)</td>
</tr>
<tr>
<td>13:30</td>
<td>Screen break</td>
</tr>
<tr>
<td>13:45</td>
<td>Breakup and Atomization Models (Ashgriz)</td>
</tr>
<tr>
<td>15:00</td>
<td>Screen break</td>
</tr>
<tr>
<td>15:15</td>
<td>Secondary Atomization (Tropea)</td>
</tr>
<tr>
<td>16:00</td>
<td>Screen break</td>
</tr>
<tr>
<td>16:15</td>
<td>Flash Boiling Atomization (Sher)</td>
</tr>
<tr>
<td>17:00</td>
<td>Close of first day</td>
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#### Tuesday 23 February 2021
**Characterization and Diagnostics**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session/Activity</th>
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<tbody>
<tr>
<td>8:45</td>
<td>Session open for joining</td>
</tr>
<tr>
<td>9:00</td>
<td>Spray Characterization – Quantifiers and Standards (Tropea)</td>
</tr>
<tr>
<td>9:45</td>
<td>Imaging Techniques (Leick)</td>
</tr>
<tr>
<td>10:30</td>
<td>Screen break</td>
</tr>
<tr>
<td>10:45</td>
<td>Measurement Techniques (Tropea)</td>
</tr>
<tr>
<td>11:45</td>
<td>Screen break</td>
</tr>
<tr>
<td>12:00</td>
<td>Measurement of Drop Temperature and Composition (Lemoine)</td>
</tr>
<tr>
<td>13:00</td>
<td>Screen break (Lunch)</td>
</tr>
<tr>
<td>13:30</td>
<td>Nozzle Designs and their Spray Characteristics (Ashgriz)</td>
</tr>
<tr>
<td>14:30</td>
<td>Screen break</td>
</tr>
<tr>
<td>14:45</td>
<td>Droplet Impingement Cooling with Evaporation (Stephan)</td>
</tr>
<tr>
<td>15:30</td>
<td>Screen break</td>
</tr>
<tr>
<td>15:45</td>
<td>Fundamentals of Modelling (Yarin)</td>
</tr>
<tr>
<td>16:30</td>
<td>Close of Second Day</td>
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</table>

#### Wednesday 24 February 2021
**Modeling and Simulation**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session/Activity</th>
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<tbody>
<tr>
<td>8:45</td>
<td>Session open for joining</td>
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<tr>
<td>9:00</td>
<td>Direct Numerical Simulation of Primary Jet Breakup (Weigand)</td>
</tr>
<tr>
<td>10:30</td>
<td>Screen break</td>
</tr>
<tr>
<td>10:45</td>
<td>A Survey on Numerical Simulation Methods for Multiphase Flows (Bothe)</td>
</tr>
<tr>
<td>11:30</td>
<td>Volume-of-Fluid Method for Drop Collision (Bothe)</td>
</tr>
<tr>
<td>12:15</td>
<td>Screen break (Lunch)</td>
</tr>
<tr>
<td>12:45</td>
<td>Heat and Mass Transfer from Drops: Fundamentals (Brenn)</td>
</tr>
<tr>
<td>13:30</td>
<td>Screen break</td>
</tr>
<tr>
<td>13:45</td>
<td>Drop/Wall Interactions (Yarin)</td>
</tr>
<tr>
<td>14:45</td>
<td>Screen break</td>
</tr>
<tr>
<td>15:00</td>
<td>Atomization in Forensic and High Power Applications (Yarin)</td>
</tr>
<tr>
<td>15:45</td>
<td>Screen break</td>
</tr>
<tr>
<td>16:00</td>
<td>Spray Painting (Chandra)</td>
</tr>
<tr>
<td>16:45</td>
<td>Close of Third Day</td>
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#### Thursday 25 February 2021
**Applications & Advanced Topics**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session/Activity</th>
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<tbody>
<tr>
<td>8:45</td>
<td>Session open for joining</td>
</tr>
<tr>
<td>9:00</td>
<td>Atomizers for Fuel Injection (Leick)</td>
</tr>
<tr>
<td>10:00</td>
<td>Screen break</td>
</tr>
<tr>
<td>10:15</td>
<td>Drop Combustion (Sher)</td>
</tr>
<tr>
<td>11:00</td>
<td>Screen break</td>
</tr>
<tr>
<td>11:15</td>
<td>Atomization of Complex Fluids (Brenn)</td>
</tr>
<tr>
<td>12:00</td>
<td>Screen break (Lunch)</td>
</tr>
<tr>
<td>12:30</td>
<td>Powder Production in Spray Processes (Fritsching)</td>
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<tr>
<td>13:30</td>
<td>Screen break</td>
</tr>
<tr>
<td>13:45</td>
<td>Spray Coating (Chandra)</td>
</tr>
<tr>
<td>14:30</td>
<td>Screen break</td>
</tr>
<tr>
<td>14:45</td>
<td>Spray Cooling (Roisman)</td>
</tr>
<tr>
<td>15:30</td>
<td>Close of Short Course</td>
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