



UiT The Arctic University of Norway

What is Multiphysics? Definition and Examples.

22nd November 2023

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Department of Automation and Process Engineering (IAP)
IR, Spectroscopy, and Numerical Modelling Research Group*

Collaborations with Chinese Universities

- Guest Lecturer - Henan University of Science and Technology (HAUST), November 2023
- Invited by BIT to apply for 1000 Young Talents Plan as a Researcher, September 2019
- Conference Organizer - MULTIPHYSICS 2023 at Beijing Institute of Technology (BIT), Beijing, China, December 2017



UiT The Arctic University of Norway

4 campuses
70° north (latitude)
3500 staff (1700 academics)
17000 students



TROMSØ, NORWAY



Source: <https://www.visitnorway.com/places-to-go/northern-norway/tromso/>

Biography

Research Group Leader, UiT, Norway (2015-)

Associate Professor, UiT, Norway (2014-)

Post-Doctoral Researcher, UiT, Norway (2012-2013)

MPhil and PhD in Engineering, Cambridge, UK (2008-2012)

Bachelor in Aerospace Engineering,
NUST, Pakistan (2002-2007)



My Research Portfolio – Multiphysics

Research Portfolio:

70+ Journal Publications

100+ Conference Presentations

10+ PhD Students Supervisions

20+ Master Students Supervisions

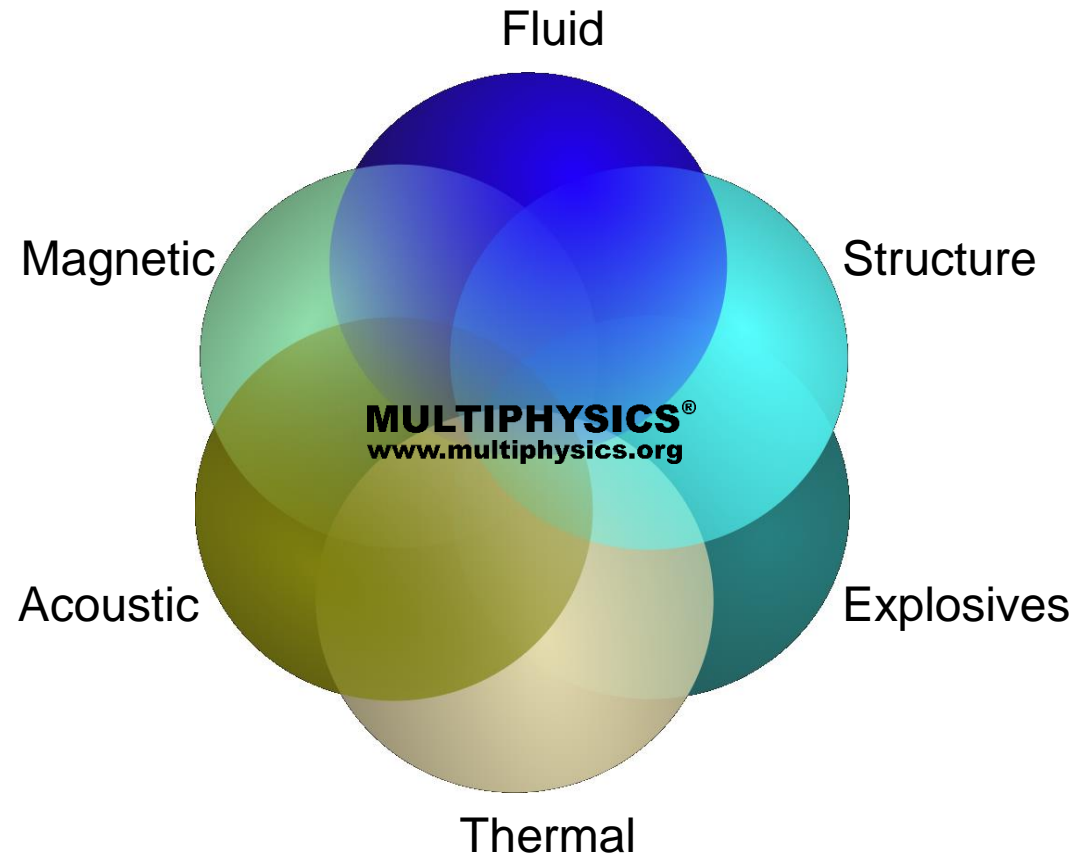
15+ International Funded Projects

Developed Master/PhD courses:

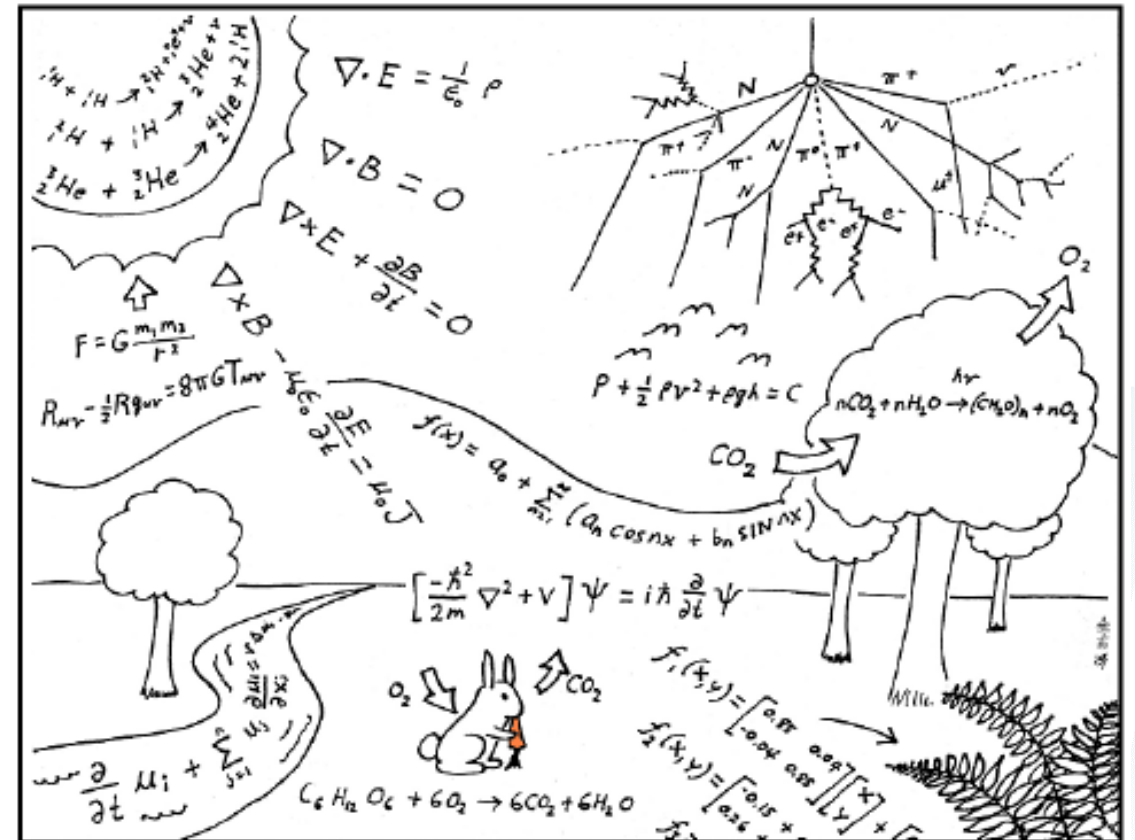
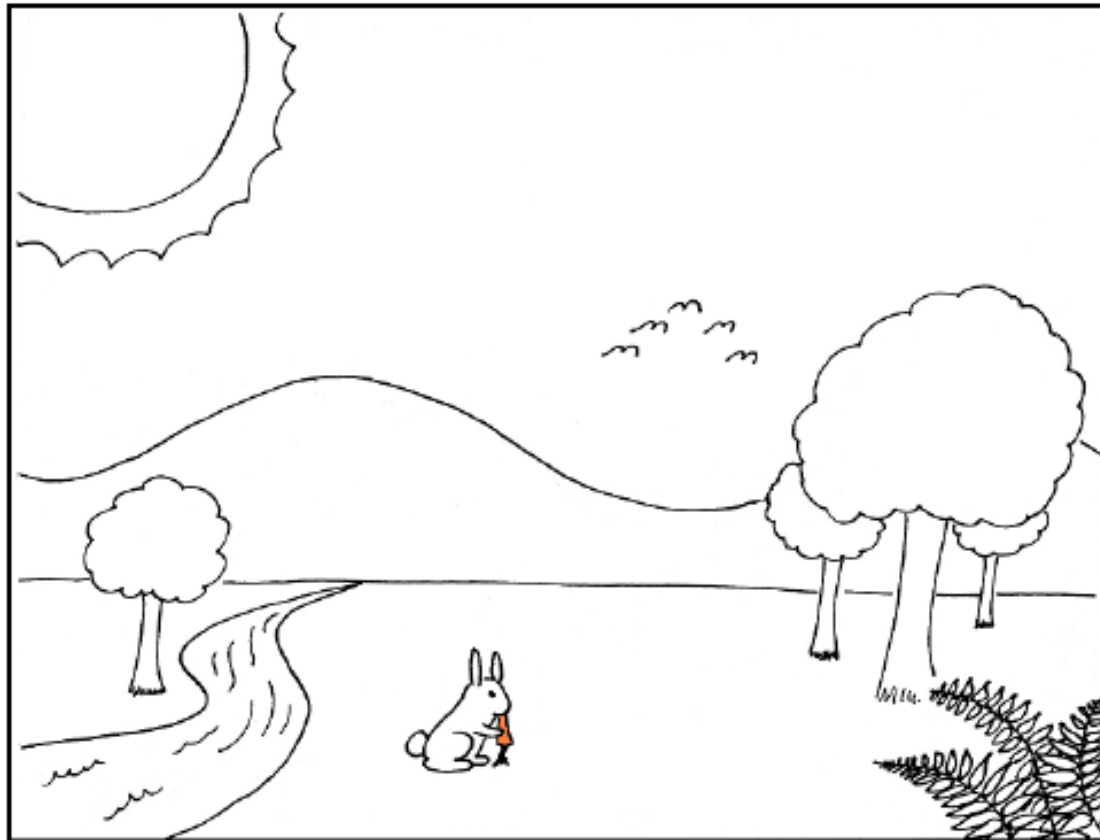
- Multiphysics Simulation
- Thermography and Spectroscopy

International Collaborations:

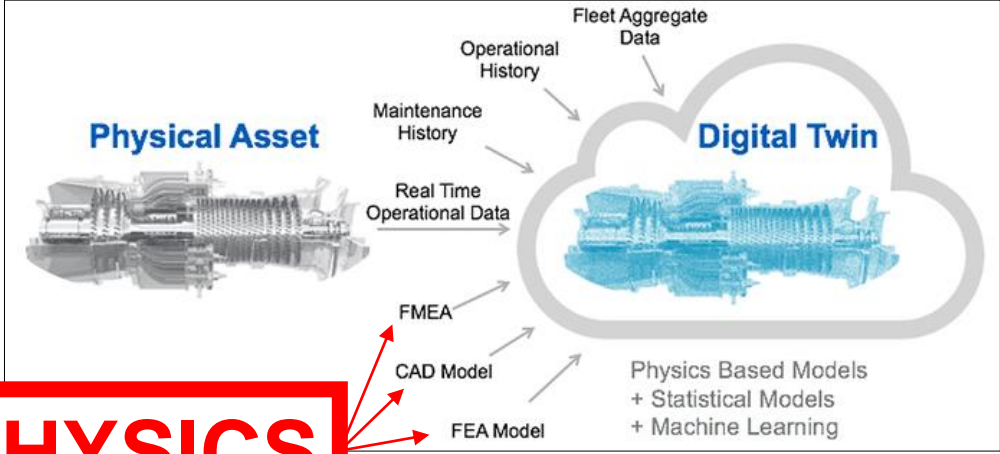
Canada, China, Ethiopia, France, Norway,
Pakistan, Philippines, Poland, Russia, Sweden,
Saudi Arabia, Switzerland, United Arab
Emirates, United Kingdom, and United States



What is Multiphysics?



The interdependence between different physical models result in a complex-coupled system, referred to as multiphysics, where the outputs of one or more models becomes the inputs for the others.



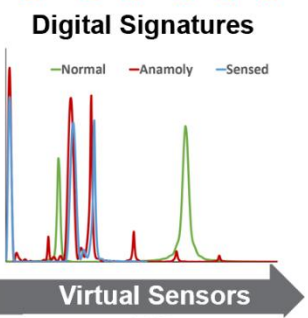
MULTIPHYSICS

DIGITAL TWIN

As Designed
MODEL-BASED ENTERPRISE & SYSTEMS ENGINEERING

As Operated
INTEGRATED IOT ASSETS & ECOSYSTEMS

FLUIDS | **STRUCTURES** | **ELECTRONICS** | **SEMICONDUCTOR** | **EMBEDDED SOFTWARE**

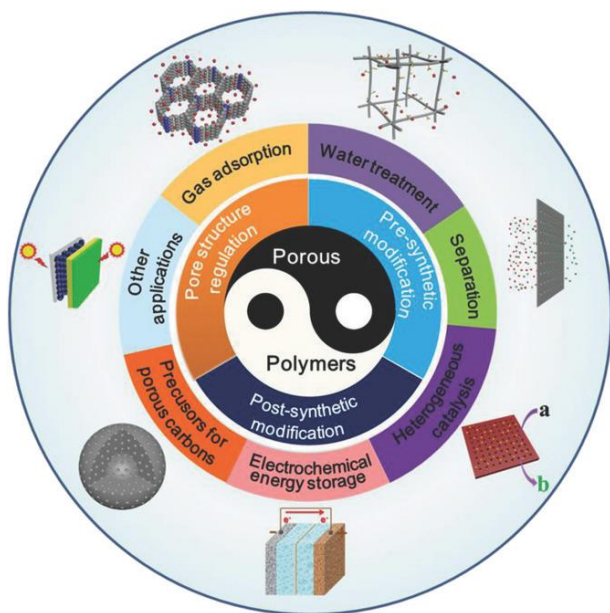
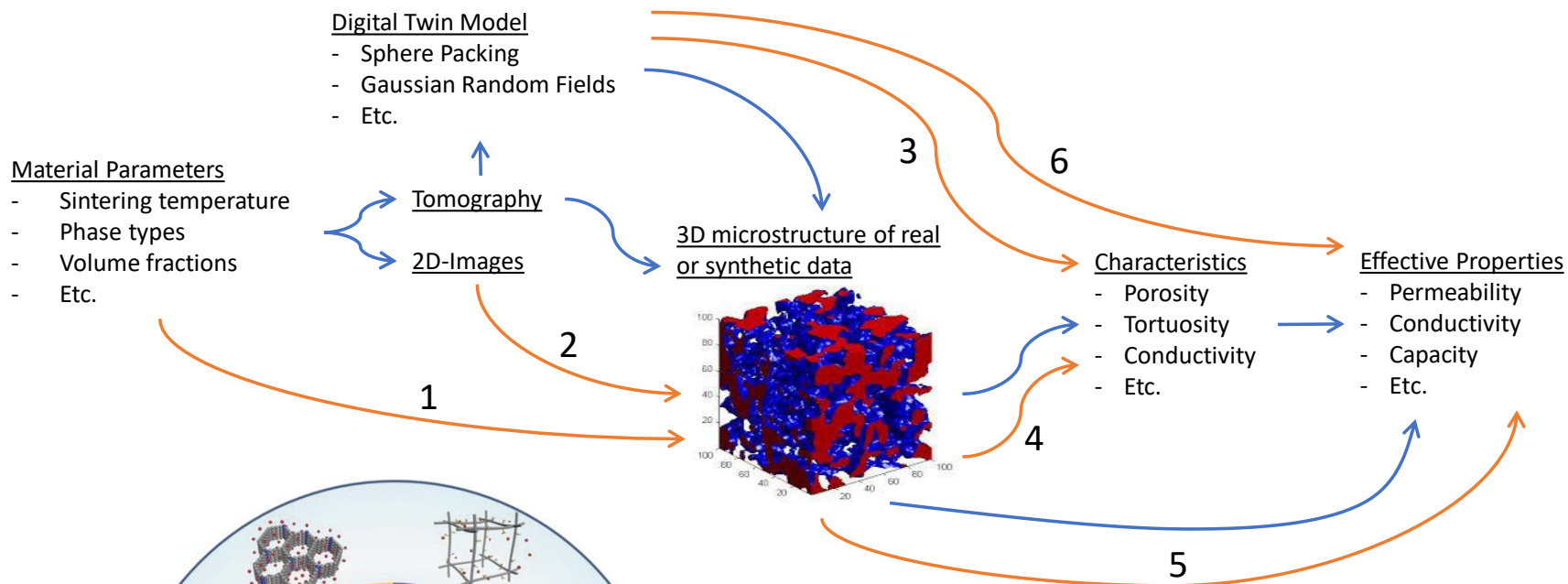


- Further improve:
- Cost
 - Weight
 - Efficiency
 - Robustness



- Assess:
- Performance
 - Life / Durability
 - Diagnostics
 - Optimization

Microstructure Model – AI/ML Simulation



Ice Detection/Mitigation – CHT Design

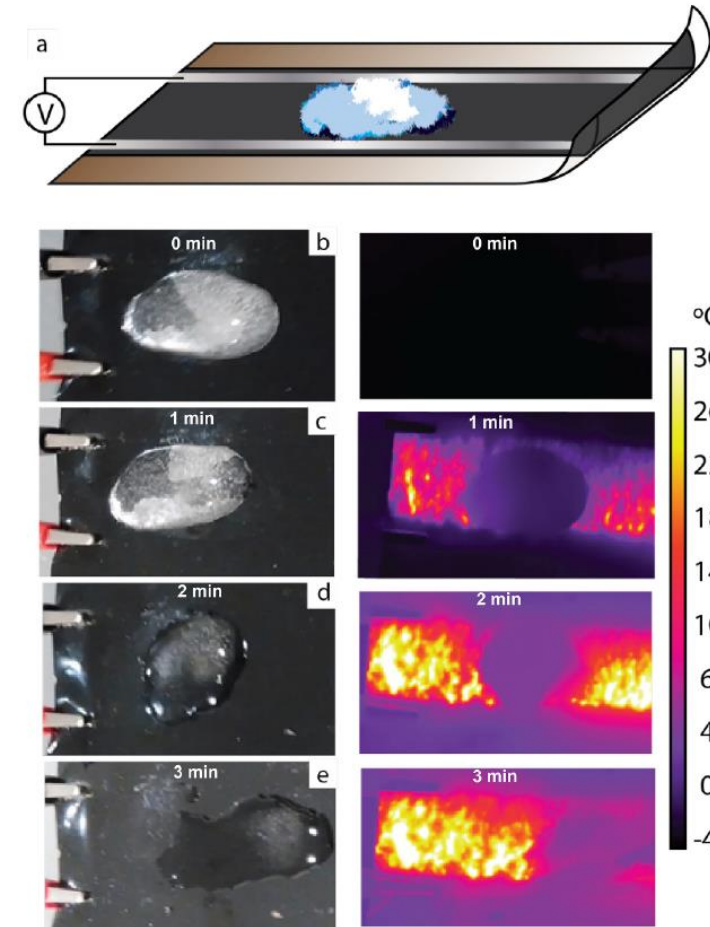
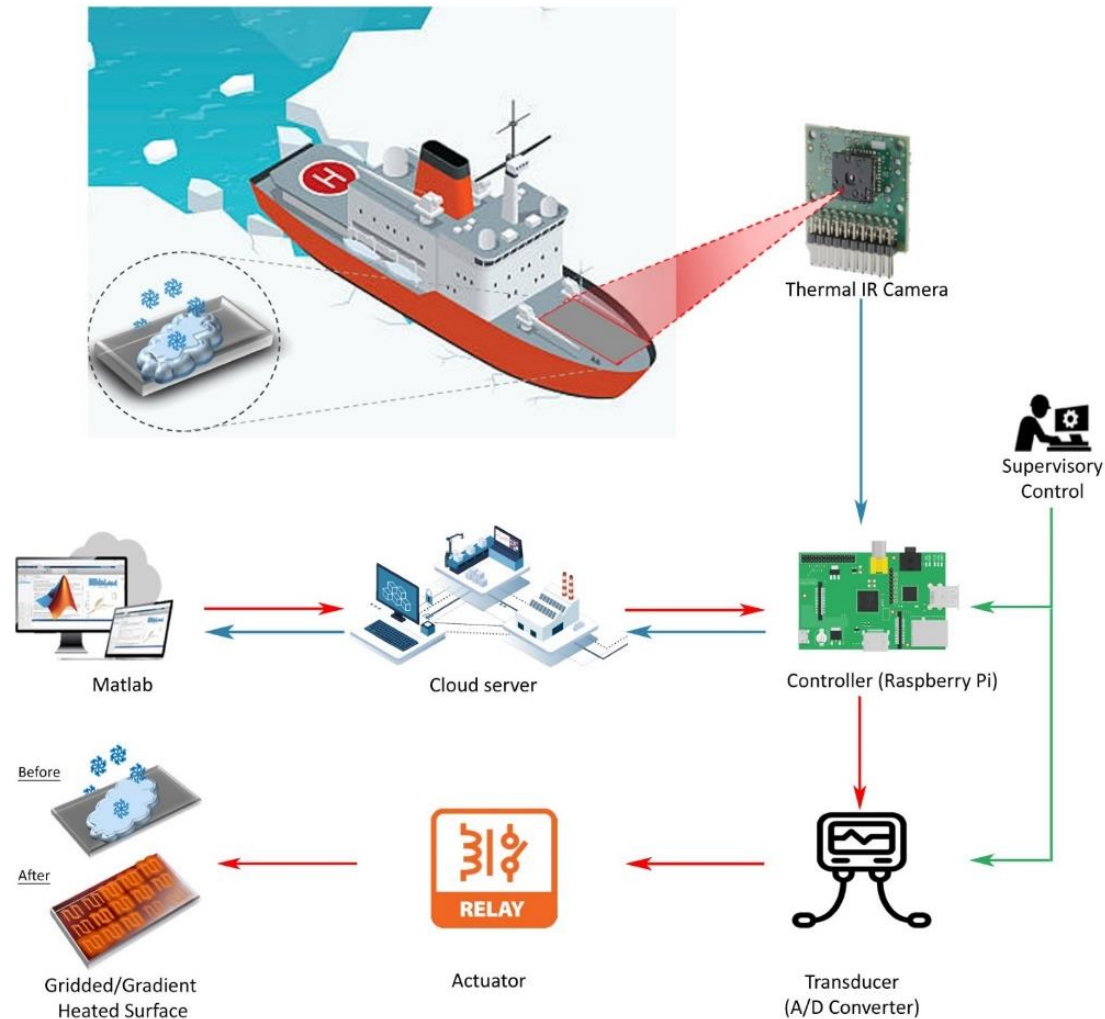
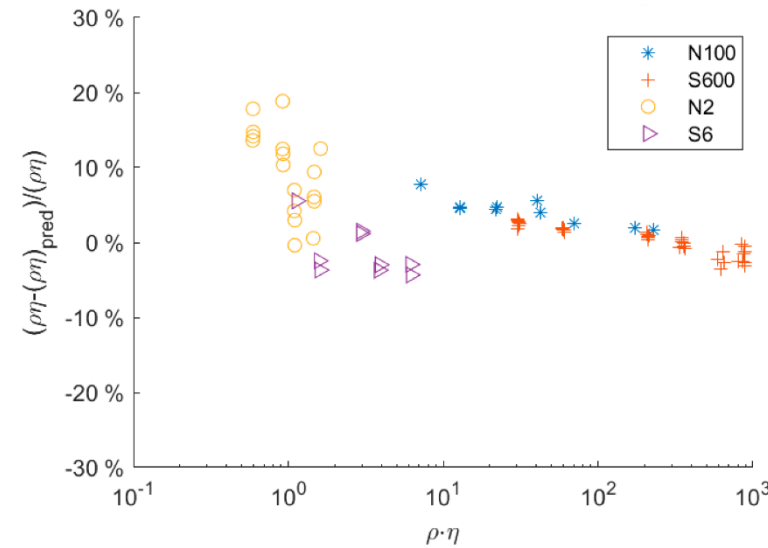
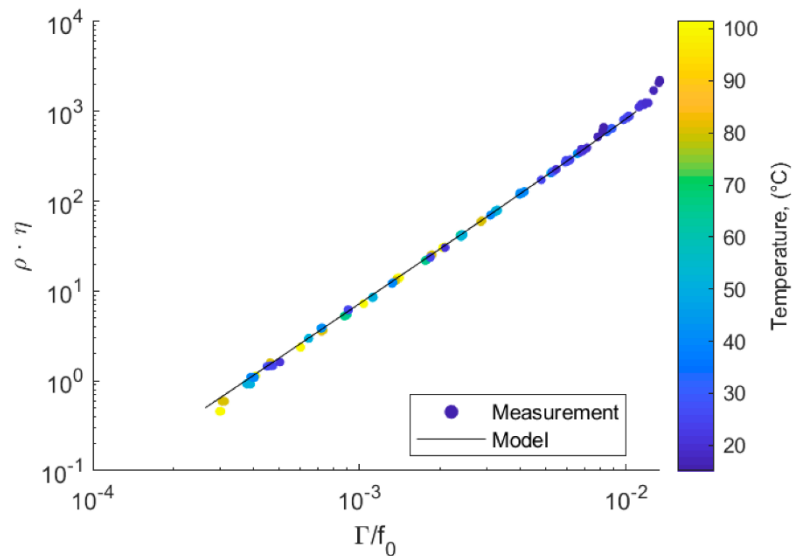
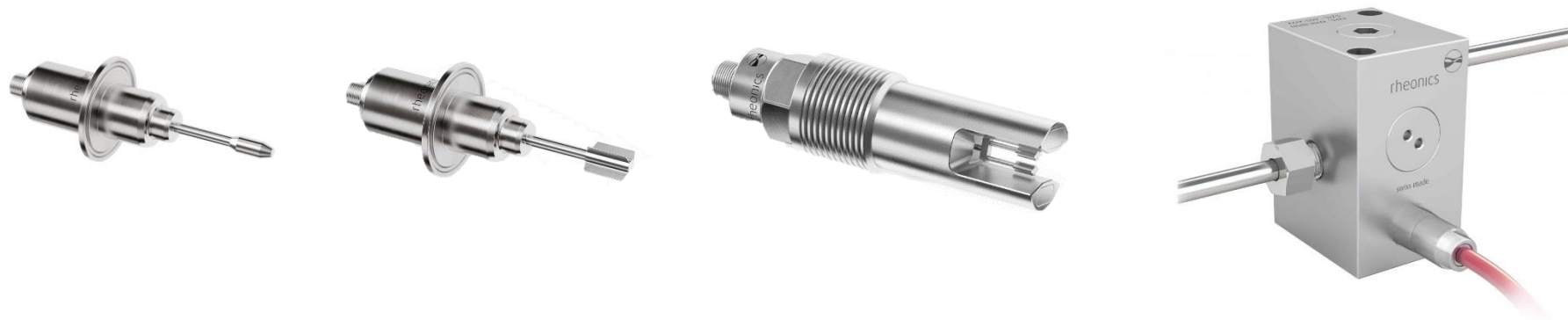


Fig. 4. De-icing demonstration of R2R CNT coated sheet (IR and colour images), when ice is frozen inside cold room at steady state temperature of -2°C .

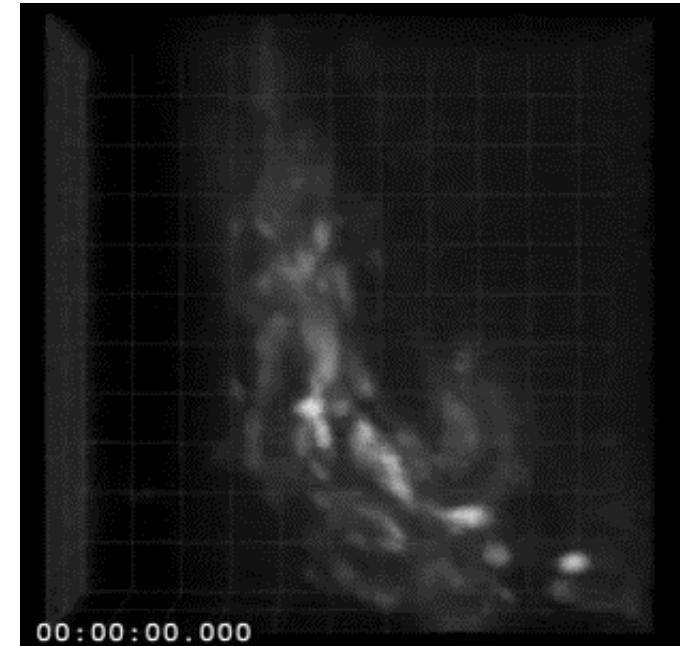
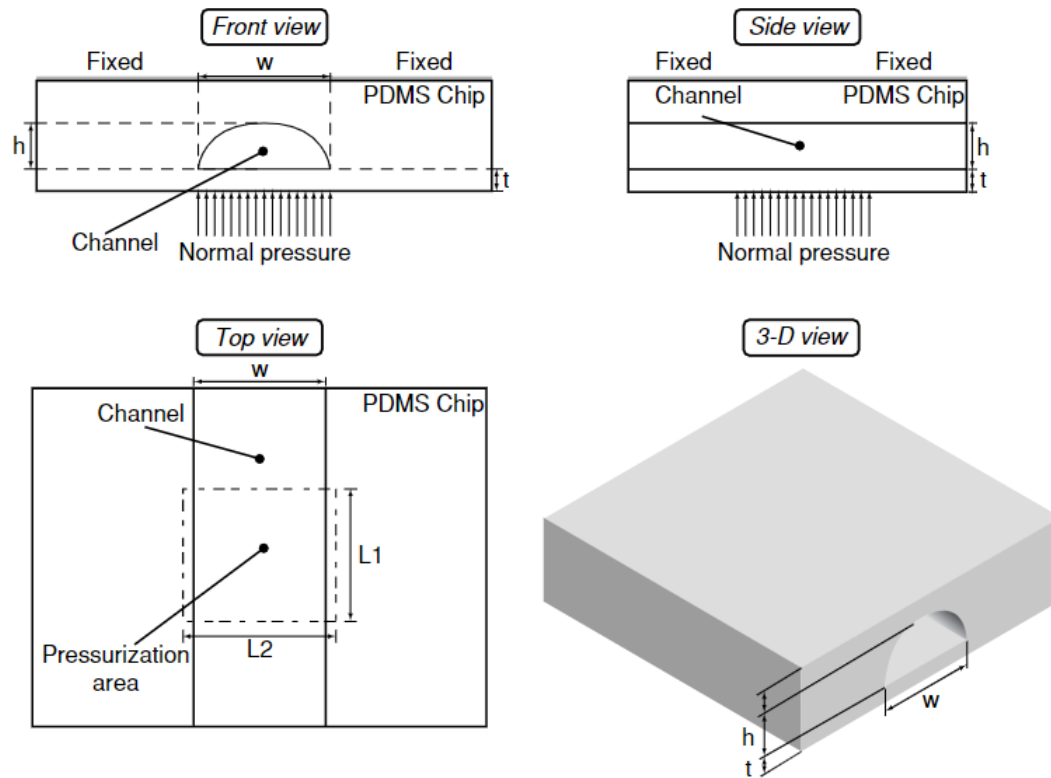
Fluid Viscosity-Density Sensor – FSI Design



rheonics

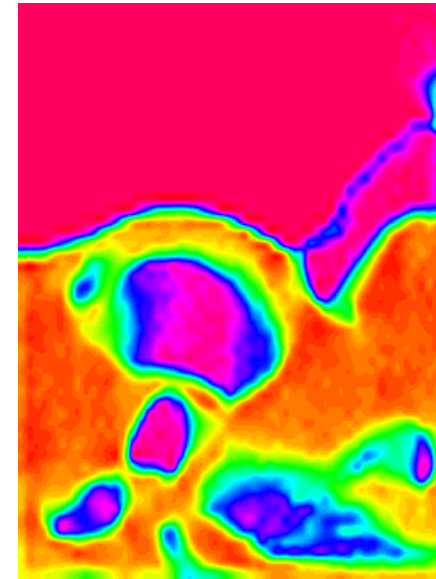


Micro-Fluidic Pump – FEM Design

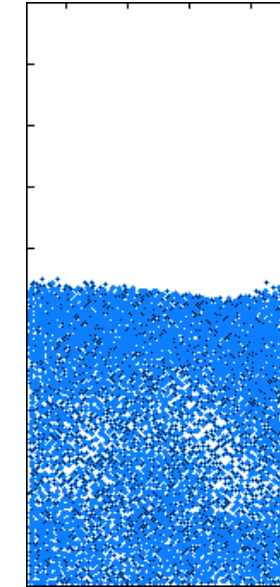


H Khawaja, I Raouf, K Parvez, A Scherer. Optimization of elastomeric micro-fluidic valve dimensions using nonlinear finite element methods. The International Journal of Multiphysics, 2009, 3(2): pp. 187 - 200. <http://dx.doi.org/10.1260/175095409788837847>

Fluidized Bed – CFD-DEM Simulation



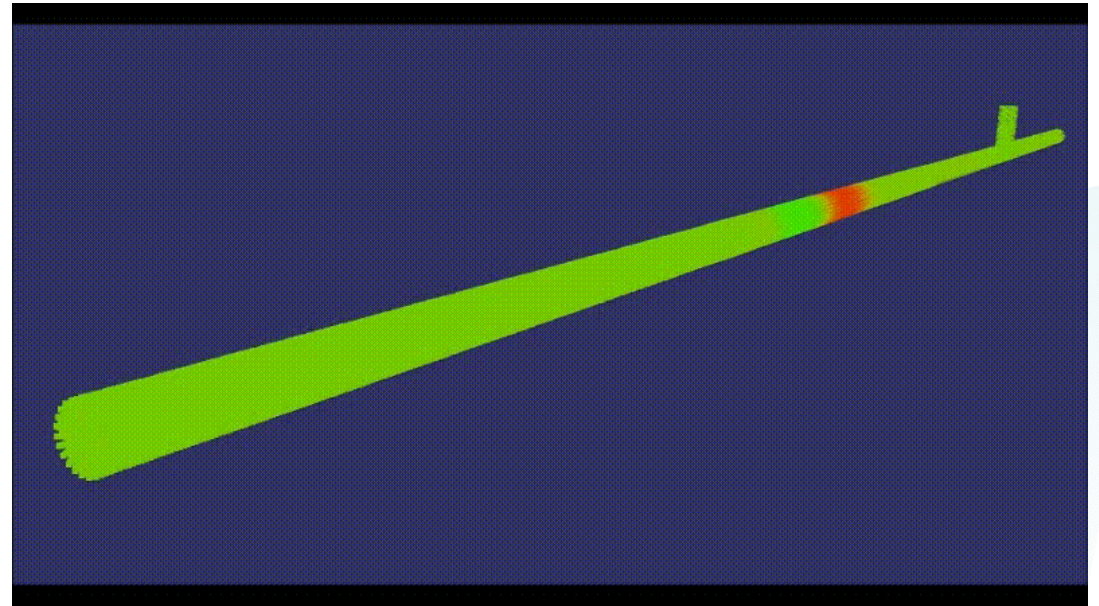
Fluid Inlet



Fluid Inlet

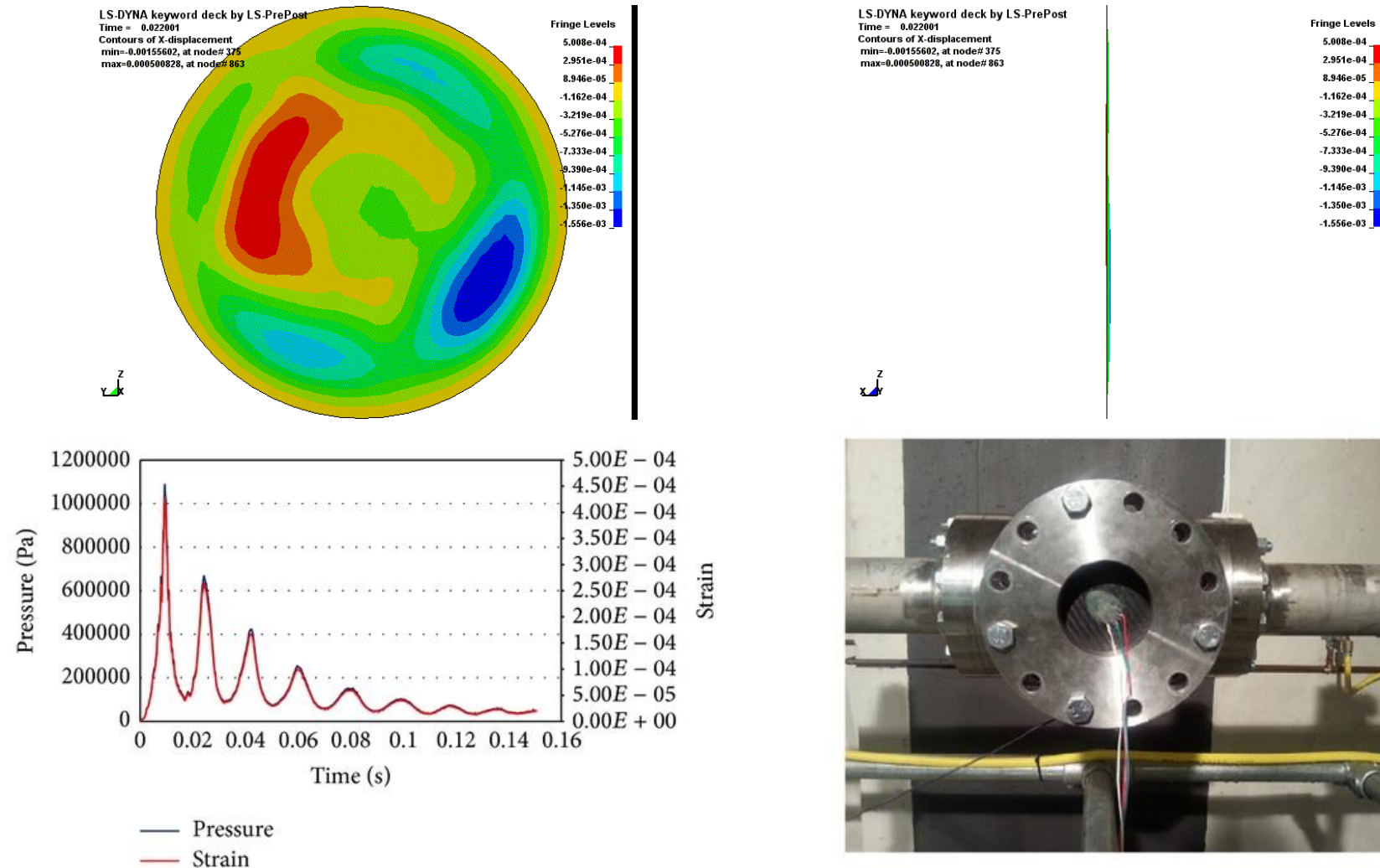
Shock Tube – ALE CFD Simulation

Real Time Footage

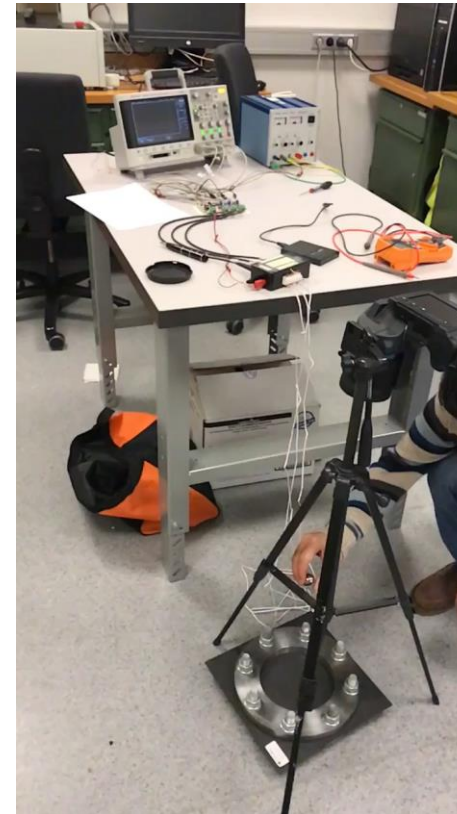
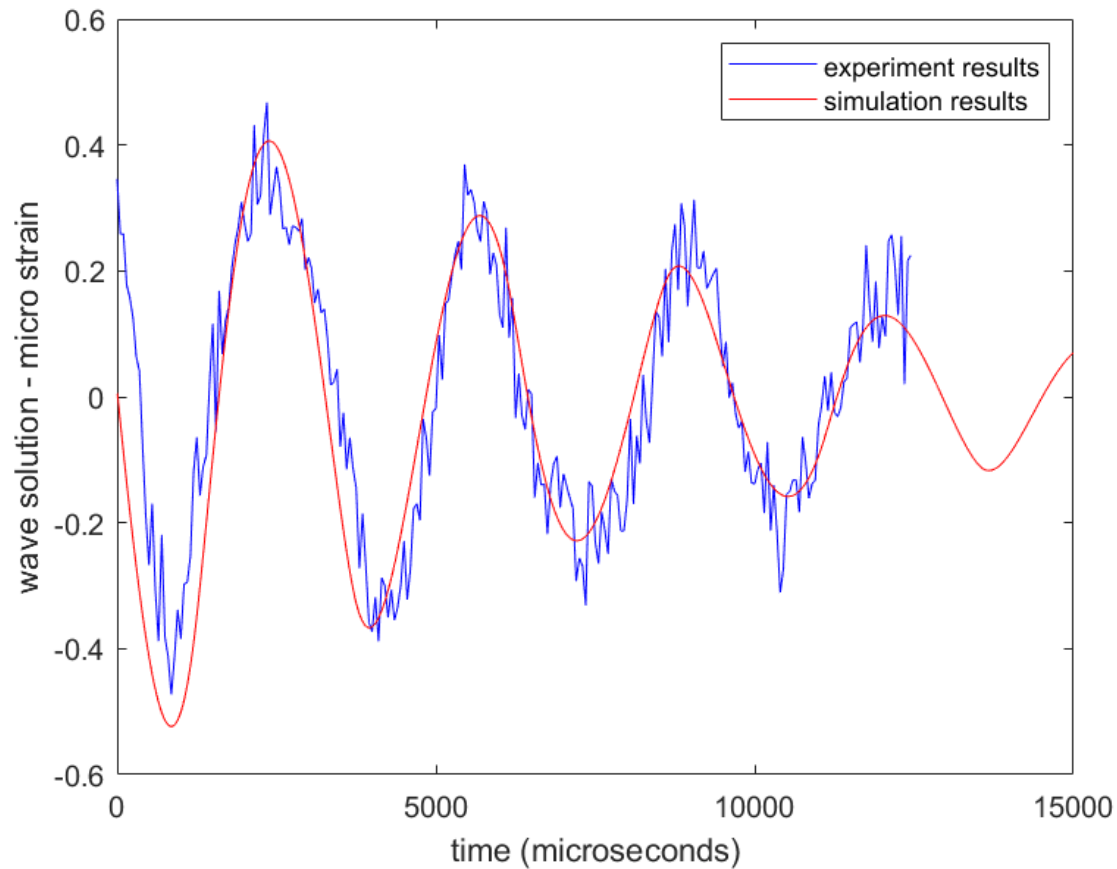


H Khawaja et al. Experimental and Numerical Study of Pressure in a Shock Tube. ASME Journal of Pressure Vessel Technology, 2016, 138(4): 041301.
<http://dx.doi.org/10.1115/1.4031591>

Shock Tube – FSI Simulation

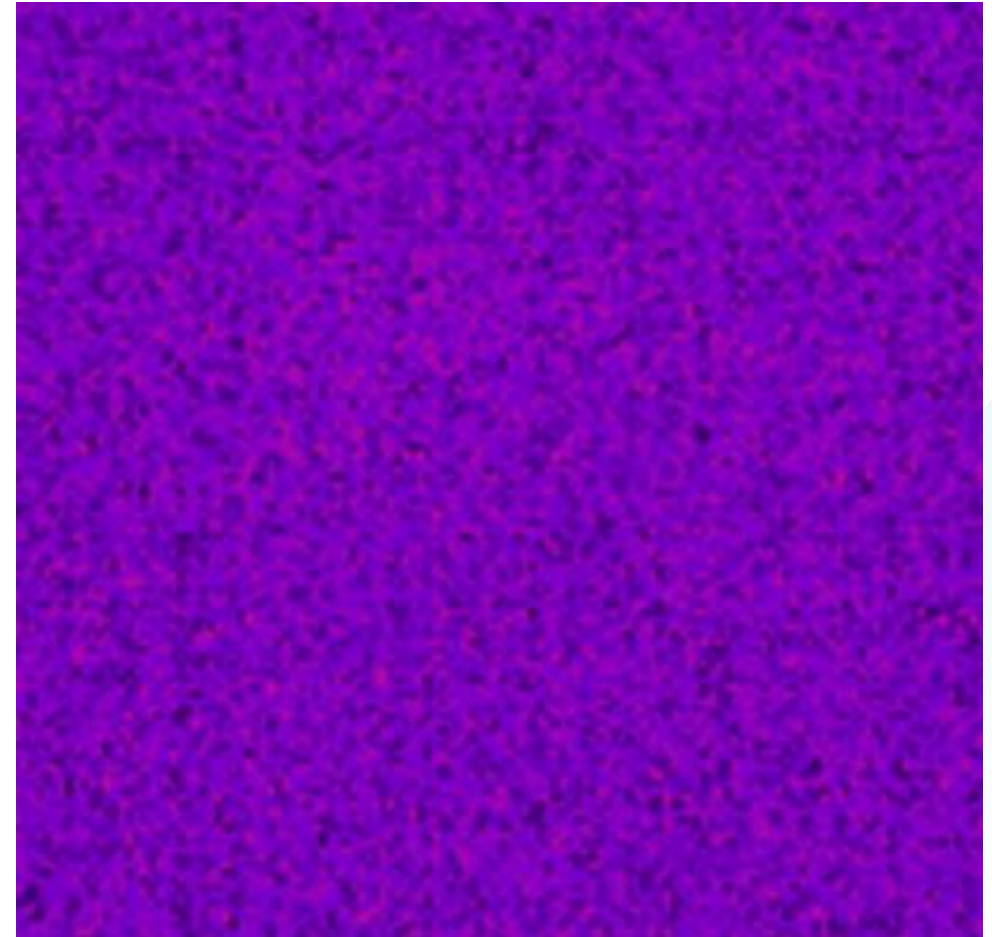
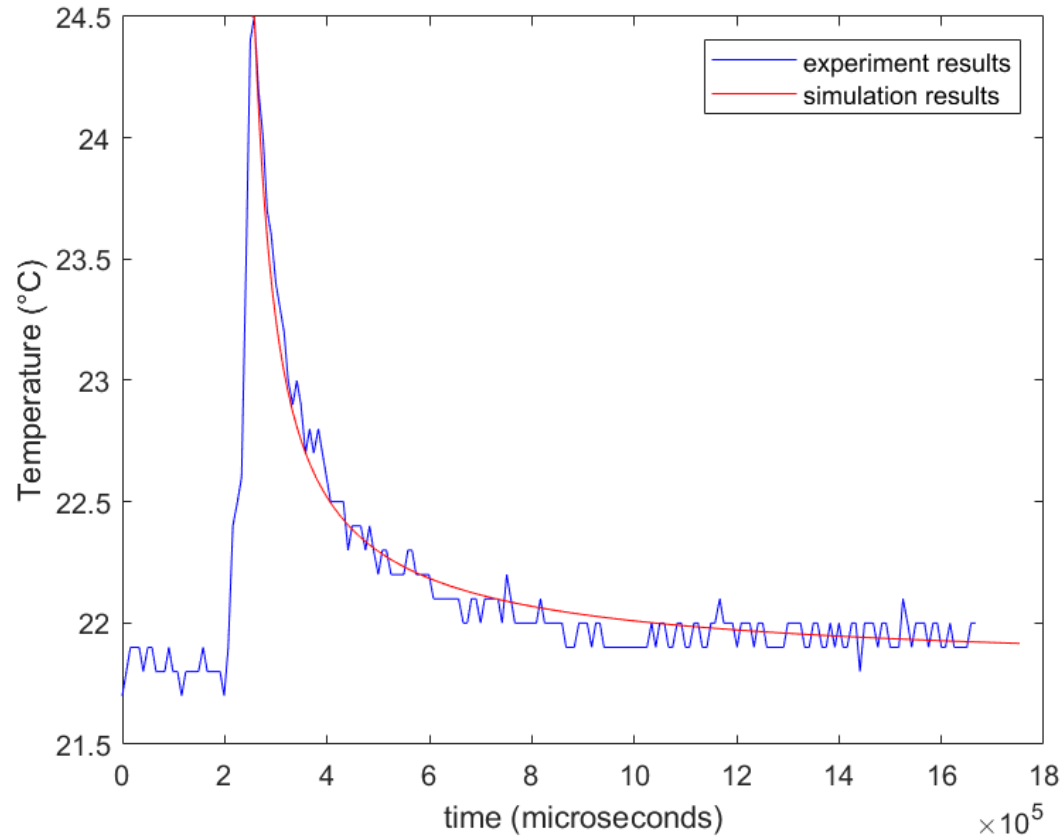


CFRP Impact – Strain Wave Simulation



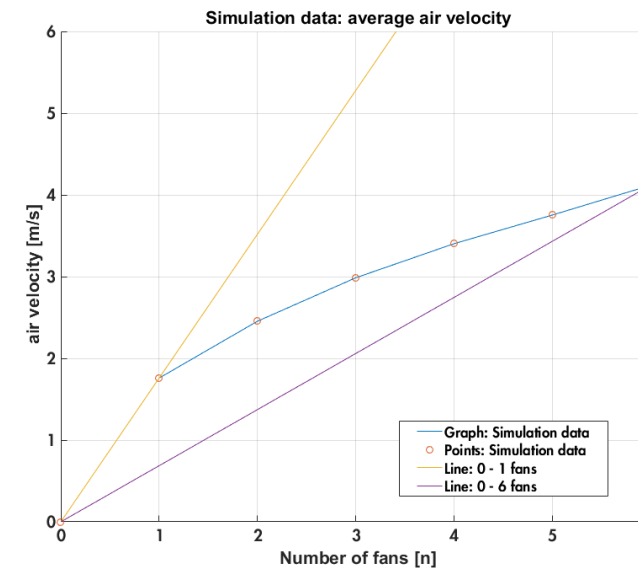
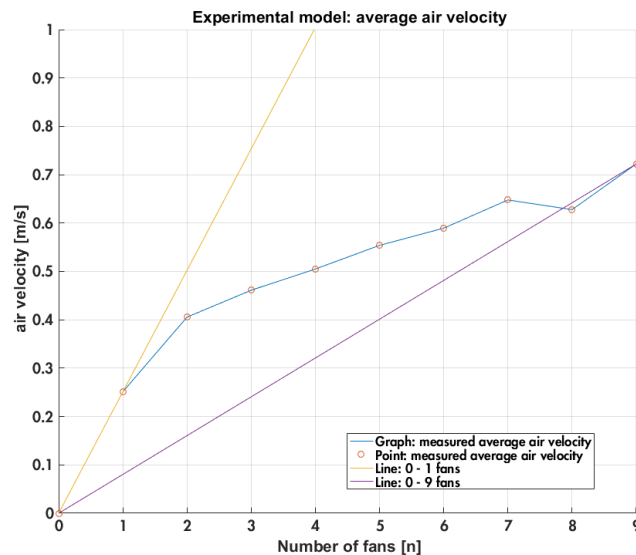
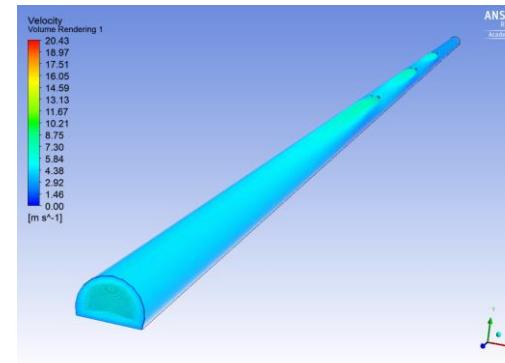
Zahra Andleeb, Sohail Malik, Hassan Khawaja, Ståle Antonsen, Taimur Hassan, Ghulam Hussain, Mojtaba Moatamedi. Strain Wave Analysis in Carbon-Fiber-Reinforced Composites subjected to Drop Weight Impact Test using ANSYS®. The International Journal of Multiphysics, 2021, 15(3): 275-290. <https://doi.org/10.21152/1750-9548.15.3.275>

Thermography – CHT Simulation

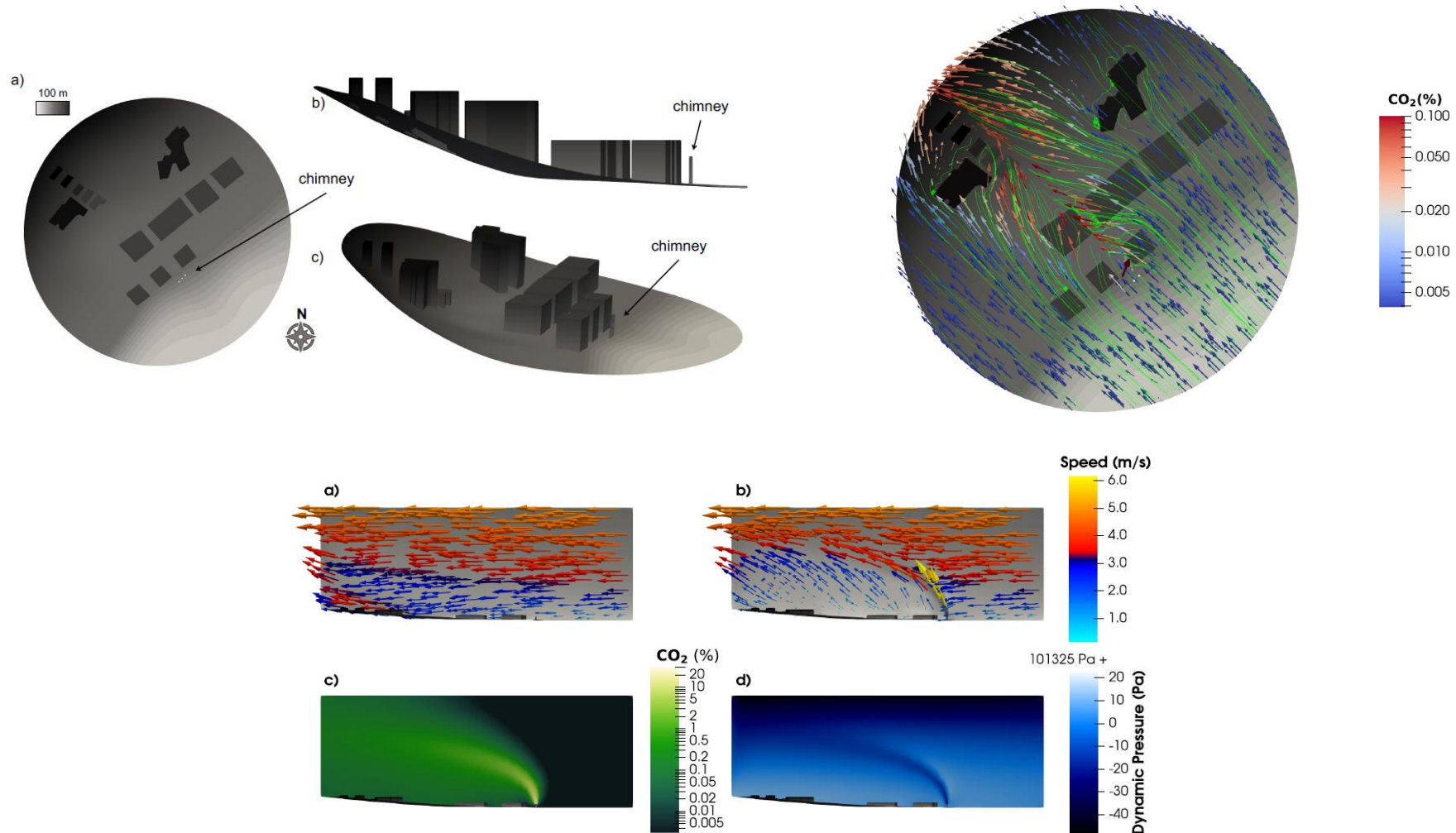


Zahra Andleeb, Sohail Malik, Hassan Khawaja, Anders Nordli, Ståle Antonsen, Ghulam Hussain, Mojtaba Moatamedi. Thermoelastic Investigation of Carbon-Fiber-Reinforced Composites using Drop Weight Impact Test. Applied Sciences, 2021, 11(1): <https://doi.org/10.3390/app11010207>

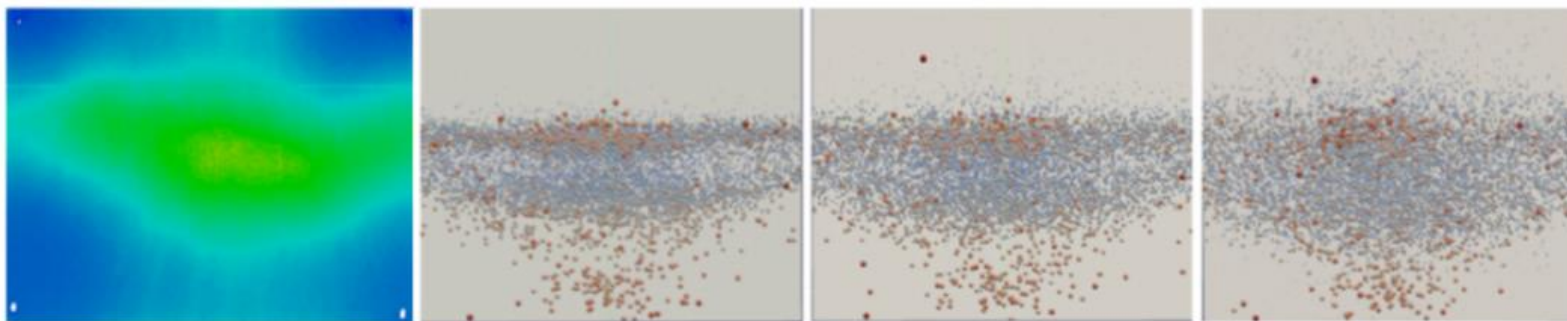
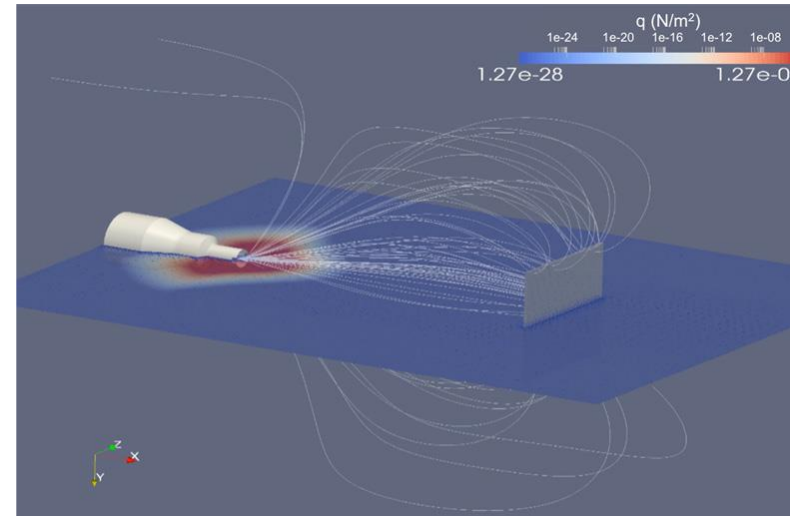
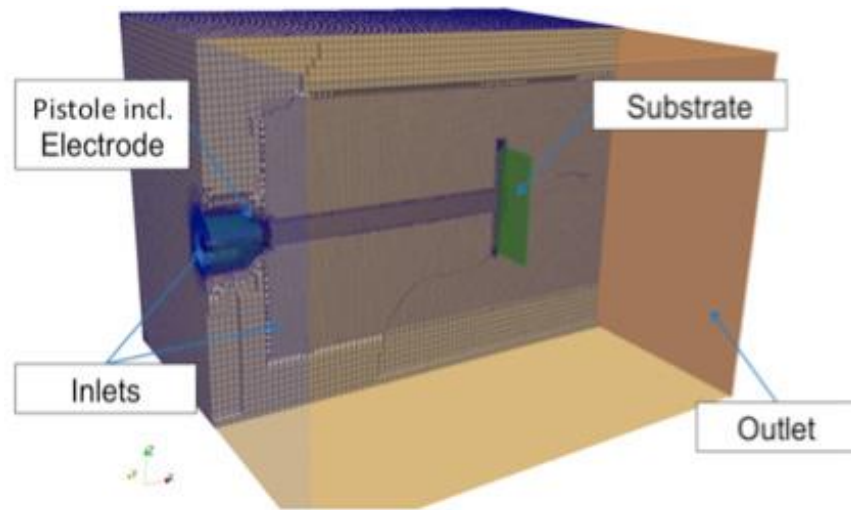
Flow in Highway Tunnel – CFD Simulation



Emission Breivika Port – CFD Simulation



Powder ES Spray – CFD/ES/EM Simulation



Experiment

k-factor: 0.5

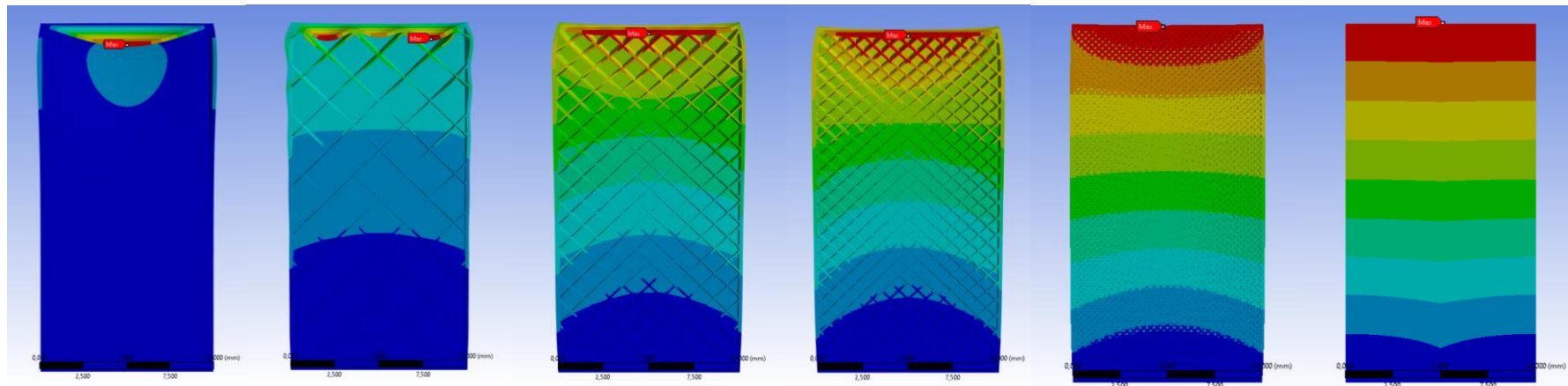
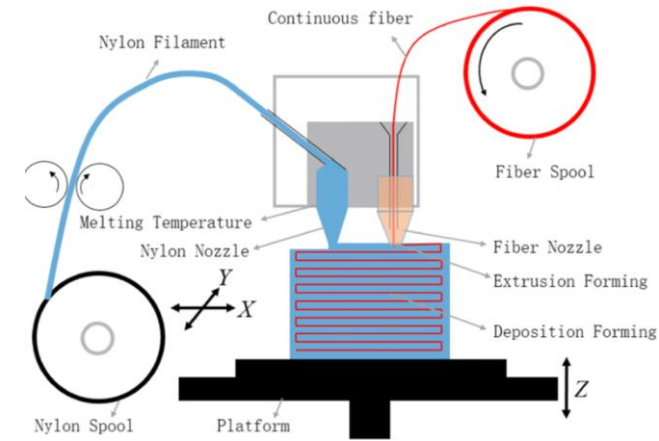
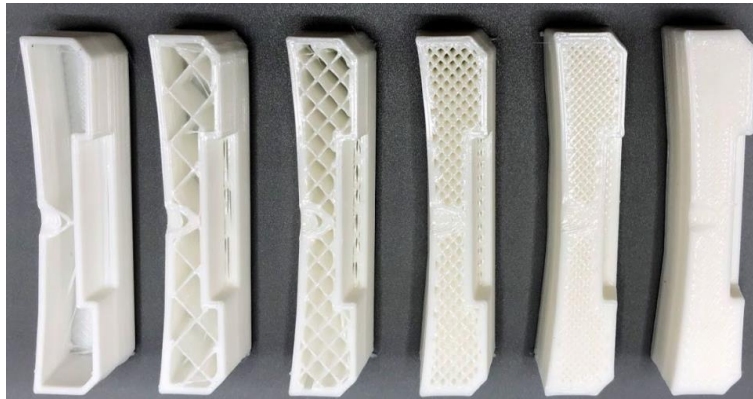
k-factor: 1

k-factor: 2

Gernot Boiger, Marlon Boldrini, Viktor Lienhard, Bercan Siyahhan, Hassan Khawaja, Mojtaba Moatamedi. Multiphysics Eulerian-Lagrangian Electrostatic Particle Spray Model for OpenFOAM® and KaleidoSim® Cloud-Platform. The International Journal of Multiphysics, 2020, 14(1): pp.1-16.

<http://dx.doi.org/10.21152/1750-9548.14.1.1>

3D Print Structure Integrity – FEM Simulation



Zahra Andleeb, Hassan Khawaja, Kristian Andersen and Mojtaba Moatamedi. Finite Element Analysis to determine the impact of Infill density on Mechanical Properties of 3D Printed Materials. The International Journal of Multiphysics, 2022, 16(3), pp. 317-335. <https://doi.org/10.21152/1750-9548.16.3.317>



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Thank you and questions!

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