OTTO VON GUERICKE UNIVERSITÄT MAGDEBURG

Institut of Process Engineering
Chair of Mechanical Process Engineering

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**Vita**

## Summary

Fabian Sewerin's research is focused on the physical description of turbulent flows in which particles are immersed that may interact with each other and with the ambient fluid both mechanically and chemically. These dispersed multiphase flows occur in many environmental and engineering applications, ranging from the atmospheric condensation of clouds and the formation of soot in hydrocarbon flames to the combustion of metal powders and the cultivation of cells. In order to enhance our physical understanding and augment prediction and design capacities, Fabian's long-term objective is to establish model formulations for multiphase flows that require a minimum of experimental calibration and to develop innovative numerical solution schemes that achieve an optimal balance of accuracy and computational expense, while minimizing user intervention. With the aid of the combined physical descriptions and numerical methods, Fabian works on answering open questions on the realizability of emerging technologies that could assist the industrialization of regenerative therapies and the transition to a sustainable energy economy.

## Method development

- PDF methods for turbulent particle-laden flows
- Eulerian stochastic solution methods
- Direct discretization methods based on moving meshes
- GPU acceleration

## About myself

Fabian obtained a Diploma in Aerospace Engineering from the Technical University of Munich and a Master of Science in Solid Mechanics from the University of California at Berkeley. During his stay at Berkeley, he was supported by a University Scholarship of the German-American Fulbright Commission. From 2013 to 2017, Fabian worked at the Imperial College in London as a doctoral researcher, exploring the use of graphics cards to accelerate combustion simulations and enhancing the large eddy simulation framework by a capacity to predict aerosol size distributions. The applications he considered in this context encompassed crystal precipitation, droplet condensation and soot formation. Towards the end of his PhD, Fabian was appointed lecturer at the Technical University of Braunschweig. Here, he taught classes on finite element methods, continuum mechanics and stochastic analysis. Since 2021, Fabian has been establishing a Junior Research Group on Dispersed Multiphase Flows within the Emmy Noether Program of the German Research Foundation. His group develops a probabilistic modelling framework for turbulent flows with immersed particles that circumvents existing mathematical and physical assumptions and can be deployed to analyze and design metal fuel combustors and bioreactors for the cultivation of stem cells.

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| 2021 – Present | Emmy Noether Junior Research Group Leader<br><br>*Otto-von-Guericke-Universität Magdeburg* |
| 2017 – 2020 | Lecturer<br><br>*Technische Universität Braunschweig* |

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| 2013 – 2017 | PhD Student<br>*Imperial College London* |
| 2010 – 2011 | MSc Program on Solid Mechanics<br>*University of California, Berkeley* |
| 2006 – 2013 | Diploma Program on Aerospace Engineering<br>*Technische Universität München* |

### Emmy Noether Group for Dispersed Multiphase Flows

Fabian currently leads the Emmy Noether Group for Dispersed Multiphase Flows which was established at the Otto-von-Guericke University Magdeburg in January 2021 and is hosted by Professor Berend van Wachem at the Institute of Process Engineering. The research work of the Emmy Noether Group targets an improvement in our understanding of the small-scale processes that occur in dispersed multiphase flows and which control and drive their large-scale behaviour. This understanding combined with a reliable, reactor-independent physical description is particularly important for the development and industrialization of two emerging technologies, the combustion of metal fuels and the cultivation of stem cells on microcarriers.

Metal fuels are micron-sized particles of pure metals, for example, iron, aluminum or lithium that can be burned in air in a similar way to hydrocarbons, releasing chemically stored energy as heat. During combustion, the metal particles are converted into metal oxide particles which can, at least in principle, be extracted from the exhaust fumes, collected and recycled using regenerative energy sources. Potentially, this metal oxidation-reduction cycle could form the basis of a carbon-free, sustainable energy economy in which the metal fuels play a role akin to high-temperature batteries. Presently, however, estimates of the oxide size distributions are scarce and economical technologies for separating the fine oxide particles from the exhaust gases have not yet been assessed. Furthermore, many questions related to the achievable power density, the potential formation of harmful nitrogen oxides and the degree of fuel conversion remain unanswered. By virtue of the novel physical modelling and numerical solution methods, we aim at assessing the viability of the metal fuel concept and the feasibility of the oxide recycling step.

Physically, very similar processes and small-scale interactions occur with a completely different application that we investigate, the industrial cultivation of mesenchymal stem cells. *In vivo*, mesenchymal stem cells play the role of injury drugstores that coordinate and orchestrate regenerative measures and modulate the immune response. In an allogeneic therapy, these cells are extracted from a donor’s bone marrow, multiplied by industrial cultivation and, subsequently, transplanted into patients’ tissues.  A characteristics property of mesenchymal stem cells is that they require a surface for adhesion in order to multiply and proliferate. For this reason, one technology that is currently explored on the lab-scale for economical and well-controllable cell amplification consists in seeding the cells on so-called microcarriers and agitating the cell-populated microcarriers in a stirred-tank reactor. Upon amendment of the novel modelling framework by kinetics for the cell metabolism and cell fission, we target predictions of the cell yield, while taking into account small-scale dispersion, collisions and inhomogeneities in the substrate and metabolite distributions. Ultimately, our objective is to derive recommendations for the design and operation of bioreactors that aid the transition from the lab scale to industrial cultivations.

Group members

- Dr. Fabian Sewerin, Group Leader
- Jannis Finke, MSc, Research Scientist