

## **PICLas: A Highly Flexible Particle Code for the Simulation of Reactive Plasma Flows**

*Stephen Copplestone and Claus-Dieter Munz  
Institute of Aerodynamics and Gas Dynamics  
University of Stuttgart, Pfaffenwaldring 21  
70569 Stuttgart, Germany*

*Marcel Pfeiffer and Stefanos Fasoulas  
Institute of Space Systems  
University of Stuttgart, Pfaffenwaldring 29  
70569 Stuttgart, Germany*

**PICLas**<sup>1</sup> is a parallel high-order three-dimensional PIC-DSMC solver developed cooperatively by the Institute of Space Systems and Institute of Aerodynamics and Gas Dynamics at the University of Stuttgart. Application areas include the simulation of electric propulsion systems, atmospheric entry manoeuvres and laser ablation. As other state-of-the-art simulation codes, PICLas couples methods that consider charged particles as well as particle collisions with chemical reactions, which are handled in a stochastic manner. Possible chemical reactions that occur at different stages within a plasma, are modeled on a microscopic level by employing the recently developed Q-K model<sup>2</sup>.

The talk will focus on the combined concepts realised in PICLas for the simulation of reactive plasma flows. Additional emphasis will be directed towards the laser ablation of metals, where the impacting laser generates a plasma plume in front of a surface that expands into vacuum or a background medium. Different effects within the expanding plume are responsible for charge separation and particle acceleration<sup>3</sup>, which fundamentally affect the expansion characteristics that are important for subsequent laser-plasma interactions.

1. C.-D. Munz, M. Auweter-Kurtz, S. Fasoulas, A. Mirza, P. Ortwein, M. Pfeiffer, and T. Stindl. "Coupled Particle-In-Cell and Direct Simulation Monte Carlo method for simulating reactive plasma flows". *Comptes Rendus Mécanique* 342.10-11 (2014), 662–670

2. G. A. Bird, "The QK model for gas-phase chemical reaction rates", *Physics of Fluids*, Vol. 23, Issue 10, 2011, p. 106101.

3. T. Nedelea and H. Urbassek, "Particle-in-cell-study of charge-state segregation in expanding plasmas due to three-body recombination", *Journal of Physics D: Applied Physics*, Vol. 37, Issue 21, 2004, pp. 2981-2986.

---

\* Work supported by the Deutsche Forschungsgemeinschaft (DFG) within the Collaborative Research Center SFB 716.