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Towards single shot diagnostics in low temperature plasmas

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Abstract - Low temperature plasmas at atmospheric pressure are often characterized by high dynamics in space and time. For example, filamentary plasma jets interacting with liquids such as used in plasma medicine show a stochastic development of plasma pathways in a turbulent multiphase environment. This affects the electric field (leading to plasma breakdown), the plasma's species composition, and consequently its reactivity. To understand the fundamental processes of plasma generation and energy dissipation that drive a plasma's reactivity, a detailed characterization and plasma diagnostics are required. High gradients and small-scale species' distribution in filamentary plasmas challenge conventional diagnostic methods.

The talk describes ways to measure low intensity stochastic events on short time scales on the examples of fs-laser electric field measurements (E-fish) and Rayleigh scattering measurements. Single shot measurements accurately represent real time events. Highly sensitive measurements, however, typically require averaging procedures to sufficiently increase signal to noise ratio. For random events in space or time, averaging can easily lead to unwanted smearing and distortion of results. Post processing of data presents the possibility to combine the accuracy of single shot data recording with the benefits of averaging procedures. Three approaches will be discussed in which single shot data of stochastic events such as the electric field and the flow field of an atmospheric pressure plasma jet are collected. Firstly, *time binning* sorts electric field measurements in a post-processing routine according to their random delay with respect to the applied voltage in order to increase the time resolution. Secondly, *advanced averaging* yields an increased signal to noise ratio from post-processing that averages electric field measurements sorted into groups. Finally, *space slicing* allows "discretized 3D-measurements", spreading multiple laser sheets across the measurement volume. The described methods are presented exemplarily for real time event monitoring.

Short Bio:

Stephan Reuter is associate professor for plasma physics and spectroscopy at the Engineering Physics Department of Polytechnique Montréal, Canada and holds the TransMedTech chair for plasma medicine. He received his PhD from the University of Duisburg-Essen, Germany and is alumnus of the Alexander von Humboldt Foundation.
From 2017 to 2018, he was Feodor-Lynen Fellow at Princeton University. He was visiting professor at Université Paris-Sud/Paris-Saclay and at Lublin Technical University, Poland. He established the “plasmatis” physics research group for plasma medicine at the Leibniz Institute for Plasma Science and Technology INP Greifswald, Germany, where he led a research team from 2010 to 2016. In 2008/09, he was a research fellow at the center for plasma physics at Queen’s University Belfast, UK.
His research involves the interaction of non-thermal plasmas with liquids. He develops diagnostic methods using ultrafast laser spectroscopy, spectral imaging, and single shot techniques. Studied application fields are plasmas for medicine, environment, and material synthesis.