P 21: Codes and Modeling II

Time: Friday 9:00–10:30 Location: KH 01.013

Invited Talk P 21.1 Fri 9:00 KH 01.013

Performance Pitfalls and Design Principles of Retarding Potential Analyzers — •Thomas Trottenberg — Institute of Experimental and Applied Physics, Kiel University, Kiel, Germany

Retarding potential analyzers (RPAs) are standard diagnostics for ion energy distribution measurements, yet their performance is often limited by subtle but critical mechanical design choices. Grid alignment, aperture geometry, grid thickness, and spacing can strongly affect the measured current-voltage characteristics and may introduce non-monotonic behavior and artificial humps.

In this talk, experimental results and trajectory simulations of a four-grid RPA with drilled grids are presented, systematically quantifying the impact of grid orientation and hole geometry. It is shown that certain grid alignments introduce strong correlation effects between adjacent grids, resulting in enhanced transparency and pronounced anomalies close to the falling edge in the characteristics.

These findings reveal fundamental performance pitfalls of RPAs and form the basis for practical design guidelines. Concrete recommendations for grid geometry and alignment are derived, aiming at robust, monotonic characteristics and reliable ion energy distribution functions.

Invited Talk P 21.2 Fri 9:30 KH 01.013

Microwave cavity resonance spectroscopy: a novel approach for spatially resolved electron density measurements — •Jens Oberrath — Modeling and Simulation, South Westphalia University of Applied Sciences, Soest, Germany

Electron density is a critical parameter of plasma. Its non-invasive measurement becomes particularly challenging when spatial resolution is required. A promising technique for this purpose is Microwave Cavity Resonance Spectroscopy (MCRS), where electromagnetic waves are coupled into a plasma-filled cavity to excite resonances. These resonances, which also occur in vacuum, are shifted by the presence of the plasma. MCRS has been known since the 1950s. While significant improvements have been made over the past few decades, a robust approach for measuring spatially resolved electron densities has yet to be fully developed. The scattering behavior of a plasma-filled cavity with a finite number of connected waveguides can be described by the shell-model approach developed by Mahaux and Weidenmüller. Using functional analytic methods, the scattering matrix S for such a cavity can be derived. Assuming a cold plasma model for the electrons, the calculated elements of S (reflection and transmission coefficients) contain the spatially dependent electron density. For a specific type of plasma, a density profile can be assumed and expanded as a function with a certain number of unknown parameters. By comparing the calculated elements of S with the measured ones, these unknown parameters in the density profile can be determined, enabling the spatially resolved measurement of electron densities.

P 21.3 Fri 10:00 KH 01.013

Event-driven simulation of X-ray Thomson scattering for warm dense matter probing — •Uwe Hernandez Acosta[1,2], Thomas Gawne[1,2], Jan Vorberger[1], Hannah Bellenbaum[1,2], and Tobias Dornheim[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Germany — [2]Center for Advanced Systems Understanding, Görlitz, Germany

X-ray Thomson scattering (XRTS) is a central diagnostic for investigating matter under extreme conditions, including laser-driven pump-probe experiments at X-ray free-electron lasers that probe high-energy-density states such as warm dense matter and the compression path of inertial confinement fusion capsules. The analysis of XRTS spectra is often challenging due to low photon counts, evolving sample conditions, and strong geometric and instrumental effects, which are only partially captured by conventional forward-modeling approaches based on convolutions of the dynamic structure factor with simplified source and instrument functions.

We present a proof-of-principle event-driven approach to XRTS modeling that directly connects microscopic electronic-structure physics with realistic detector simulations. Individual scattering events are sampled from the XRTS differential cross section and propagated through a detector model, naturally incorporating instrument response, geometry, and counting statistics. Focusing on non-resonant XRTS in a synthetic diagnostic setup, we demonstrate the technical feasibility and physical consistency of the method and benchmark it against conventional forward models.

P 21.4 Fri 10:15 KH 01.013

Characterising strongly compressed Beryllium using a combined ray tracing and forward-fitting approach — •Hannah Bellenbaum[1,2,3] and Tobias Dornheim[2,1] — [1]Center for Advanced Systems Understanding, Untermarkt 20, 02826 Görlitz, Deutschland — [2]Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstraße 400, 01328 DresdenHelmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstraße 400, 01328 Dresden, Deutschland — [3]Institut für Physik, Universität Rostock, Albert-Einstein-Str. 23, 18059 Rostock, Deutschland

X-ray Thomson scattering (XRTS) is a commonly used diagnostic in the warm dense matter regime, as it can be used to simultaneously characterise density, temperature and ionisation degree. Extracting these parameters however commonly relies on a forward-modelling approach where a simple model is fitted to experimental data, since the measured spectrum is a convolution of the dynamic structure factor (DSF) describing the plasma conditions and the source-instrument function (SIF) of the detector . This introduces a number of uncertainties and model-dependencies, and fundamentally relies on the model chosen for the SIF. Here, we present a forward-fit using a new open-source XRTS code (xDave) in combination with the ray tracing code HEART to analyse spectra measured for imploding Beryllium capsules at the National Ignition Facility. The coupling of this ray tracing code with a reduced model for the DSF introduces far fewer uncertainties in both the instrument response function and the source spectrum, allowing us accurately study a typical NIF capsule during implosion.