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Frequency Resolved Fe Opacities Measurements at Conditions Approaching the Base of the Solar Convection Zone

T. Nagayama, J. E. Bailey, G. Loisel, G. A. Rochau, S. Hansen

Sandia National Laboratories, Albuquerque, New Mexico 87185, USA

Knowledge of the Sun is a foundation for other stars. However, after the solar abundance revision in 2005, standard solar models disagree with helioseismic measurements particularly at the solar convection zone base (CZB, r~0.7 R_{sun}) [Basu, *et al*, Physics Reports **457**, 217 (2008)]. One possible explanation is an underestimate in the Fe opacity at the CZB [Bailey, *et al*, Phys. Plasmas **16**, 058101 (2009)].

Opacity measurements are crucial to benchmark modeled opacities used in plasma simulation codes (e.g. standard solar models, hydrodynamic simulations). However, the measurements are, in general, rarely done due to challenging criteria for reliable opacity measurements: 1) smooth and strong backlighter, 2) plasma condition uniformity, and 3) simultaneous measurements of plasma condition and transmission. We believe that these requirements can be satisfied by radiation produced by Sandia National Laboratories (SNL) Z-pinch dynamic hohlraum (ZPDH) and plasma condition measurements by K-shell spectroscopy of a tracer element.

To better constrain the solar abundance problem, frequency resolved Fe opacities are measured at different conditions (T_e=150-200 eV and n_e=7x10^{21}-5x10^{22} cm^{-3}) at SNL. Fe sample is volumetrically heated by radiation from ZPDH to achieve uniform condition. The smooth and strong backlighter is also provided by the ZPDH at stagnation. Fe plasma condition is measured by mixing Mg into the Fe sample and employing Mg K-shell line transmission spectroscopy. Also, an experiment is designed and performed to measure the level of non-uniformity in the Fe plasma by mixing Al and Mg dopants on the opposite side of the Fe sample and analyzing their space-resolved spectra. Based on the inferred conditions, we achieved similar charge state distribution at different density. This is very important because such data have potential to investigate the validity of the atomic data from the low-density data, and then study how the opacity spectra change as density increases due to continuum lowering, Stark lineshapes, and possibly the density effects on the atomic data themselves.

The focus of the talk is spectroscopic measurement of Fe plasma condition and its uniformity, and current status on non-local thermal equilibrium effects on the data as well as comparison between the modeled opacities and the measured opacities.

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