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Measurements of ion-electron equilibration utilizing low-velocity ion stopping in High Energy Density Plasmas at OMEGA[1]

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Obtaining a fundamental understanding of ion-electron (i-e) equilibration in High Energy Density Plasmas (HEDP) is essential for advancing basic plasma science and for correctly modeling the energy balance in Inertial Confinement Fusion (ICF) implosions. I-e equilibration has therefore been the subject of extensive analytical and numerical studies over decades. However, only a limited set of experimental data exists to test these theories. The lack of data is generally due to the dynamic and complex nature of HEDP, seriously compromising any methods that try to directly relate observables to the i-e equilibration process. To address this issue, we have developed and utilized a novel method for diagnosing i-e equilibration through low-velocity ion-stopping-power measurements. This method relies upon the fact that the cross section for the i-e energy transfer is identical for the ion-stopping power and i-e equilibration process when the ion velocity is less than the mean velocity of the thermal distribution of electrons, meaning that the information about the i-e equilibration is encoded in the energy loss of the low-velocity ions. Precision measurements of i-e equilibration were therefore conducted using 1-MeV tritons from DD reactions and 3.7-MeV alphas from D3He reactions in D3He gas-filled implosions. These implosions were doped with a trace amount of argon to diagnose the electron density and temperature, which fall in the ranges of $3\text{x}10^{23}$ – $2\text{x}10^{24}$ cm^{-3} and 1.3 – 2.1 keV, respectively. The i-e equilibration results observed in these experiments are well described by the Brown-Singleton and Gerkie-Murillo-Schlanges theories. Finally, future experiments are being planned to use this method to study i-e equilibration in higher-density plasmas where theories are more divergent. Co-authors: P. E. Grabowski, J. Frenje, S. D. Baalrud, B. Bachmann, A. Bose, R. Florido, V. Glebov, F. Graziani, S. X. Hu, M. G. Johnson, T. Joshi, N. V. Kabadi, B. Lahmann, C. K. Li, R. Mancini, S. P. Regan, F. H. Seguin, B. Srinivasan, C. Stoeckl, G. D. Sutcliffe, R. D. Petrasso

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