Enhanced laser-energy absorption in laser-foil interactions driven by recirculating electron currents

R. Wilson[1], R. J. Gray[1], M. King[1], S. D. R. Williamson[1], R. J. Dance[1], C. Armstrong[1,2], C. Brabetz[3], F. Wagner[3], B. Zielbauer[3], V. Bagnoud[3], D. Neely[2,1], P. McKenna[1]

[1] *SUPA Department of Physics, University of Strathclyde. Glasgow, UK*

[2] *Central Laser Facility, STFC Rutherford Appleton Laboratory, Oxfordshire, UK*

[3] *Plasma Physics Department, GSI GSI Helmholtzzentrum fuer Schwerionenforschung GmbH, D-64291 Darmstadt, Germany*

Laser energy absorption in dense plasma is fundamental to a range of intense laser-driven particle and radiation generation mechanisms. The coupling of energy to plasma electrons defines the properties of the radiation beams produced and strongly influences the optical properties of the plasma. Using the high power PHELIX laser at the GSI laboratory, we measure the total reflected and scattered laser energy as a function of intensity, by using an integrating (Ulbricht) sphere. We distinguish between the influence of pulse energy and focal spot size on total energy absorption, in the interaction of intense laser pulses with thin foils. We confirm the scaling of absorption with intensity by variation of laser pulse energy as previously reported in reference [1], but find a slower scaling when changing the focal spot size. The results were recently published in reference [2]. Using 2D particle-in-cell simulations, we show that the measured differences arise due to energetic electrons recirculating within the target. These electrons undergo multiple interactions with the laser pulse, enhancing absorption in the case of a large focal spot. This effect is found to be dependent on the laser pulse duration, the target thickness and the divergence of the fast electron beam. The parameter space over which this occurs is explored via an analytical model. The experimental, simulation and model results will be presented, and the impact of the results on our understanding of the fundamental physics of laser energy absorption in solids will be discussed.

[1] Y. Ping et al, Phys. Rev. Lett., 100, 085004 (2008).

[2] R. J. Gray et al, New J. Phys., At press (2018): DOI:10.1088/1367-2630/aab089