Looking into solid-density plasmas using attosecond XUV dispersion

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Extreme-ultraviolet (XUV) pulses can propagate through ionized solid-density targets, unlike optical pulses, and thus have the potential to probe the interior of such plasmas on sub-femtosecond time scale. We present a synthetic diagnostic method for solid-density laser-generated plasmas based on the dispersion of an XUV attosecond probe pulse, in a pump–probe scheme.

We demonstrate the theoretical feasibility of this approach through calculating the dispersion of an extreme-ultraviolet probe pulse propagating through a laser-generated plasma [1]. The plasma dynamics is calculated using a particle-in-cell simulation, while the dispersion of the probe is calculated with an external pseudo-spectral wave solver. By separating the plasma simulation and probe propagation, high numerical accuracy, at a low numerical cost, is achieved when calculating the dispersion. The dispersion of the pulse is quantified via the relative group delay of the frequency components, as would be measured experimentally by the RABBIT or attosecond streak camera methods [2, 3]

We illustrate the application of this method on thin-film plastic and aluminium targets irradiated by a high-intensity pump pulse. By comparing the dispersion of the probe pulse at different delays relative to the pump pulse, it is possible to follow the evolution of the plasma as it disintegrates – from initial laser compression to hydrodynamical expansion. The high-frequency asymptotic behaviour of the group delay provides information on the line-integrated electron density along the path of the probe. By following the group delay at a fixed frequency when varying the pump–probe delay, the group delay at lower frequencies are mostly affected by the highest density encountered along the path of the probe. In this way, the effect of the laser-induced compression of the target can be followed. In addition, the presence of thin-film interference – requiring well-defined plasma–vacuum boundaries – in the transmitted probe pulse could be used to study the evolution of the plasma surface.

References

[1] A. Sundström, I. Pusztai, P. Eng-Johnsson, and T. Fülöp, *Submitted to JPP* (2022), `https://arxiv.org/abs/2202.00406`.

[2] P. M. Paul et al., Science **292**(5522) 1689 (2001).

[3] J. Itatani et al., Phys. Rev. Lett. **88** 173903 (2002).