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Bulk ion acceleration from ultrathin foils in PW-class interactions on the ASTRA GEMINI laser

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During the interaction of ultra-intense laser pulses with ultrathin foils, advanced mechanisms of ion acceleration take place which can be controlled and optimized in view of further progress towards high energy ranges of medical relevance on upcoming multi-PW facilities.
In the framework of the activities of the UK-wide A-SAIL project, recent campaigns at the ASTRA GEMINI laser facility (Rutherford Appleton Laboratory) have investigated and characterised ion acceleration from 2-100 nm thick Carbon foils irradiated by 40 fs laser pulses at intensities of 1020-1021 W/cm2. The experiments have highlighted a strong dependence of the ion energy from the target thickness and the laser polarisation, and suggested the onset of Light Sail Radiation Pressure acceleration from the bulk of the target when using circularly polarized pulses.
Following initial results (published in PRL, 119, 054801, 2017), following campaigns have led to an enhancement of the ion energies (up to ~35 MeV/n for Carbon 6+) and to observations of an intensity-dependent optimal thickness, consistently with analytical predictions. Comparison with extensive Particle-in-Cell simulations clarifies the complex interplay of multispecies dynamics during the acceleration, as well as the role of relativistically-induced transparency, and allows predictions of future performance at increased laser power and intensity.

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