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Radiation pressure effects on ion acceleration with ultra-intense laser pulses[1]

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In most laser-driven ion acceleration studies carried out to date, ions are accelerated by sheath fields established by relativistic electrons at target surfaces, via the so-called Target Normal Sheath Acceleration (TNSA). A separate mechanism, Radiation Pressure Acceleration (RPA), has attracted extensive theoretical attention in recent years. Radiation pressure is exerted at the laser reflection point on a foil surface via the ponderomotive force, which results in local electron-ion displacement, and ion acceleration via the ensuing space-charge field. Cyclical reacceleration of the target ions in the Light Sail RPA mode accessible with ultrathin foils is predicted to lead to high acceleration efficiencies, and to energetic, narrow band ion beams. While at extreme intensities ($>10^{23}$ W/cm^2) RPA is expected to dominate over TNSA, the use of circularly polarized light has been suggested as a means to isolate radiation pressure effects at intensities presently accessible. After reviewing the relevant theoretical and numerical background, this presentation will discuss the results of recent campaigns carried out at CLF-RAL (UK) by the UK-wide LIBRA consortium where ion acceleration has been investigated using high-contrast pulses at intensities in the 10^{20}-10^{21} W/cm^2 range and ultrathin dielectric and metallic foils. Ion spectral features deviating significantly from typical TNSA spectra have been observed, with the emergence of clear, narrow peaks in proton and carbon spectra. The dependence of these features on laser polarization, intensity and on the target composition and areal density has been studied. Comparison of these results with Particle in Cell simulations suggests a scenario in which radiation pressure effects start to play a significant role.

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