



Fourth International Conference on

SUPERSTRONG FIELDS IN PLASMAS

October 2010, Sunday 3 to Saturday 9
Villa Monastero, Varenna, Italy

Radiation pressure acceleration of ions from thin foils irradiated by ultraintense laser pulses

M. Borghesi

Centre for Plasma Physics, The Queen's University of Belfast

Belfast BT7 1NN (UK)

m.borghesi@qub.ac.uk, <http://www.qub.ac.uk/cpp>

In most of the laser-driven ion acceleration studies carried out to date, ions are driven 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 acceleration of the ions via the ensuing space-charge field. Two regimes have been highlighted in the literature: the so-called hole-boring regime, where dense ion bunches are injected from the front surface into relatively thick targets, and the more promising Light Sail (LS) regime, where, in sufficiently thin foils, the whole irradiated target region is detached and pushed forward. While at extreme intensities (10^{23} W/cm²) RPA should dominate, the use of circularly polarized light has been suggested as a way to isolate Radiation pressure effects at present intensities, where they are normally suppressed or masked by electron heating and TNSA features. Cyclical reacceleration of the target ions in LS RPA is predicted to lead to high acceleration efficiencies, and produce monoenergetic beams, with multi-GeV/nucleon energies at $I \sim 10^{22}$ W/cm².

After reviewing theoretical background and context, we will present the results of recent campaigns carried out at the Rutherford Appleton Laboratory, investigating the emergence of RPA effects in ion acceleration from ultra-thin foils (down to 10 nm thickness). The experiments, carried out in the framework of the UK-wide collaborative LIBRA project, employed the ASTRA GEMINI and VULCAN Petawatt systems, providing peak intensities in the range $1\text{-}5 \cdot 10^{20}$ W/cm², obtained respectively with 50 and 500 fs pulse durations. In both cases, interaction with ultrathin foils has led to highly non thermal spectra, presenting pronounced, correlated Proton and Carbon narrow band peaks, with energy scaling almost linearly with laser intensity. A strong dependence on the laser polarization and target thickness characterizes the data. These results, and the comparison with PIC simulations, suggest the onset of the Light Sail RPA regime. The simulations indicate that, while energies observed so far are in the 10-30 MeV /nucleon range, 100 MeV/nucleon peaks are within reach via this mechanism with a moderate intensity increase.

Contributors: D.Doria, M.Geissler, K.Kakolee, S. Kar, R.Prasad, B. Qiao, K.Quinn, L.Romagnani, S. Ter-Avetisyan, M. Zepf (Queen's University Belfast), D.Carroll, O.Tresca, X.Yuan, P.McKenna (Strathclyde University), C.Brennan, P.Foster, J.Green, P.Gallegos, A.P.L.Robinson, D. Neely (STFC Rutherford Appleton Laboratory), N.Dover, C. Palmer, Z.Najmudin (Imperial College), J.Schreiber (MPQ Munich) A.Macchi (Pisa University), T.Liseikina (MPIK, Heidelberg).