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Ion acceleration using ultra-high intensity lasers

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For the past several years there has been significant experimental and theoretical developments into the generation of highly directional energetic proton and ion beams from the interaction of intense ultra-short laser pulses with thin solid targets. Recent results have shown that these beams can be produced with mono-energetic features and that they can also be generated from underdense interactions. With the recent construction of many Petawatt-class high intensity laser systems around the world – both high energy picosecond laser systems as well as Titanium:Sapphire high repetition rate lasers (including the HERCULES laser system at Michigan) – ion/proton beams having energies of several hundred MeV may soon be produced. New mechanisms for the generation of very energetic beams have also been proposed which use ultra-thin (less than 100 nm) targets. Such experiments consequently require very careful control of the properties of the laser pulses used. The proton beams produced from present experiments are already important as a diagnostic of electric/magnetic fields within laser-produced plasmas and using the new facilities under construction these beams may soon become relevant for fusion, medicine and homeland security applications.