Experimental observation of transverse modulations in laser-driven proton beams

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The advent of a new generation of high repetition rate Petawatt (PW) laser systems in combination with recent experimentally achieved proton energies of up to 45 MeV from ultra-short pulse (~ 50 fs) facilities \cite{1, 2} is expected to strongly advance the application of laser-plasma based accelerators for ions, e.g. in medicine.

For the pursuit of higher ion energies at higher laser intensities available at PW laser systems, a thorough characterization and understanding of laser intensity dependent plasma instabilities will be essential for a reliable scaling of present acceleration mechanisms (e.g. target normal sheath acceleration TNSA \cite{3}) and associated proton or ion beam properties.

In this contribution, we report on the experimental observation of transverse modulations in proton beams accelerated from micrometer thick targets which were irradiated with ultra-short (30 fs) laser pulses of a peak intensity of $5 \cdot 10^{20}$ W/cm$^2$ \cite{4}. The net-like proton beam modulations were recorded using radiochromic film and the data show a dependence on laser energy and target thickness for their onset and strength. Numerical simulations suggest that intensity-dependent instabilities in the laser-produced plasma at the target front side lead to electron beam break-up or filamentation, then serving as the source of the observed proton beam modulations.

\cite{1} K. Ogura \textit{et al} 2012 Opt. Lett. 37 2868–70
\cite{2} I. J. Kim \textit{et al} 2013 Phys. Rev. Lett. 111 165003
\cite{3} S. C. Wilks \textit{et al} 2001 Phys. Plasmas 8 542–9
\cite{4} J. Metzkes \textit{et al} 2014 New J. Phys. 16 023008