Abstract

Laser driven shock wave acceleration of protons in a plasma has been demonstrated at the UCLA Neptune Laboratory. This was achieved using a multiterawatt CO\textsubscript{2} laser pulse train focused onto a gas jet target achieving proton energies up to 20 MeV contained within an energy spread of ~1%.

Summary

Laser driven ion acceleration (LDIA) has the potential to deliver compact and affordable accelerators for applications in many fields of science and medicine. Specifically, radiotherapy of cancerous tumors requires ion energies in the range of 200-300 MeV/a.m.u. and with energy spreads on the order of ~5%, parameters thus far beyond the LDIA experimental results using the most powerful lasers in the world. Recently, it was shown experimentally that laser-driven collisionless shocks can accelerate proton beams to 20MeV with extremely narrow energy spreads of about 1% and low emittances [1]. This was achieved using a linearly polarized train of CO\textsubscript{2} laser pulses having a peak power of 4TW interacting with a hydrogen gas-jet target. Computer simulations show that the laser pulse drives the plasma density up locally near the critical surface causing the formation of a shock wave. The shock wave is driven to high velocities by strong electron heating and can subsequently accelerate ions to high energies as it passes through the long scale-length exponentially decaying plasma. This plasma profile, naturally provided by the gas jet and plasma expansion, keeps the sheath electric field small and relatively constant allowing for the generation of a monoenergetic ion beam. Simulations predict the production of ~200MeV protons needed for radiotherapy by using state-of-the-art lasers with an a\textsubscript{0}~10. These results may open a way for developing a compact and versatile, high-repetition-rate ion source for medical and other applications.