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Generation of focused high-energy ion beams via hole-boring radiation pressure acceleration of curved-surface low-density targets

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Relativistic ion beams have wide applications ranging from proton therapy, neutron beam/warm dense matter generation, and fast ignition of fusion pellets. In particular, generating a monoenergetic high energy flux ion beam is of great interest, since fast-ignition scheme of fusion targets require energy fluxes of ~GJ/cm^2. We show that a foam-based target with parabolically shaped front surface can be accelerated and focused to a micron-scale spot using available laser systems and targets. The focal length is controlled by the target front surface shape, and the ion energy: by laser intensity and target mass density. An analytic model based on Hole-Boring Radiation Pressure Acceleration mechanism is developed to explain the result. This scheme is scalable and can be used for a wide range of laser power and target densities to focus monoenergetic ions with different energy to variable focal lengths and can generate fs-scale ultrahigh energy density/flux beams. The mechanism is robust and can be implemented using realistic transverse laser profiles, multi-species targets, or targets with finite longitudinal step-like boundaries.

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