Turbulent wakefield acceleration of relativistic particles

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Abstract

Ever since the discovery of cosmic rays, the origins of cosmic rays have been longstanding open question more than a century. While the galactic cosmic rays are considered to be accelerated by the diffusive shock acceleration at non-relativistic collisionless shocks, the extragalactic origins are not well understood. A possible candidate is wakefield acceleration in extreme astrophysical settings [1]. At relativistic perpendicular collisionless shocks, large amplitude light waves propagate in the upstream as precursor waves [2]. The strong ponderomotive force of the light excites the wakefield, and then, the wakefield nonthermally accelerates upstream particles [2]. The large-scale light waves are subject to self-modulation and filamentation instabilities, which make the wakefield turbulent. Numerical studies in an upstream system show the universal production of power law energy distribution functions of accelerated electrons with an index of -2 independent of the light and plasma conditions [3]. Astrophysical objects are inaccessible and there is no way to observe the plasma quantities to discuss these models. We have performed model experiments of the cosmic ray acceleration due to the turbulent wakefield. Preliminary results with Gekko PW laser show the power law tails with an index of -2 independent of the plasma density [4,5]. We have performed a relevant experiment with the 100 TW laser facility at National Central University [6], which is completely different scale from the Gekko PW laser. Our results show that the turbulent wakefield nonthermally accelerates particles and universally generates power law spectra with an index of -2.

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