HIGH ANGULAR MOMENTUM DENSITY PHYSICS DRIVEN BY HIGH-INTENSITY LASERS

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Relativistic laser pulse has been used as an important research tool in well known high energy density physics as well as in ultrahigh momentum density which has many important applications like radiation pressure acceleration. But another important character of relativistic laser, orbital angular momentum (OAM) effect was ignored.

When a relativistic laser pulse with a high photon density interacts with a specially tailored thin foil target, a strong torque is exerted on the resulting spiral-shaped foil plasma, or "light fan." Because of its structure, the latter can gain significant orbital angular momentum (OAM), and the opposite OAM is imparted to the reflected light, creating a twisted relativistic light pulse. Such an interaction scenario is demonstrated by particle-in-cell simulation as well as analytical modeling, and should be easily verifiable in the laboratory. As an important characteristic, the twisted relativistic light pulse has a strong torque and ultrahigh OAM density. [1]

Relativistic light has opened new research fields in high-field physics, including laser acceleration and relativistic high-order harmonics, because it has a high energy density. Now, relativistic twisted light has high angular momentum density, which may result in many new physical phenomena.

Here we give three main application. First, we propose a simple and effective scheme to generate ultra intense high-order optical vortices that carry large orbital angular momentum in the extreme ultraviolet region by relativistic harmonics from surface of solid target. This method may for the first time produce LG pulses simultaneously of high intensity (in relativistic region), short wavelength, and high charge. [2]

Second, we propose to intense LG pulse to drive an intense walk field for proton acceleration. There is an electron pillar formed in the middle of the bubble since the laser intensity is zero in the middle of the laser. Such electron pillar provides a transverse focusing field for protons so that the protons can be accelerated for a long distance. [3]

Third, the interaction of such intense LG laser with solid density foil is also discussed. The interaction is quite different to in the case using usual Gaussian pulse. [4]

Possible application of LG pulse for inertial confinement fusion is discussed.

[1] Yin Shi, Baifei Shen, Lingang Zhang, Xiaomei Zhang, Wenpeng Wang, Zhizhan Xu, Light Fan Driven by a Relativistic Laser Pulse, *Physical Review Letters* 112(23), 235001(2014).

[2] Xiaomei Zhang, Baifei Shen, Yin Shi, Xiaofeng Wang, Lingang Zhang, Wenpeng Wang, Jiancai Xu, Longqiong Yi, and Zhizhan Xu, *Physical Review Letters* 114, 173901 (2015).

[3] Xiaomei Zhang, Baifei Shen, Lingang Zhang, Jiancai Xu, Xiaofeng Wang, Wenpeng Wang, Longqiong Yi, Yin Shi, Proton acceleration in underdense plasma by ultraintense Laguerre-Gaussian laser pulse, *New Journal of Physics* 16, 123051(2014).

[4] Wenpeng Wang, Baifei Shen, Xiaomei Zhang, Lingang Zhang, Yin Shi and Zhizhan Xu, "Hollow screw like drill in plasma using an intense Laguerre Gaussian laser." *SCIENTIFIC REPORTS*, 5, 8274 (2015).