Plasma channel based new laser wakefield staging scheme and radiation source

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Multistage coupling of laser-wakefield accelerators with independent driving laser pulses is essential to overcome laser energy depletion for high energy applications such as the TeV level electron-positron collider. Currently a staging scheme is achieved by feeding a second laser pulse via a plasma mirror and by controlling the electron beam focusing via active plasma lenses. Here a more compact and efficient scheme is proposed to realize simultaneous coupling of the electron beam and the laser pulse to the second stage with plasma channels [1]. A special designed bending channel is used to guide a fresh laser into a following straight channel, while the electron beam always propagate in the straight channel. Benefiting from the shorter coupling distance and continuous guiding of the electron beam in plasma, its transverse dispersion is suppressed. With moderate laser parameters, our particle-in-cell simulations demonstrate that the electron beam from the previous acceleration stage can be efficiently injected into the following stage for further acceleration, where the re-injection ratio, stability, and beam quality can be kept at a high level.

At the same time, based on plasma channel, we propose a new scheme of controlled X-ray radiation [2,3]. The laser centroid motion in a plasma channel can be well controlled by tuning the channel depth and width. Wakefield behind the driver laser makes similar transverse oscillation, which makes the electrons inside the wake structure do transverse betatron motion and radiate. Three-dimensional PIC simulation and VDSR radiation calculation codes are used to study plasma channel based Helical plasma undulator radiation. It shows both the radiation spectrum and polarization can be well controlled.

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[2] M. Chen, et al., *Light: Science & Applications* **5**, e16015 (2016).
[3] J. Luo, et al., *Sci. Rep.* 6, 29101 (2016)