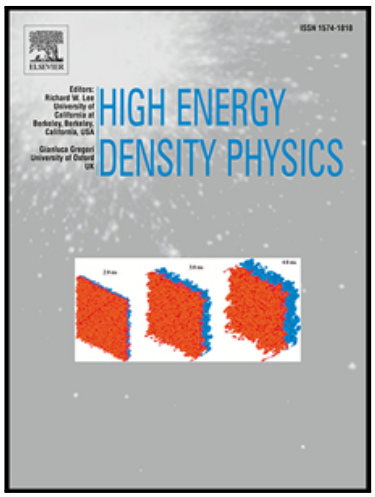

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Interaction of a relativistic electron beam with a laser pulse in the presence of a magnetized plasma medium

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Abstract

Significant progress has been made using plasma channels to guide relativistic e-beams in magnetostatic wiggler free-electron lasers (FELs). In this regard, we study the interaction of an intense laser pulse (as a laser wiggler) with a relativistic electron beam embedded in a background of magnetized plasma. The short wavelength of the laser wiggler ($\sim \mu m$) allows a higher radiation frequency to be obtained than from conventional magnetostatic wigglers. Laser-plasma interaction in a magnetized plasma channel has been studied. Numerical results reveal that the laser self-focusing and self-compression can be enhanced with increasing the external axial magnetic field strength, which leads to a decrease in the spot size of the laser beam. Hence, we employ the laser beam as a suitable laser wiggler in a FEL-device. Injection of plasma in the interaction region of a laser-wiggler-FEL suggests the possibility of producing short wavelengths ($\sim x$-ray) using lower energy beams ($\sim O(10)\ MeV$). Furthermore, this configuration has a higher tunability by controlling the plasma density in addition to the e-beam energy tunability of the conventional FELs. Effects of the external axial guide magnetic field and plasma medium on the gain of the FEL have been studied. It is found that by increasing the plasma frequency the FEL-gain increases. The effects of e-beam self-electric and self-magnetic fields on the laser gain have also been investigated in the presence of various plasma frequencies. The results indicate that in the presence of beam self-fields, the sensitivity of the gain increases in the vicinity of resonance regions. Besides, the normalized wiggler-induced self-magnetic field has been obtained which reveals that it is a positive parameter, i.e., it can act as a paramagnetic correction to the wiggler magnetic field, therefore, the gain enhancement can be due to the paramagnetic effect of the self-magnetic field. This concept opens a path toward a new source of soft x-ray pulse based on table-top plasma loaded laser wigglers.

Keywords: free-electron laser, laser wiggler, magnetized plasma background, laser self-focusing and self-compression, e-beam self-fields

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