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Study of Transverse Instabilities in Proton Driven Hollow Plasma Wakefield Acceleration

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Hollow plasma has been introduced into the proton-driven plasma wakefield accelerator to overcome the issue of beam quality degradation caused by the nonlinear transverse wakefields varying in radius and in time in uniform plasma. It has been demonstrated that the electrons can be accelerated to energy frontier with well-preserved beam quality in a long hollow plasma channel. However, this scheme imposes tight requirements on the driving beam to be on axis of the hollow channel, otherwise the transverse instabilities are deduced. For long-term relativistic beam-plasma interaction, the driving instabilities are of big concern as they could develop excessively and distort the driving bunch dramatically in a long time scale. This would successively trigger a series of nontrivial issues such as reduction of the energy transfer efficiency, nonuniformities of the wakefields and degradation of the beam quality etc. In this contribution, we examine these detrimental effects from theoretical and numerical aspects and discuss the effect of the transverse wakefields on the beam and the resultant beam breakup instability in terms of the beam and plasma parameters.

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