Particle acceleration by stimulated emission of radiation: Theory and experiment

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The interaction of electromagnetic radiation with free electrons in the presence of an active medium has some appealing outcomes. Among them is particle acceleration by stimulated emission of radiation (PASER). In its framework, energy stored in an active medium (microscopic cavities) is transferred directly to an *e*-beam passing through. We have developed a two-dimensional analytic model for the evaluation of the energy exchange occurring as a train of electron microbunches traverses a dilute resonant medium. Efficient interaction occurs at resonance—namely, when the frequency of the train matches the resonance frequency of the medium. It is shown that the energy exchange is γ independent for relativistic energies and it drops dramatically with an increase of the beam's radius. Based on this model, we have evaluated the relative change in the kinetic energy of a 0.1-nC 45-MeV macrobunch traversing an excited CO_2 gas mixture—the former being modulated at the CO_2 laser wavelength. Good agreement is found between the theoretical predictions and the results of the PASER experiment performed recently at Brookhaven National Laboratory.

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