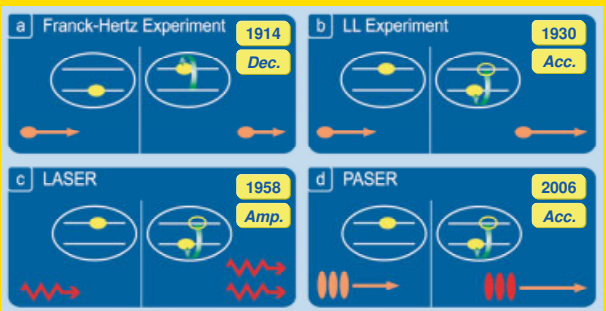
**Abstract** We review the theory and the experimental demonstration of one of the novel advanced particle acceleration techniques dubbed PASER - for particle acceleration by stimulated emission of radiation. In such an acceleration paradigm, bundles of electrons are accelerated using the same principle as in laser. A proof-of-principle experiment, conducted at the Brookhaven National Laboratory, demonstrated this novel acceleration scheme. A 45 MeV electron macrobunch was modulated by a high-power $CO_2$ laser in a wiggler, and then injected into an excited $CO_2$ gas mixture. The emerging microbunches reveal a 0.15% relative change in the kinetic energy in less than 40 cm long interaction region. This is the first experimental demonstration of coherent collisions of the second kind. The fundamental physics underlying the PASER paradigm is discussed via the analysis of a two-dimensional analytic model used to evaluate the energy exchange occurring as a train of electron microbunches traverses an active medium. Furthermore, advanced PASER concepts such as non-linear interaction of electrons and waves in an active medium, the occurrence of resonant absorption instability, and PASER-based optical Bragg accelerators, are considered as well. The possible impact of PASER-based accelerators on future compact medical accelerators, and on high-energy physics applications is discussed.




Light-electron-atom interaction. (a) The Franck-Hertz experiment – collision of the first kind. (b) The Latyscheff-Leipunsky experiment – collision of the second kind. (c) LASER – light amplification by stimulated emission of radiation. Photons coherent multiple collisions. (d) PASER – particle acceleration by stimulated emission of radiation. Coherent collisions of the second kind. Reprinted with permission from [49]. Copyright (2006) by the American Physical Society.



# PASER – particle acceleration by stimulated emission of radiation: theory, experiment, and future applications

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