Steering Smith-Purcell Radiation Angle in a Fixed Frequency by the Metal Grating

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Abstract— Terahertz electromagnetic radiation has unique properties lead to various applications in science and technology, becoming a research hotspot, because of terahertz in a relatively special area on the electromagnetic spectrum, where the wavelength is between millimeter waves and infrared. One of the compact and cost-efficient high-intensity terahertz radiation sources is offered by the Smith-Purcell effect, which generating terahertz radiation by a beam of charged particles passing parallel over a periodic structure. In this paper, we demonstrate that the metal grating can excite the direction-tunable Smith-Purcell radiation by changing the electron beam velocity. For the metal grating, the resonance frequency remains largely unaffected by variations in electron beam velocity and the structure achieves the direction of the Smith-Purcell radiation can be controlled through modulation of the electron beam velocity at the locked frequency without altering the geometric parameters of the structure or increasing the external coupling structure, distinct from the conventional Smith-Purcell radiation at the fixed angle. Remarkably, this approach control radiation angle from 69 degrees to 109 degrees by altering the velocity of electron beam from 0.45\textit{c} to 0.65\textit{c}. Theoretical analysis, PIC simulation, and analytical simulation were used to verify the consistency of the relationship between the radiation direction and the electron beam velocity. This discovery not only opens up a new way to manipulate the electron-beam-induced emission in the near-field region but also promises compact, tunable and efficient light sources and particle detectors.