# Active experiments in space with relativistic electron accelerators

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Electron-beam experiments in space date back to the seventies. They operated primarily in the high-density ionosphere and explored fundamental aspects of space plasma physics such as spacecraft charging, beam-plasma interactions and the generation of very-low-frequency emissions, and radiation belt physics [1]. New scientific and national-security drivers, however, will require the operation of high-power electron beams in the low-density magnetosphere. In one such application, electron beams are used as magnetic-field-line tracers to unambiguously connect physics phenomena occurring in the magnetosphere with their image in the ionosphere and answer long-standing magnetosphere-ionosphere-coupling questions [2]. Another potential application is radiation belt remediation, whereby beam-generated waves can precipitate energetic particles and protect space assets by reducing harmful radiation belt fluxes induced by a high-altitude nuclear explosion [3].

The major obstacle to operating high-power electron beams in low-density plasma environments is spacecraft charging: without spacecraft-charging mitigation, the spacecraft charges to high levels and electrostatically pulls the beam back, preventing beam emission. Strong charging could also induce catastrophic damage to the spacecraft platform. The recent development of compact, relativistic electron accelerators reduces spacecraft charging constraints and, combined with suitable spacecraft-charging mitigation strategies, might open up a new era of active experiments in space.

In this talk, I will present an overview of ongoing research efforts to develop active experiments in space with high-power electron beams. I will primarily motivate the discussion with a new mission concept, called CONNection EXplorer (CONNEX), to connect magnetospheric physical processes to auroral phenomena. CONNEX is based on an electron beam fired from a magnetospheric spacecraft along magnetic field lines and optically imaging the beam spot in the atmosphere/ionosphere [2]. The mitigation steps undertaken for the successful development of CONNEX will be discussed, with a particular focus on a new spacecraft-charging mitigation scheme. The scheme was initially developed with theory and simulations [4], but it has now been successfully validated in laboratory experiments [5]. Last, I will introduce a newly-selected NASA experiment, called B-SPICE, that will validate the spacecraft-charging mitigation scheme on an ionospheric rocket experiment. Time permitting, I will also discuss another NASA ionospheric rocket experiment, called Beam-PIE, that aims at generating plasma waves with next-generation electron accelerators. Beam-PIE supports both CONNEX and radiation belt remediation applications.

Collaborators: Joe Borovsky (Space Science Institute), Brian Gilchrist (University of Michigan), Grant Miars (University of Michigan).

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