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Two New Active Experiments Using Electron Beams in Space

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Many long-standing, unanswered questions stem from our inability to make fundamentally new measurements. Active experiments hold the potential to overcome some of those challenges. We describe here two active experiments using electron beams to probe the microphysics of wave-particle interactions and the global physics of magnetosphere-ionosphere coupling in the auroral/tail transition regions.

Active experiments using electron beams were reasonably popular in the 1970's and 1980's and produced outstanding results. Nevertheless, thirty years of technological innovation now enables a fundamentally new set of measurements with advanced instrumentation and digital signal processing. The experiments we describe here utilize a newly-developed RF linear accelerator to produce highly-customizable electron beams similar in capability to laboratory-based linacs.

The first experiment is a rocket-based experiment called the Beam Plasma Interactions Experiment (Beam PIE) which is set for launch in 2020. Beam PIE will use a 15-55 keV pulsed linear accelerator to (a) generate plasma waves at ionospheric altitudes of ~500 km and (b) measure the scattering of electrons by those artificial waves. A particularly new aspect of this experiment is the ability to generate both whistler mode and extraordinary (X-mode) waves. The X-mode waves, are expected to be particularly effective at pitch angle scattering. By controlling beam energy, pulsing frequency, and duty cycle we can test theories and models of wave particle interactions in unprecedented detail.

We will also describe a new mission proposal designed to resolve the long-standing controversies surrounding magnetic connectivity: the Magnetosphere Ionosphere Connections Explorer. CONNEX is a co-designed magnetospheric constellation and ground-based array. It uses MeV-class linear accelerator on spacecraft in an approximately 5 x 8 Re near-equatorial orbit which is the tricky transition region between the dipole magnetosphere and the magnetotail. The MeV electron beam is powerful enough to produce an artificial auroral 'spot' that can be detected by ground-based imaging arrays and incoherent scatter radars to unambiguously determine the magnetic footpoint of the satellite. A constellation of smaller satellites provides spatial-temporal gradients of key quantities in the vicinity of the main satellite and ground-based observations provide regional-scale context of the auroral ionospheric processes.