Excitation of whistler-mode chorus waves in a laboratory plasma

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Motivated by the puzzles of chorus wave excitation in space and by their recognized importance in radiation belt dynamics, the excitation of whistler-mode chorus waves is studied in the Large Plasma Device at UCLA, by the injection of a helical electron beam into a cold plasma. Incoherent broadband whistler waves similar to magnetospheric hiss are observed in the laboratory plasma. Their mode structure is identified by the phase-correlation technique. It is demonstrated that the waves are excited through a combination of Landau resonance, cyclotron resonance and anomalous cyclotron resonance. To account for the finite size effect of the electron beam, linear unstable eigenmodes of whistler waves are calculated by matching the eigenmode solution at the boundary. It is shown that the perpendicular wave number inside the beam is quantized due to the constraint imposed by the boundary condition. Darwin particle-in-cell simulations are carried out to study the simultaneous excitation of Langmuir and whistler waves in a beam-plasma system. The electron beam is first slowed down and relaxed by the rapidly growing Langmuir wave parallel to the background magnetic field. Subsequently, the electrons that compose the high-energy tail of the core plasma are trapped by the large amplitude Langmuir wave and are accelerated in the parallel direction. The excitation of whistler waves through Landau resonance is limited by the saturation of Langmuir waves, due to a faster depletion rate of the beam free energy from the inverted population by the latter compared to the former. Recent computational support for triggered emissions in the laboratory will also be presented.