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Resonant excitation of waves by a spiraling ion beam on the large plasma device[1]

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The resonant interaction between energetic-ions and plasma waves is a fundamental topic of importance in the space, controlled magnetic-fusion, and laboratory plasma physics. We report new results on the spontaneous generation of traveling shear Alfvén waves and high-harmonic beam-modes in the lower-hybrid range of frequencies by an intense ion beam. In particular, the role of Landau and Doppler-shifted ion-cyclotron resonances (DICR) in extracting the free-energy from the ion-beam and destabilizing Alfvén waves was explored on the Large Plasma Device (LAPD). In these experiments, single and dual-species magnetized plasmas ($n \approx 10^{10}$–10^{12} cm^{-3}, $T_e \approx 5.0$–10.0 eV, B = 0.6–1.8 kG, He^+ and H^+ ions, 19.0 m long, 0.6 m diameter) were produced and a spiraling hydrogen ion beam (5–15 keV, 2–10 A, beam-speed/Alfvén-speed = 0.2–1.5, J $\approx$ 50–150 mA/cm^2, pitch-angle $\approx 53°$) was injected into the plasma. The interaction of the beam with the plasma was diagnosed using a retarding-field energy analyzer, three-axis magnetic-loop, and Langmuir probes. The resonance conditions for the growth of shear Alfvén waves were examined by varying the parameters of the ion-beam and ambient plasma. The experimental results demonstrate that the DICR process is particularly effective in exciting left-handed polarized shear Alfvén waves that propagate in the direction opposite to the ion beam. The high-harmonic beam modes were detected in the vicinity of the spiraling ion beam and contained more than 80 harmonics of Doppler-shifted gyro-frequency of the beam.

[1] Tripathi et. al., Rev. Sci. Instrum. 82, 093501 (2011)
[2] Tripathi et. al., Phys. Rev. E 91, 013109 (2015)

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