DPP14-2014-000550

Abstract for an Invited Paper
for the DPP14 Meeting of
the American Physical Society

Cyclotron Mode Frequency Shifts in Multi-Species Ion Plasmas[1]

MATTHEW AFFOLTER[2], University of California, San Diego

Plasmas exhibit a variety of cyclotron modes, which are used in a broad range of devices to manipulate and diagnose charged particles. Here we discuss cyclotron modes in trapped plasmas with a single sign of charge. Collective effects and electric fields shift these cyclotron mode frequencies away from the "bare" cyclotron frequencies $\Omega_s \equiv qB/m_s c$ for each species s. These electric fields may arise from applied trap potentials, from space charge including collective effects, and from image charge in the trap walls. •We will describe a new laser-thermal cyclotron spectroscopy technique, applied to well-diagnosed pure ion plasmas. This technique enables detailed observations of $\cos(m\theta)$ surface cyclotron modes with $m = 0$, 1, and 2 in near rigid-rotor multi-species ion plasmas. For each species s, we observe cyclotron mode frequency shifts which are dependent on the plasma density through the $E \times B$ rotation frequency, and on the charge concentration of species s, in close agreement with recent theory.[3] This includes the novel $m = 0$ radial "breathing" mode, which generates no external electric field except at the plasma ends. These cyclotron frequencies can be used to determine the plasma $E \times B$ rotation frequency and the species charge concentrations, in close agreement with our laser diagnostics. Here, this plasma characterization permits a determination of the "bare" cyclotron frequencies to an accuracy of 2 parts in 10^4. •These new results[4] give a physical basis for the "space charge" and "amplitude" calibration equations of cyclotron mass spectroscopy, widely used in molecular chemistry and biology. Also, at high temperatures there is preliminary evidence that radially-standing electrostatic Bernstein waves couple to the surface cyclotron modes, producing new resonant frequencies.

[1]Supported by NSF/DOE Partnership grants PHY-0903877 and DE-SC0002451.
[2]In collaboration with F. Anderegg, C.F. Driscoll, and D.H.E. Dubin.
[3]D.H.E. Dubin, Phys. Plasmas 20, 042120 (2013).
[4]M. Affolter et al., Phys. Lett. A 378, 2406 (2014).