We report experimental measurements of ion temperatures and flows in a high power, linear, magnetized, helicon plasma device, the Resonant Antenna Ion Device (RAID). RAID is equipped with a high power helicon source. Parallel and perpendicular ion temperatures on the order of 0.6 eV are observed for an rf power of 4 kW, suggesting that higher power helicon sources should attain ion temperatures in excess of 1 eV. The unique RAID antenna design produces broad, uniform plasma density and perpendicular ion temperature radial profiles. Measurements of the azimuthal flow indicate rigid body rotation of the plasma column of a few kHz. When configured with an expanding magnetic field, modest parallel ion flows are observed in the expansion region. The ion flows and temperatures are derived from laser induced fluorescence measurements of the Doppler resolved velocity distribution functions of argon ions.

**Key Results**

- Measurements of ion temperature and ion flow in RAID provide an opportunity to explore likely conditions in upcoming very high power helicon sources.
- The perpendicular ion temperature scales linearly with increasing rf power and if the scaling holds at higher rf powers, perpendicular ion temperatures > 1 eV are expected for helicon sources operating at rf powers > 10 kW.
- Since the scaling of the parallel ion temperature is much weaker, such high rf power helicon sources should be able to provide highly thermal anisotropic plasmas for studies of ion cyclotron and perhaps ion mirror instabilities at high plasma thermal anisotropy.
- In RAID, there is significant, rigid-body, azimuthal rotation of the plasma even though the measured ion metastable and plasma density profiles are nearly flat. Recent evidence suggests that a key requirement for double layer formation is the existence of a strong, radially varying, parallel electric field. The much more radially uniform structure of RAID discharges suggests that the plasma density profile will play an important role in determining if double layers will form in expanding, high rf power plasmas.

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