Direct Measurements of the Ionization Fraction in Krypton Helicon Plasmas

RICHARD MAGEE, MATTHEW GALANTE, GREG LUSK, DUSTIN MCCARREN, EARL SCIME, West Virginia University, NJAL GULBRANDSEN, University of Tromso — Helicons are efficient plasma sources, capable of producing plasma densities of $10^{19}$ m$^{-3}$ with only 1 kW of input RF power. But the ionization fraction in the core of a helicon is usually not well known, because the neutral density is typically inferred from indirect spectroscopic measurements or from edge pressure gauge measurements. We have developed a two photon absorption laser induced fluorescence (TALIF) diagnostic capable of directly measuring the local neutral density. We use TALIF in conjunction with a Langmuir probe to measure the neutral and ion density profiles as a function of driving frequency and magnetic field. We find that when the frequency of the driving wave is greater than the lower hybrid frequency ($f_{LH}$), the core ionization fraction is small (0.1 %) and the plasma density low ($10^{17}$ m$^{-3}$). As the axial magnetic field is increased, or, equivalently, the driving frequency decreased, a transition is observed at RF = $f_{LH}$. The plasma density increases by a factor of 10 or more, the plasma density profile becomes strongly peaked, the neutral density profile becomes strongly hollow, and the ionization fraction in the core reaches ~100%. The dramatic neutral depletion in the core is thought to be due to a combination of increased ionization and neutral pumping. The role of the latter is quantified by a comparison of flowing and static discharges.

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