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Two-Photon Absorption Laser Induced Fluorescence Measurements of Neutral Density in Helicon Plasma[1]

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Neutral particles play a critical role in nearly all plasmas, from the pedestal region of a tokamak fusion plasma to industrial plasma processing systems. In fusion plasmas, neutrals at the edge serve as both a source of particles and also a sink of momentum and energy. Control of the edge plasma density in tokamaks is critical for the transition to H-mode plasmas and the role of neutrals in modifying the plasma rotation in the edge is an area of active research. However, few methods exist to make localized, direct neutral density measurements. We have developed a new diagnostic based on two-photon absorption laser induced fluorescence (TALIF). We use a high intensity (5 MW/cm^2), narrow bandwidth (0.1 cm^{-1}) laser to probe the ground state of neutral hydrogen, deuterium and krypton with spatial resolution better than 0.2 cm, a time resolution of 10 ns, and a measurement cadence of 20 Hz. In this talk I will describe proof-of-principle measurements in a helicon plasma source that demonstrate the TALIF diagnostic is capable of measuring neutral densities spanning four orders of magnitude; comparable to the edge neutral gradients predicted in the tokamak pedestal. The measurements are performed in hydrogen and deuterium plasmas and absolute calibration is accomplished through TALIF measurements in neutral krypton. The optical configuration employed is confocal, i.e., both light injection and collection are accomplished through a single optical port in the vacuum vessel. The wavelength resolution of the diagnostic is sufficient to separate hydrogen and deuterium spectra and I will present measurements from mixed hydrogen and deuterium plasmas that demonstrate isotopic abundance measurements are feasible with the TALIF system. Time and spatially resolved measurements also allow us to explore the effects of wall recycling and pulse repetition rates on the neutral density profile in the plasma source.

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