TWO PHOTON ABSORPTION LASER INDUCED FLUORESCENCE OF HELIUM IONS IN A MICROWAVE ASSISTED HELICON SOURCE

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SUMMARY

The spectroscopic measurement of helium ion velocity distribution functions in a low temperature plasma is problematic for a number of reasons. First and foremost is the difficulty in accessing the UV and soft x-ray transitions to the ground state. Conventional laser induced fluorescence on ions in plasmas is routinely performed in argon, neon, xenon, and helium. Two-photon absorption laser induced fluorescence (TALIF) on neutrals has been demonstrated in hydrogen, nitrogen, and oxygen plasmas. We have successfully performed LIF on helium atoms and have had some hints of success with laser absorption spectroscopy on excited states of helium ions, the n = 5 to n = 6 transition in the infrared (1012 nm). Here we report a new approach using TALIF to access the n = 2 to n = 6 transition of singly ionized helium. The fluorescence path at 586 nm completes the three-level sequence. To obtain the electron temperatures necessary to create a sufficient population of metastable helium ions trapped in the 2S state, we have increased the electron temperature of a helium plasma with 1.2 kW of microwaves at 2.45 GHz. Here we report emission spectroscopy measurements that confirm the increase in excited state population densities and preliminary TALIF measurements on helium ions.

MICROWAVE ENHANCED HELICON SOURCE

A commercial 1.2-kW microwave source operating at 2.45 GHz is coupled into the bottom of the helicon source expansion chamber through a vacuum window. The source magnetic field is set to 800 Gauss to create a region of electron cyclotron resonance at 2.45 GHz. Plasma properties are measured with an RF compensated Langmuir probe.

HYDROGENIC TALIF

The laser system is comprised of an Nd:YAG pump operated at 20 Hz, a dye laser with 1% Rh101/B dye mixture for peak output at 615 nm, and a 2-stage tripler.

Two photons from an injected laser beam excite an electronic transition in a neutral atom or ion. The absorption rate, determined by collection of subsequent spontaneous emission, is proportional to the density.

TALIF provides greater localization than traditional LIF and allows direct ground state excitation with near-UV laser.

PROPOSED HELIUM TALIF SCHEME

Helium atoms have an ionization potential of 24.6 eV. To populate the metastable 2S level of the helium ion requires an additional 40.8 eV. The 2S level is essentially degenerate with the 2P level, so in a collisional system the 2S state is still quickly quenched by radiative decay from the 2P level to the ground state. Once in the 2S state, the helium ion can be excited to the ES or OD level by TALIF at 250 nm. Radiative decay to the 4P or 4D states occurs through emission of 656 nm photons. While conceptually feasible, the challenge in helium TALIF is the large energies, i.e., high electron temperatures, needed to populate the initial 2S state and the relatively small branching ratio from the upper ES and OD states to the n = 4 level. Survey optical emission spectroscopy is used to search for the 468 nm emission from the 4P-4D transition in microwave heated helium plasmas.

Status:
- Microwave source enhances energetic tail of electron distribution function (see McKee poster on Wednesday).
- In argon plasmas, clear indications that the enhanced electron tail increases energetic ion emission line intensities.
- In helium plasmas, first indication of helium ion emission from highly excited states.

MICROWAVE ENHANCED ARGON PLASMA

Pressure = 6.5 Torr

B = 942 G

Helium ion emission from n = 4 to n = 3 state

656.26 nm - hydrogen

605.02 nm - He II

MICROWAVE ENHANCED HELIUM PLASMA

Helium ion emission from n = 6 to n = 4 state

656.26 nm - hydrogen

605.02 nm - He II

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