

Active spectroscopy on Magnum-PSI to characterize atomic and molecular hydrogen in detached conditions

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Divertor detachment is the leading candidate for solving the heat exhaust problem in future fusion reactors. Key to understanding detachment is the interaction of the plasma with a background of neutral particles in the divertor region. Collisions of the plasma with these neutral background particles result in a rich range of physical and chemical processes, causing the plasma to dissipate its energy and momentum, and finally to recombine, preventing damage to the wall. Whereas charged particles are routinely diagnosed, information on neutral particles is often missing. The properties of neutral particles can be measured using active spectroscopy. At Magnum-PSI, a linear plasma generator that can simulate the high heat and particle flux conditions of future fusion reactors, three types of active spectroscopy are being installed: TALIF, CARS and VUV-LIF. With this combination of diagnostics one can measure the (ground-state) densities of both atomic and molecular Hydrogen, as well as the ro-vibrational state distribution of H₂ and its isotopologues. The ground state densities are important parameters in many of the detachment processes, and are also needed as input for scrape-off layer modelling. The ro-vibrational state distribution is important as it determines the reaction rate of MAR (Molecular Assisted Recombination), one of the dominant recombination processes in divertor plasmas.

Apart from the design and status of all three diagnostics, first TALIF and CARS data taken on the UPP linear device will be presented.

TALIF: Two photon Absorption Laser Induced Fluorescence

At high enough laser intensity, TALIF can be used to measure the density of H atoms in the electronic ground state. The needed laser wavelength of 205.14 nm is in the UV range. The resultant fluorescent Balmer alpha emission (in the visible range) is a measure for the density of the ground state Hydrogen atoms.

CARS: Coherent Anti-Stokes Raman spectroscopy

CARS is a four wave mixing process in which the plasma is simultaneously illuminated by two laser frequencies in the visible range, tuned to be resonant with the various ro-vibrational state transitions of H₂ molecules. The resulting emitted CARS signal is a measure for the density of the resonant ro-vibrational states, including the H₂ ground state density.

VUV-LIF: Vacuum Ultraviolet Laser Induced Fluorescence

For higher vibrational states the sensitivity of CARS is too low. The higher ro-vibrational states will hence be measured with VUV-LIF. The beamlines for both the laser and the fluorescence signal (detected using a VUV monochromator) need to be in vacuum.

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