Observation of Emission of Fast Atoms in the Linear Magnetized Plasma Device PSI-2

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Fast atoms or "hyperthermal atoms" have been observed and discussed in various types of plasmas, such as fusion plasmas, rf plasmas and atmospheric plasmas [1-5]. In this work we present experimental observations of a population of hyperthermal hydrogen (deuterium) atoms in the low temperature plasma (~2-15eV) of the linear magnetized plasma device PSI-2. The plasma ends on a tungsten target which can be biased down to -300V to accelerate positive ions. Optical emission spectroscopy is employed to measure the emission lines D_α, D_β and D_γ. A spectrometer (~0.01Å/pixel) is used to study details of the line shape (energy distribution, Doppler shift). The spatial dependence ($\|\mathbf{B}$) of light emission of fast atoms is measured by a 2D spectrometer (~0.1Å/pixel) with the plasma in front of the target being imaged onto the entrance slit. Line broadening in form of wings surrounding the cold component is observed for D_α, D_β and D_γ indicating fast neutral atoms in the energy range of ~100eV. The light emission of fast atoms arises close to the target surface and decays with distance from the target in the plasma column. The population of fast neutral excited atoms varies with bias potential and gas pressure and is pronouncedly present in hydrogen argon mix plasmas. When hydrogen is mixed with krypton, xenon or neon, the population density of fast neutral excited hydrogen atoms is strongly reduced. For helium and pure hydrogen the population could not be distinctly observed above noise level. We discuss the excitation transfer between metastable noble gas atoms and ground states of atomic hydrogen as the driving mechanism for the observed light emission. In case of argon this process is quasi-resonant. Hyperthermal neutral atoms may be usually present in hydrogen and hydrogen mixture plasmas, but for most discharge conditions and gas mixtures fast neutral hydrogen atoms are in the ground state and not visible. The observed effect provides access to the measurement of the angular and energy distribution of reflected hydrogen.

References

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