Emission of fast hydrogen atoms in a low density gas discharge: the most "natural" mirror laboratory

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The emission of hydrogen atoms at plasma solid interface is one of the most studied fields covering the topics of laboratory, astrophysical or fusion plasmas. In this work we demonstrate a new application for the line shapes of emission induced by reflected atoms: *optical properties* of the solids in contact with the plasma could be effectively measured at the wavelength of Balmer lines. The time-resolved measurement of the spectral reflectance of mirror surfaces in the optical laboratories is replaced using the wavelength separation of the direct and reflected signals *in situ* during plasma operation. One uses the Doppler effect of emission of H atoms excited by collisions with noble gases, primarily with Ar or with Kr in the energy range of 100-300 eV to separate the signals. The crucial condition for such measurements is the absence of emission induced by fast atoms in the Child-Langmuir sheath. The operational limits differ from Grimm type discharges considerably. The so-called DSRM (**D**oppler-**S**hifted **R**eflectance **M**easurements) diagnostics can be used to obtain the values of spectral reflectance, degree of polarization by reflection but also for *in-situ* monitoring the degradation of optical properties in the absence of other light sources [1, 2]. The measurements were performed in a weakly magnetized (gas pressure of 0.1 Pa, magnetic field of 0.1 T, electron density 10^{11} cm^{-3} and electron temperature of 3-5 eV) linear plasma facility PSI-2. The very good agreement between the results of the DSRM diagnostic and measurements in the laboratory is obtained for many materials including Al, Ag, C, Cu, Rh, Fe, Mo and W. The data for the energy (above 50 eV) and angular distribution of reflected atoms are obtained as results of the modelling of emission.

Nonetheless, in spite of unexplored application of the DSRM diagnostic, the crucial question on the source of the strong signal in case of Ar exists still. The emission signal observed in case of excitation of H or D atoms by Ar exceeds the signal induced by collisions with Kr atoms by a factor of five [3]. The only available experimental data for the ground state excitation shows practically equal cross-sections for both gases in the energy range of study [3]. The excitation by collisions with ions can be excluded on the basis of experimental data. Instead, another possible source of excitation of hydrogen atoms remains the metastable fraction of Ar. The latter was measured independently using the laser absorption spectroscopy at PSI-2. The new data of metastable fraction demonstrate a relatively flat profile so that the excitation transfer could be not excluded completely. Finally, the work summarizes *pros- and cons-* arguments for excitation of hydrogen atoms by the ground state or the metastable fraction of Ar.

References

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