Electron impact study of H_2 and D_2 continuum radiation

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Synopsis We report our recent experimental study regarding H_2 and D_2 continuum radiation ($a^3\Sigma_g^+ \rightarrow b^3\Sigma_u^+$) in the spectral range of 200 – 650 nm, excited by electron impact at near-threshold impact energies. In contrast to earlier studies, present results indicate that H_2 and D_2 continuum radiation is detectable in the spectral range above 500 nm. To supplement this, we present excitation-emission photon efficiency curves (PEC) of D_2 measured at 650 nm, with precautions taken to rule out other possible signal sources.

Hydrogen and deuterium range among the most widely studied molecules in modern science [1, 2]. High-quality kinetic data of processes involving H_2 and D_2 are crucial for modeling of fusion and other plasmas. We are using the electron induced fluorescence (EIF) technique, where precise control of electron kinetic energy and high photon detection sensitivity allows obtaining high-quality spectral and kinetic data. The experiment is capable of measuring emission spectra initiated by electron impact and corresponding photon efficiency curves. These can be subsequently calibrated to obtain excitation-emission cross-sections.

In this abstract we present results of our recent experiments involving H_2 and D_2 continuum radiation spectra originating from their $a^3\Sigma_g^+ \rightarrow b^3\Sigma_u^+$ transition. The hydrogen continuum spectrum is a superposition of narrower continua corresponding to excitation of different vibrational states in the upper electronic state and their radiative decay to the lower unbound state [1, 3].

The EIF apparatus is described in detail in [4]. In present experiment we have used electron beam with electron energy resolution of 0.5 eV FWHM at few hundreds nA of electron current. Photon emission was measured using optical system comprising of Cornerstone 260 grating monochromator, focusing optics and Hamamatsu H4220P PMT module, with spectral range from 200 to 670 nm. Spectral sensitivity calibration was performed using tungsten filament emission, taking gray body radiation model above 500 nm and using known H_2 continuum radiation shape for wavelengths above 200 nm [5].

Fluorescence spectra of H_2 and D_2 were recorded in 200 – 650 nm spectral range. Distinct spectral features, such as the continuum maximum and Fulcher bands were visible. Uniqueness of these spectra lies in observation of the continuum radiation up to 650 nm, which is much higher than commonly reported 500 nm limit. Spectral sensitivity of the PMT module did not allow to extend the measurements to longer wavelengths.

To prove the origin of the 650 nm radiation is in the $a^3\Sigma_g^+ \rightarrow b^3\Sigma_u^+$ transition, we have measured excitation-emission PEC of D_2 continuum at this wavelength and compared its shape to PEC measured at 230 nm (Figure 2). 420 nm cut-off optical filter was used to cancel higher order diffraction from the monochoromator grating.

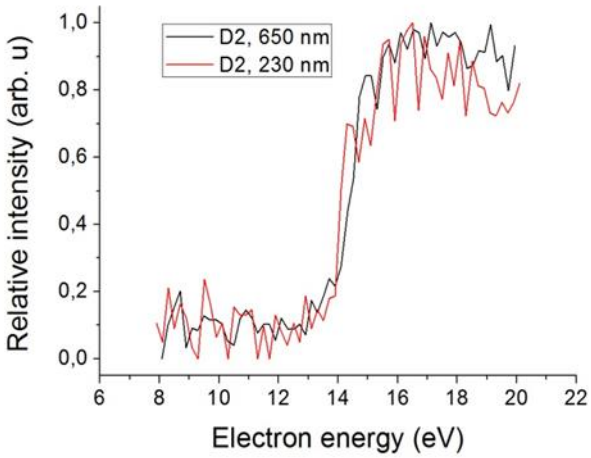

Figure 1. Photon efficiency curves of D_2 at 230 nm and 650nm (measured with optical filter).

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References

[1] B. P. Lavrov et al. 1999 *Phys. Rev. E* **59** 3526
[2] M. Ajello, D. E. Shemansky 1993 *ApJ* **407** 820
[3] H. M. James et al. 1939 *Phys. Rev.* **55** 184
[4] M. Danko et al. 2013 *J. Phys. B* **46** 045203
[5] G. K. James et al. 1998 *J. Geophys. Res.* **103** 20113

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