Contribution ID: **73** Type: **Oral**

Validating Collision-Radiation-Predissociation Dataset for Molecular Hydrogen with Visible Emission Spectra

Tuesday, 28 November 2023 12:15 (30 minutes)

The need for quantitative spectroscopy of molecular hydrogen has experienced substantial demand, leading to the accumulation of diverse elementary-processes data encompassing radiative transitions, electron-impact transitions, and predissociations. In this study, we attempt an experimental validation of this dataset by comparing the vibronic populations across multiple molecular hydrogen levels: EF1Σ+g, H1Σ+g, D1Π±u, GK1Σ+g, I1Π±g , J1Δ±g , h3Σ+g, e3Σ+u, d3Π±u, g3Σ+g , i3Π±g, and j3Δ±g , measured from thousands of emission lines observed with a custom-made Echelle spectrometer. Our analysis incorporates a collisional-radiative model (CRM) that relies on the most up-to-date dataset and on spectrally observed populations from Large Helical Device (LHD) plasmas. Remarkably, we find that predissociation, which is the spontaneous dissociation process of excited molecules, is crucial for accurately replicating the observed outcomes, although many of the previously-reported CRM for molecular hydrogen have neglected this effect. We also demonstrate the possibility of a new divertor diagnostic technique utilizing the measured molecular spectrum interpreted through the CRM with predissociation included. This research also highlights that incorporation of predissociation data for hydrogen molecular isotopologues (H_2, H_2, T_2, HD, HT, DT) is essential for the interpretation of future burning-fusion plasma spectroscopic diagnostics.

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Session Classification: CR