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Challenges in the analysis of the spectra of tritium-containing molecules

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Fulcher Bands of the hydrogenic molecular spectra are complex triplet bands in the visible region (590-630 nm). The electronic transition is identified as d ($3p^3\Pi_u$) at approximately 14 eV level energy to a ($2s^3\Sigma_g^+$) at 12 eV, but this is not the sole electronic transition in this region, as the g⟶c ($3d\ ^3\Sigma_g^+ \rightarrow 2p^3\Pi_u$) transition is present in this wavelength region as well. Lines from both of those bands have been identified e. g. in the experimental measurements from divertor regions of the JET tokamak. The d⟶a transition is widely used to learn about molecular behavior in the divertor plasma, but the spectral analysis of such a complex spectrum is challenging. There are large catalogues of experimentally verified wavelength of the rotationally resolved wavelengths of the electronic-vibrational-rotational transitions in the homonuclear H_2 [1] and D_2 [2] molecular spectra (also some for the heteronuclear HD). They include also those of the g⟶c interfering band. Unfortunately, experimental data even for main FB transition are sparse for tritium-containing molecules, and most of the diatomic constants are either calculated using isotope effect or from relatively restricted and old research published by Dieke and Tomkins in 1950. Even for homonuclear tritium the data are restricted to first several (at most ten) rotational transitions for each vibrational transition. In the TEXTOR [3] and JET-C deuterium [4] and tritium/DT [5] experiments the higher rotational transitions were not observed, but in JET-ILW we see a change of ro-vibrational population depending on local injection and recycling at the target places which was not seen in previous experiments. Those conditions result in a rotational overpopulation of the first main-diagonal band, where in the case of high molecular density the observed rotational temperature can even reach the electron temperature. In such cases lines up to J= 17 can be easily observed (e.g. [6] in D_2, [7] in H_2), which adds to the complexity of the analysis, both because the wavelengths for such lines may not be following low-order diatomic expansion values, and because the spectra from different vibrational contributions do overlap. For heteronuclear molecules the analysis even more challenging, as in this case there is an overlap between spectra from at least one homonuclear molecule and a heteronuclear one (see e.g. [8]).

In this presentation will be shown experimental spectra from JET tokamak divertor measurements, containing T_2, HT and DT molecular contributions. The existing molecular data and resulting line identifications and estimations of energy distribution functions will be discussed and compared with available results from other isotope spectra.

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[6] G. Sergienko et al, *Journal of Nuclear Materials* **438** (2013) S1100–S1103.

[7] E. Pawelec et al, *Europhysics Conference Abstracts*, **46A**, (2022) O2.J501

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