

DEVELOPMENT OF THE EXOMOL DATABASE

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The desire to characterize and model the atmospheres of the many extrasolar planets that have been discovered over the last three decades is a major driver of current astronomy ¹. This goal is impacted by the lack of spectroscopic data for the molecules in question since it requires significant quantities of spectroscopic data, in many cases billions of lines, to accurately reproduce the spectroscopic features of the atmospheres of hot exoplanets ².

The ExoMol database ³ provides molecular data for interpreting spectra and modelling atmospheres of hot exoplanets, cool stars, brown dwarfs, and other hot astronomical atmospheres and its molecules are selected because they are deemed to be important for exoplanets and other studies of hot atmospheres ⁴. The core of the ExoMol database is comprehensive high-temperature molecular line lists; these are supplemented with partition functions, state lifetimes, cooling functions, Landé g-factors, temperature-dependent cross sections, opacities, pressure broadening parameters, k-coefficients and dipoles. The ExoMol line lists are systematically published as a series in the journal *Monthly Notices of the Royal Astronomical Society* and summarised in release papers ^{5,6}.

The continuous updating of the ExoMol database is particularly important. Here we present the recent developments of the ExoMol database, which include:

1. Photodissociation cross sections and continuum absorption ⁷;
2. Collisional broadening ⁸;

¹[doi:10.1093/mnras/stu944](https://doi.org/10.1093/mnras/stu944), E.J. Barton et al., *Mon. Not. R. Astron. Soc.*, **442** (2), 1821–1829 (2014).

²[doi:10.1073/pnas.1324219111](https://doi.org/10.1073/pnas.1324219111), S.N. Yurchenko et al., *Proc. Nat. Acad. Sci.*, **111**, 9379–9383 (2014).

³<https://www.exomol.com/>.

⁴[doi:10.1093/astrogeo/atab102](https://doi.org/10.1093/astrogeo/atab102), J. Tennyson and S.N. Yurchenko, *Astron. Geophys.*, **62** (6), 6–16 (2021).

⁵[doi:10.1016/j.jms.2016.05.002](https://doi.org/10.1016/j.jms.2016.05.002), J. Tennyson et al., *J. Mol. Spectrosc.*, **327**, 73–94 (2016).

⁶[doi:10.1016/j.jqsrt.2020.107228](https://doi.org/10.1016/j.jqsrt.2020.107228), J. Tennyson et al., *J. Quant. Spectrosc. Radiat. Transf.*, **255**, 107228 (2020).

⁷[doi:10.1093/rasti/rzad014](https://doi.org/10.1093/rasti/rzad014) J. Tennyson et al., *RASTI*, **2**, 231 (2023).

⁸[10.1093/rasti/rzac004](https://doi.org/10.1093/rasti/rzac004) J. Buldyreva et al., *RASTI*, **1**, 43 (2022).

3. MARVELisation of line lists with and inclusion of uncertainties;
4. JSON format for the line list APIs (Application Programming Interface);
5. Adopting the IAEA (International Atomic Energy Agency) standards for the atomic and molecular information;
6. Ancillary database LiDB: Molecular vibronic state radiative lifetimes for plasma processes ⁹;
7. High-resolution line list database ExoMolHR ¹⁰;
8. A Python program PyExoCross ¹¹ is designed to post process both ExoMol and HITRAN line lists ¹².

⁹A. Owens et al., *Plasma Sources Sci. Technol.*, in press (2023).

¹⁰Jingxin Zhang et al., “ExomolHR: High-resolution ExoMol linelists”, In preparation (2023).

¹¹<https://github.com/ExoMol/PyExoCross.git>

¹²Jingxin Zhang et al., “PyExoCross: a Python program for generating spectra from molecular line lists”, In preparation (2023).