Spectroscopy and chemistry of exoplanets

Jonathan Tennyson

Department of Physics and Astronomy, University College London, London WC1E 6BT, UK

Exoplanets are now know to be ubiquitous, so naturally scientific enquiry is turning is turning towards characterisation. The obvious question to ask is what are exoplanets made of? Observational biases mean that it much easier to study spectroscopically (transiting) exoplanets close to their host star so these planets are hot.

At elevated temperatures the spectra of polyatomic molecules become extremely complicated with millions, or even billions, of transitions potentially playing an important role. The atmospheres of cool stars and "hot Jupiter" extrasolar planets are rich with molecules in the temperature range 1000 to 3000 K and their properties are strongly influenced by the infrared and visible spectra of these molecules. So far there are extensive, reliable lists of spectral lines for a number species including some stable diatomics, water, ammonia. Data is almost completely lacking for many key species.

The ExoMol project (www.exomol.com) aims to construct line lists of molecular transitions suitable for spectroscopic and atmospheric modelling of cool stars and exoplanets [1]. As huge numbers of lines are required. Line lists are therefore computed on the basis of a thorough quantum mechanical treatment of problem, which is tested against available laboratory data, rather than constructed experimentally. The methodology used to perform these calculations will be outlined.

Illustrative examples will be discussed including recent work on methane [2], for which we computed 10 billion lines, and water.

References

[1] Tennyson J. & Yurchenko S.N., Mon. Not. Roy. astr. Soc. 425, 21 (2012).
[2] Yurchenko S.N., Tennyson J., Bailey J., Hollis, M.D.J. & Tinetti G.,
Proc. Nat. Acad. Sci., 111, 9379 (2014).