Optical spectra of some metal-containing diatomics seen in the laboratory and through the telescope

Amanda. J. Ross

Institut Lumière Matière, Unité Mixte de Recherche 5306, CNRS & Université Lyon 1, 69622 Villeurbanne, France.
Tel.:+33 472448256 , E-mail: amanda.ross@univ-lyon1.fr

Several transition metal monohydrides have been identified in sunspots, and in the spectra of cool stars. They have been noted as possible probes of magnetic field, particularly for cool stellar objects. FeH, cited for example by Afram et al.[1], seems particularly promising in this respect, with a very strong Zeeman response in the near infrared. Laboratory spectra are required to supply reliable parameters for spectropolarimetric analysis of such remote objects, and this talk focuses on progress in this direction. One obvious hurdle arises from the equilibrium temperatures of 'cool' stellar objects – usually more than 3000 °C – far higher than the range of temperatures typically accessible in the laboratory, particularly when high spectral resolution is required.

I will illustrate some of our recent work in this area, showing spectra of FeH and NiH formed in a hollow-cathode sputtering source [2] as examples. We have used cw laser excitation and Fourier-transform resolved fluorescence to study Zeeman patterns, working at magnetic fields between 0.3 and 0.9 Tesla provided by permanent magnets. Dispersed fluorescence spectra actually give access to the Zeeman response of lower-state levels that are not thermally accessible in the laboratory. This approach has the advantage of recording many transitions simultaneously, in identical conditions (magnetic field strength, pressure, laser polarisation ...), but remains useful only for systems with generous transition dipole moments. FeH spectra have been recorded as total fluorescence signals, as the near infrared system of FeH identified for example in the solar atlas [3] happens to be quite weak. Magnetic response has been measured, line by line, for a selection of transitions in the two lowest spin-components of the F $^4\Delta_{7/2}$ excited state of this system.

We have also investigated the profiles of FeH lines observed in sunspot spectra, recorded in Stokes V polarisation at the solar Telescope THEMIS in Tenerife [4]. Atomic lines (notably Ti and Fe) can also be used to characterise the magnetic field. We find that the field deduced from atomic lines (Ti,Fe) is around 10~\% higher than that found from FeH, compatible with molecules forming at higher altitudes in the solar atmosphere.

[1] N. Afram, S.V. Berdyugina, D.M. Fluri, S.K. Solanki , A. Lagg. *Astron. & Astrophys.* **2008** *482* 387-95.
[2] A.J. Ross, P. Crozet, C. Richard, H. Harker, S.H. Ashworth, D.W. Tokaryk. *Mol. Phys.* **2012** *110* 2019-33.
[3] L. Wallace, W. Livingstone, P. Bernath, R.S. Ram. *N.S.O. Technical Report N° 1998-002,* **1998**. *Available online : ftp://nsokp.nso.edu/pub/atlas/spot3alt*
[4] P. Crozet, G. Tourasse, A.J. Ross, F. Paletou, A. Lopez Ariste. *ESA Publications Series* **2012** *58* 63-67.