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Water and titanium oxide in late-type M dwarfs

H. R. A. Jones

Astrophysics Group, Liverpool John Moores University, Byrom Street, Liverpool L3 3AF, UK

S. Viti, S. Miller, J. Tennyson

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

F. Allard

Department of Physics and Astronomy, Wichita State University, Wichita, KS 67260-0032, USA

P. Hauschildt

Department of Physics and Astronomy, Arizona State University, Tempe, AZ 85287-1504, USA

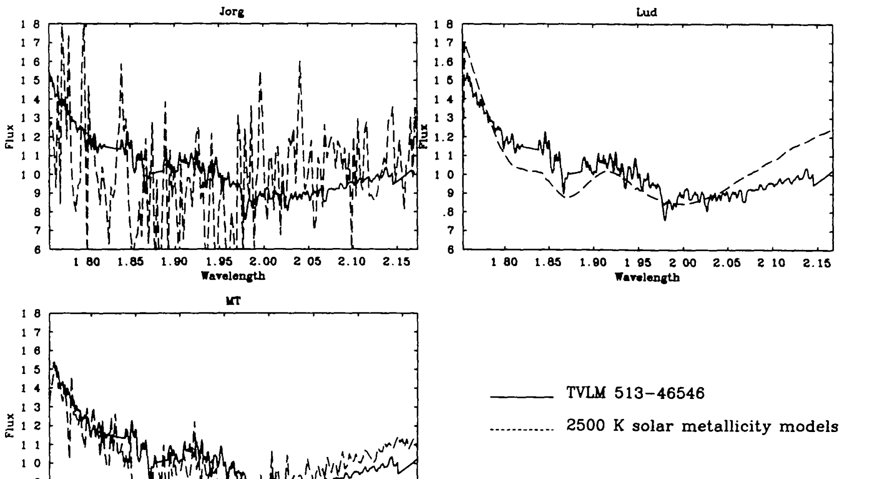
1. Introduction

Despite the identification of brown dwarf candidates the lack of understanding of M dwarfs has meant that it has not been possible to unambiguously distinguish these candidates from cool M dwarfs. Unlike hotter stars their atmospheres are dominated by a variety of species of molecules, many with billions of line transitions modulating their energy output. We have recently examined water vapour and titanium oxide opacities which are the most important sources of opacity in cool low-mass stars.

2. Observations and Models

Observations were made during the commissioning of the upgraded Cooled Grating Spectrometer 4 (CGS4, Puxley et al. 1995) on the UK Infrared Telescope (UKIRT) on Mauna Kea, Hawaii. The observations presented here were made in May 1995 during excellent conditions (optical seeing $\sim$ 1 arcsec and low atmospheric humidity $\sim$ 20 per cent). We are confident that the spectra have good cancellation of atmospheric features. In particular we believe that we have managed to *accurately* measure the water vapour bands in TVLM 513-46546 – one of the coolest known dwarfs.

Models were taken from a large grid computed with the model atmosphere code PHOENIX. The models are described in detail by Allard & Hauschildt (1995) and references therein. Water vapour and titanium oxide are the principle opacities governing the energy output of cool stars. Their importance has led to a number of groups finding the opacities for these molecules. The figure gives an illustration of our comparisons between observations and models using different water vapour inputs. The graphs are labelled according to the source of water vapour: Jorg (for Jorgensen 1994), Lud (for Ludwig 1971) and MT (for Miller et al. 1995), comparisons were also made with other older sources of H_2O data and various sources of TiO data.



Figures show a region dominated by water vapour.
The MT model gives a promising match to the data.

3. Conclusions

• Shortward of 1.7 μm the Jorgensen (1994) water vapour input gives a reasonable match to the observed water bands at very low resolution however it should not be used for spectral analysis even at low resolutions. Beyond 1.7 μm the preliminary MT line list (Miller et al. 1994) is sufficiently complete to give a very good representation of stellar features (although the lack of hot water vapour transitions considered means that it does not match well at shorter wavelengths).

• The predicted TiO bands do not well-match the observations. The incompleteness in the TiO line lists at high ro-vibrational levels leads to serious uncertainties in the model structure.

The preliminary H_2O line list of Miller et al. (1994) suggests that an excellent match to the water vapour transitions will be possible, however to determine accurate effective temperatures for cool stars an accurate TiO line list will also be needed.

References

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