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VALIDATION OF M-DWARF ATMOSPHERE MODELS AND EFFECTIVE TEMPERATURE SCALE OF M DWARFS

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Abstract. We present a comparison of low-resolution spectra of 60 stars covering the whole M-dwarf sequence. Using the most recent PHOENIX stellar atmosphere models we do a first quantitative comparison to our observed spectra in the wavelength range 500-900 nm. We perform a first confrontation between models and observations and we assign an effective temperatures to the observed M-dwarfs. Teff-spectral type relations are then compared with the published ones. This comparison also aims at improving the models.

Keywords: M-dwarfs, cool atmosphere models

1 Introduction

Low-mass dwarfs are the dominant stellar component of the Galaxy. Our understanding of the Galaxy therefore relies upon the description of this faint component. Indeed M-dwarfs have been employed in several Galactic studies. Moreover, M dwarfs are now known to host exoplanets, including super-Earth exoplanets (see e.g. Bonfils et al., 2007). The study of M dwarfs has therefore relevant implications for both stellar and Galactic astronomy. Over the last decade, stellar models of very low mass stars have made great progresses, but they still have to use some incomplete or approximate input physics such as uncertain oscillator strengths for some line and molecular bands and missing opacities sources. Descriptions of these stars therefore need a strong empirical basis, or validation.

2 Comparison between atmosphere models and M-dwarf spectra

M-dwarfs remain elusive and enigmatic objects because of their small size and cool surface temperature. M-dwarf spectra are characterized by the presence of strong molecular absorptions such as TiO, VO, H_2O and CaH. A complete understanding of the theoretical description of the stellar atmosphere, temperature, abundances, sizes and luminosities is yet not fully understood. We compared 60 M-dwarfs (from M0 to M9) with optical spectroscopic classification (Reylé et al., 2006), on a large wavelength range, with the most recent PHOENIX stellar atmosphere models, varying the effective temperature. The models used are the most recent version BT-Settl-2010 taking into account the solar abundances from Asplund et al. (2009) and based on 2D hydrodynamic simulations including a description of dust grain formation from Freytag et al. (2010). The models are available on-line.*. Fig. 1 shows the comparison between model (blue line) and observations (red line) for a M0 star (left), a M3.5 star (middle) and a M5.5 star (right). We found some discrepencies probably due to bad opacity assumptions (see e.g. TiO absorption around 6500Å). New constraints on opacities will be drawn from this comparison. For M6 and later dwarfs, the model is not able to fit properly the blue part and the red part of the observed spectra.

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*`http://phoenix.ens-lyon.fr/simulator`

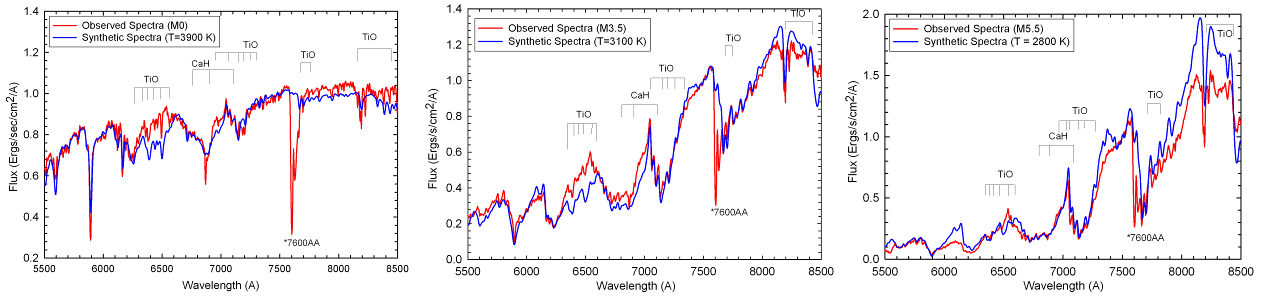

Fig. 1. Comparison between model (blue line) and observations (red line). Left: M0 star and model with Teff=3900K. Middle: M3.5 star and model with Teff=3100K . Right: M5.5 star and model with Teff=2800K.

3 Effective temperature scale of M-dwarfs

We derived the spectral type of the synthetic spectra by computing the spectral indices (TiO_5, CaH_2, CaH_3, PC3) and derived a SpT-Teff relation. This relation is not valid for Teff<2800K or SpT earlier than M6 where we did not find a good fit between observed and synthetic spectra. Thus we do not used the PC3 indices valid for >M6. The adopted SpT (solid lines) is the average from TiO_5, CaH_2 and CaH_3 spectral indices. The relation is compared to others found in the literature (Fig. 2).

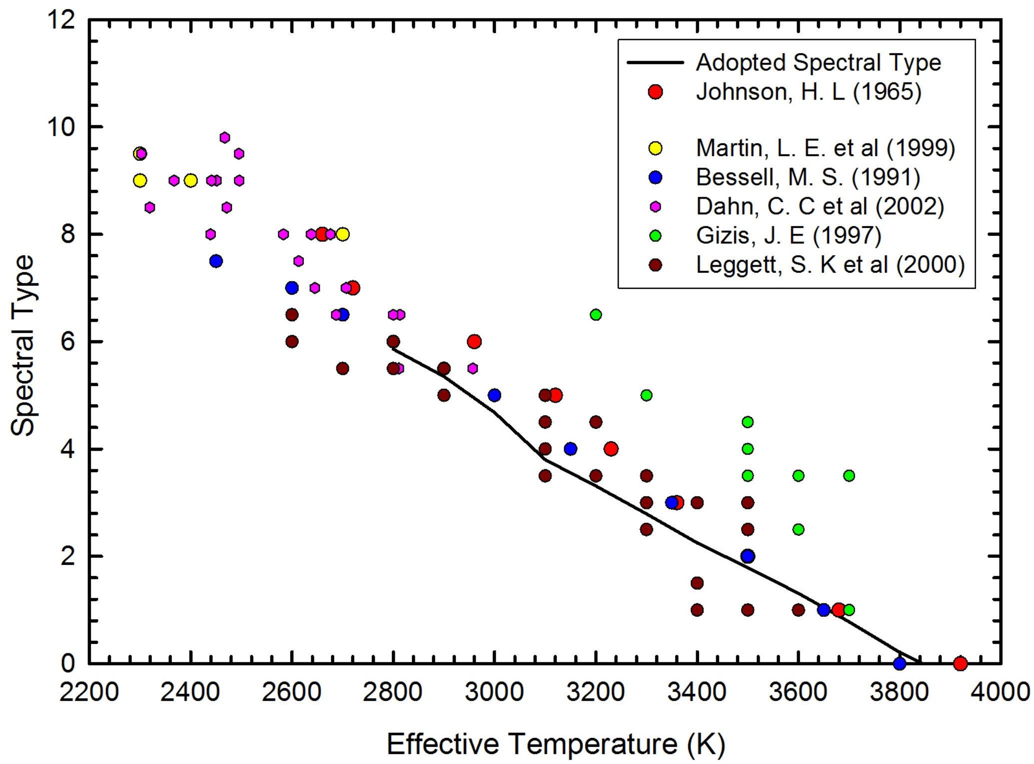

Fig. 2. Our adopted spectral type - Teff relation (solid line) compared to relations from Johnson (1964), Bessel (1991), Gizis (1997), Martín et al. (1999), Leggett et al. (2000), Dahn et al. (2002)

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