Brown Dwarfs
IAU Symposium, Vol. 211, 2003
E. L. Martín, ed.

A Near-Infrared Spectral Sequence of Late M, L, and T Dwarfs

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Abstract. We present the initial results of a medium resolution, 0.8 to 4.2 μm spectroscopic survey of M, L, and T dwarfs. We have identified the most prominent molecular and atomic absorption features found in the spectra of these late-type dwarfs. We have also compared the spectra to a laboratory FeH emission spectrum and identified nearly 100 features common to the FeH spectrum and the dwarf spectra from 0.99 to 1.8 μm.

1. Introduction

We have conducted a 0.8 to 4.2 μm, R=2000, spectroscopic survey of ~10 M, ~ 10 L, and 2 T dwarfs using SpeX (Rayner et al., 1998, in preparation) on the NASA Infrared Telescope Facility. The observing strategy and data reduction techniques can be found in Cushing et al. (in preparation).

After identifying the known molecular features and bandheads and as many atomic features as possible, we found that many unidentified absorption features remained. Motivated by the recent tentative identification of the $E\ ^4\Pi - A\ ^4\Pi$ system of FeH near 1.6 μm in umbral and cool star spectra (Wallace & Hinkle 2001), we have compared the dwarf spectra to a laboratory FeH emission spectrum (S. Davis 2002, private communication). We have identified nearly 100 FeH absorption features that are present in the z-, J-, and H-band spectra of the dwarfs and in the laboratory FeH spectrum. A more thorough discussion of these features can be found in Cushing et al. (2002). In the following sections, we present the z-, J-, and H-band spectra of GJ 1111 (M6 V), VB 10 (M8 V), Kelu-1 (L2 V), and 2MASS 1507−1627 (L5 V) and identify the major molecular and atomic absorption features present, including the newly identified FeH features.

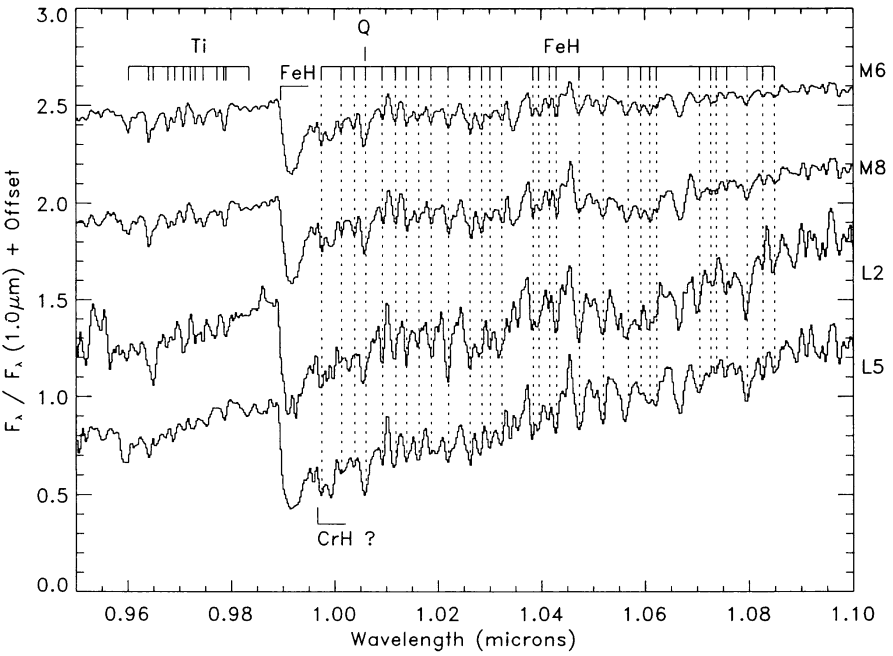

Figure 1. z-band spectra of the four dwarfs. The FeH bandhead and positions of the FeH lines are shown as well as the positions of the Ti lines.

2. z-Band Spectra

Figure 1 shows the z-band spectra of the four dwarfs. The most conspicuous feature is the bandhead of the 0−0 band of FeH ($F\ ^4\Delta - X\ ^4\Delta$) at 0.99 μm. Longward of 0.99 μm the spectra are almost completely dominated by FeH absorption features. Although Schiavon et al. (1997) found the spectra of a sample of early- to mid-type M stars were dominated by FeH absorption from 0.9850 to 1.0200 μm, our results indicate FeH is still an important opacity source out to ∼1.09 μm. The feature at 1.0060 μm arises from the the $F\ ^4\Delta_{7/2} - X\ ^4\Delta_{7/2}$ Q-branch of FeH (Phillips et al. 1987). There are also some Ti absorption lines centered at 0.97 μm which arise primarily from the $a\ ^5\mathrm{F} - z\ ^5\mathrm{F}$ multiplet. We also question the identification of the feature at 0.99685 μm as the 0−1 CrH bandhead (e.g., Kirkpatrick et al. (1999)) since there are strong FeH absorption features near this wavelength.

3. J-Band Spectra

Figure 2 shows the J-band spectra of the four dwarfs. This wavelength range contains both atomic and molecular features. Atomic features include Al, K, and Na. The most prominent molecular features are the FeH bandheads of the 0−1 and 1−2 bands ($F\ ^4\Delta - X\ ^4\Delta$) at 1.1939 and 1.2389 μm, respectively. The

https://doi.org/10.1017/S0074180900210978 Published online by Cambridge University Press

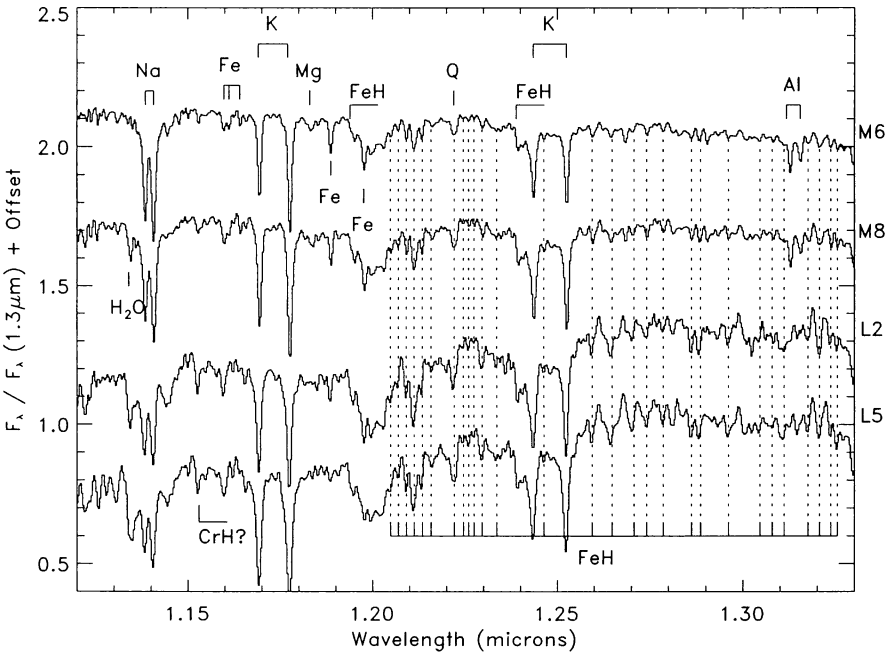

Figure 2. *J*-band spectra of the four dwarfs. The FeH bandheads and positions of the FeH lines are shown as well as the positions of the atomic absorption features due to Al, Na, and K.

features at 1.20907, 1.21126, 1.21348 and 1.22210 μm were previously identified as FeH absorption features by Jones et al. (1996). We have identified the feature at 1.22210 μm as the $F\ ^4\Delta_{7/2} - X\ ^4\Delta_{7/2}$ Q-branch (Phillips et al. 1987). There is also a H_2O feature located at 1.1347 μm which grows in strength through the L sequence. Finally, the feature at 1.153 μm may be a CrH bandhead (Burrows et al. 2002).

4. *H*-Band Spectra

Figure 3 shows the *H*-band spectra of the four dwarfs. Three bandheads of the new FeH system ($E\ ^4\Pi - A\ ^4\Pi$) identified by Wallace & Hinkle (2001) are shown as well as the 32 new FeH features we have identified. Almost the entire *H*-band is dominated by FeH absorption. There is a feature at 1.64053 μm which has no counterpart in the FeH spectrum and remains unidentified.

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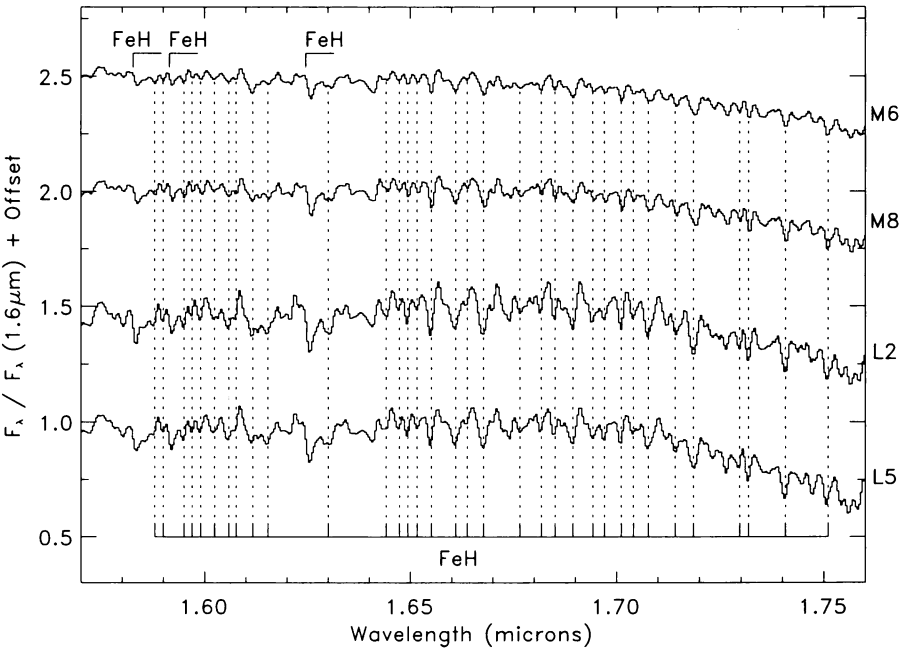

Figure 3. *H*-band spectra of the four dwarfs. The FeH bandheads and positions of the FeH lines are shown.

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