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New M and L Dwarfs Identified in the Sloan Digital Sky Survey Early Data Release

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Abstract. Spectra from the Sloan Digital Sky Survey (SDSS) Early Data Release (EDR) reveal 645 late-type (spectral type M and L) dwarfs. Additional SDSS spectra have been obtained of 34 L dwarfs from SDSS data not contained within the EDR. Stars were assigned spectral types from the spectral sequence of Kirkpatrick et al. (1999) using measurements of spectral indices and least squares fits to templates. Correlations between spectral type, optical (SDSS) and infrared (2MASS) colors are investigated.

1. Introduction

Large sky surveys such as SDSS, 2MASS, and DENIS have proven to be fertile ground for identifying extremely late type stars (Reid and Hawley, 2000). In particular, the photometric measurements conducted by the SDSS collaboration are well suited to identifying promising objects for later spectral confirmation (Fan et al. 2000; Schneider et al. 2001). Here we present M and L dwarfs identified from the SDSS spectral database. These and additional results are described in detail by Hawley et al. (2001).

2. Spectral Identification of M and L dwarfs in SDSS

The Sloan Digital Sky Survey's mission (York et al. 2000) to map a quarter of the night sky, acquiring accurate photometry of 100 million objects in 5 filters (Fukugita et al. 1996, Gunn et al. 1998) and accumulating over 1 million spectra, promises to provide astronomers with an unprecidented source of new astronomical objects. The Early Data Release (EDR) consists of the first data from the survey to be released to the public (Stoughton et al. 2001). The SDSS EDR contains spectra of more than 55,000 objects obtained with the Sloan spectrograph mounted on the SDSS 2.5 meter telescope. From these, we selected candidates which satisfied at least one of the following three criteria: a) colors of $(r^*{-}i^*) > 1.8$ and $(i^*{-}z^*) > 1.0$; b) identified automatically as late type stars by the SDSS processing software; and c) targeted for spectral observation as a possible brown or red dwarf on the basis of photometric colors. These selection criteria returned a sample of ∼1000 objects, which was reduced to 645

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objects after removing spectra that were too noisy to positively identify with a spectral type, or that were clearly not M, L, or T dwarfs. An additional sample of candidate L dwarfs with SDSS spectra not contained within the EDR was created by including more recently observed objects with (i*–z*) > 1.4.

3. Assigning Spectral Types

To assign spectral types we measured spectral indices identified by Kirkpatrick et al. (1999) and performed a least squares fit to spectral templates. The spectra were then examined by eye, and in rare cases the spectral type assigned by the indices and templates was corrected. We estimate an uncertainty of +/- 1 spectral type for the sample presented here. This uncertainty estimate is bolstered by our finding that objects with multiple SDSS spectra were consistently typed with identical or neighboring spectral types. Ultimately, 634 M dwarfs, and 45 L dwarfs were identified on the basis of their SDSS spectra.

4. Color Trends

Approximately 40% of the objects identified had 2MASS counterpart detections, although none of the objects later than L4 and only 6 objects of spectral type L2 or later were matched with 2MASS data. Those objects with 2MASS detections allowed investigation of the full range of optical and infrared colors.

Figure 1 shows the optical colors of M and L dwarfs spectroscopically identified in the SDSS. The (r*–i*) colors of the SDSS M and L dwarfs have a 1–1.5 magnitude spread and scatter around (r*–i*) ~2.7 past spectral type L0, making selection of L dwarfs with the (r*–i*) color alone difficult. As shown in Figure 1, the (i*–z*) color appears to plateau in the spectral type range L0 to L4, but seems to sharply increase again past L5. An (i*–z*) value of 1.7 or higher includes all L dwarfs, along with a number of late M dwarfs.

Figure 2 shows the variation of a combination optical/IR color with spectral type, as well as an optical color–color plot for SDSS M & L dwarfs. (z*–J) seems to be monotonically increasing towards later types, but the relative scarcity of data points lateward of spectral class M8 makes a definitive conclusion difficult. In fact, the only L spectral class with more than three data points shows a half magnitude spread in (z*–J). The (r*–i*) vs. (i*–z*) color–color diagram displays a sequence in early M dwarfs, but late M and early L dwarfs scatter about (r*–i*) = 2.7. Though it may be possible to divide M dwarfs from L dwarfs on the basis of these colors, it would appear that the (i*–z*) color is providing the most leverage in separating the two populations based on their optical photometry.

Figure 3 displays additional IR information acquired for those objects with detections in 2MASS. The (J-H) vs. (H-K) color-color diagram shows that using IR information alone makes separation of M and L dwarfs very difficult. However, as the (z*–J) vs. (z*–K) diagram indicates, a combination of optical and IR data separates M and L dwarfs into a coherent sequence.

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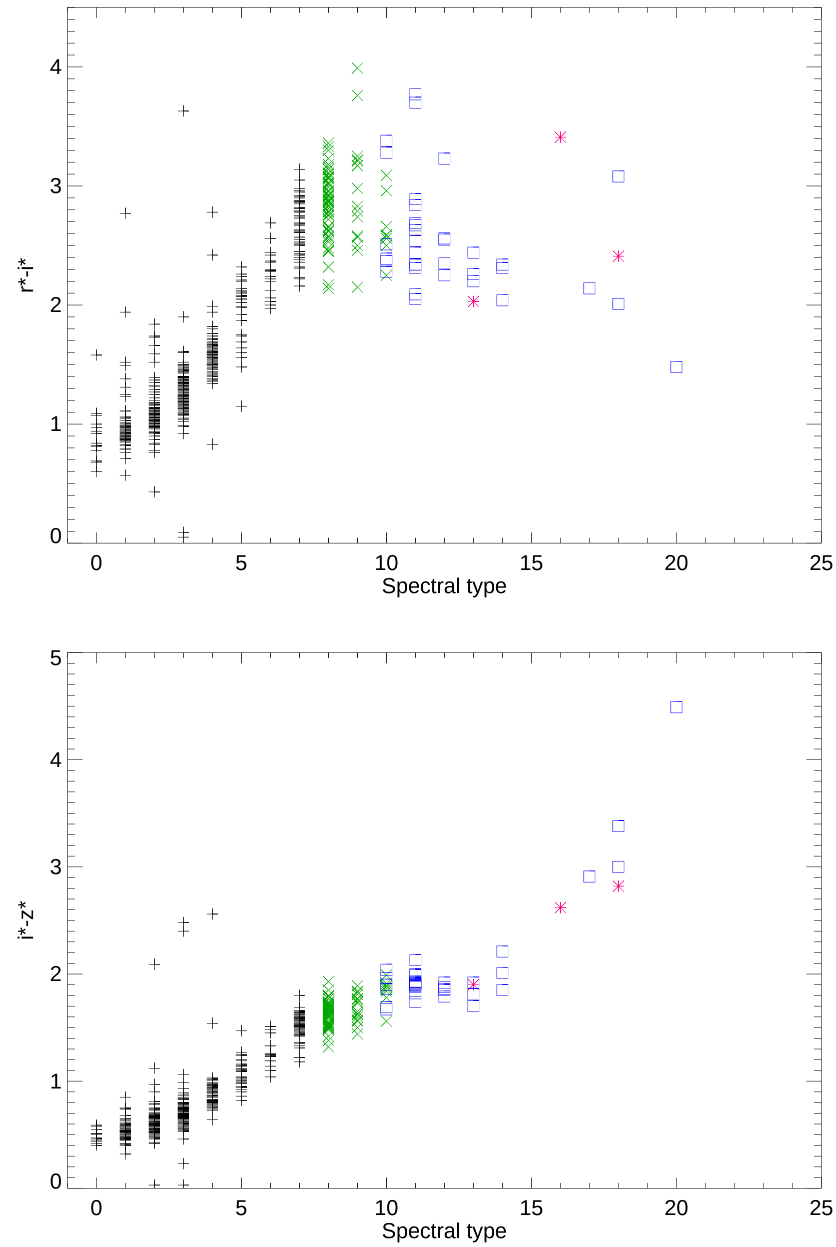

Figure 1. **Top:** (r*–i*) as a function of numerical spectral type (M0=0, M5=5, L0=10, L5=15). +'s (black), x's (green), and *'s (red) show SDSS EDR objects in bins of M0–M7, M8–L1, and L2–L8. Blue boxes show L dwarfs identified in more recent SDSS data. **Bottom:** (i*–z*) as a function of spectral type. Symbols as above.

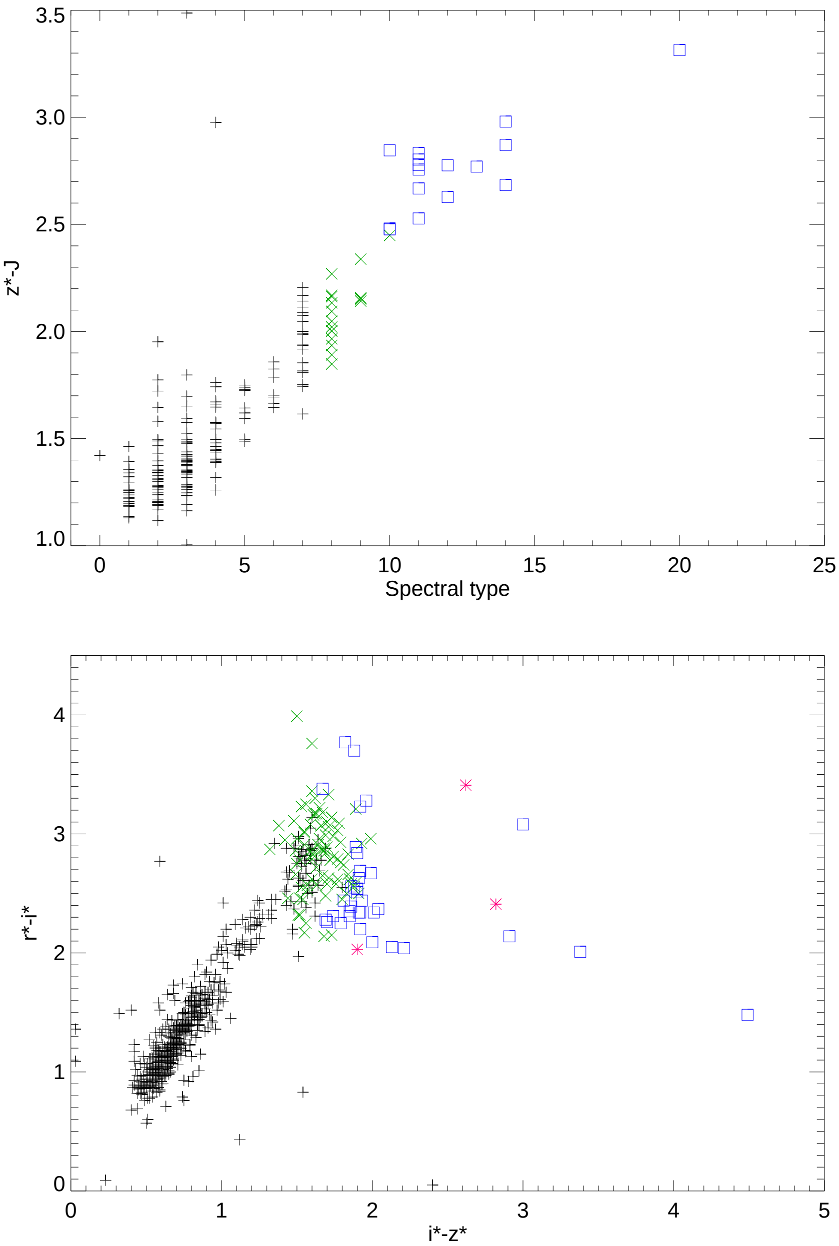

Figure 2. **Top:** (z*–J) vs. spectral type for objects detected in the SDSS and 2MASS datasets. Symbols as in Figure 1. **Bottom:** (r*–i*) vs. (i*–z*) color color diagram. Symbols as in Figure 1.

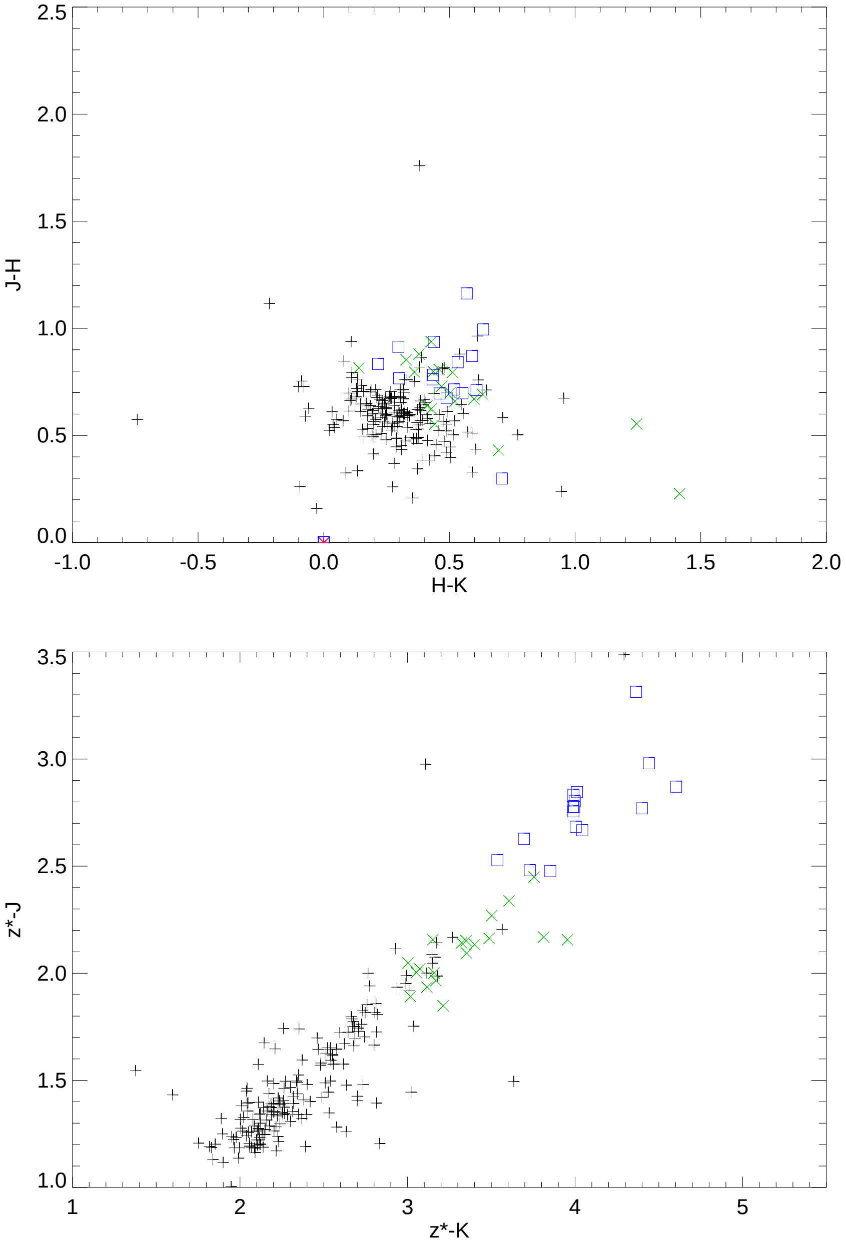

Figure 3. **Top:** (J–H) vs. (H–K) color-color diagram constructed from data for objects detected in both SDSS and 2MASS. Symbols as in Figure 1. **Bottom:** (z*–J) vs. (z*–K) color-color diagram for objects detected in both SDSS and 2MASS. Combining optical and IR data allows M and L dwarfs to be separated into a coherent sequence in this color color diagram. Symbols as in Figure 1.