Brown Dwarfs
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Candidate Brown Dwarfs in Orion OB1b

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Abstract. We have photometrically identified eleven candidate brown dwarfs in 0.2 deg^2 of the Orion OB1b association. This is consistent with a rising mass function down to $\sim$0.06M$_\odot$. Assuming the IMF of Kroupa (2002) this suggests a population of 40-200 brown dwarfs per deg^2 (0.01<M<0.075M$_\odot$).

We are conducting a large scale, multiwavelength survey of Orion OB1b (Walter et al. 2000), a young fossil OB association about 440pc from the Sun with an age of $\sim$2Myrs. Young fossil OB associations are especially good sites to study brown dwarfs (BDs) because they are relatively hot and bright.

We have used the 0.9m telescope at CTIO to conduct a shallow VRI survey of 2.7 deg^2 of the Orion OB1b association and to observe a several deep VRI fields. We determined colors and magnitudes with aperture photometry. Here we report results from 4 of our deep fields (0.2 deg^2).

We use the result of our shallow survey, complete to V$\sim$19, to characterize the position and width of the pre-main-sequence (PMS) locus (Sherry, Walter, & Wolk in prep.). We find a narrow PMS locus which is well traced by a 3-3.5 Myr isochrone (Baraffe et al. 1998). We use our deep images to search for candidate brown dwarfs (BDs). Candidate BDs lie in an extension of our empirical PMS locus, close to a 3 Myr isochrone.

We estimate masses using V-I as a proxy for effective temperature (T$_e$). Leggett (1992) relates V-I to T$_e$ and spectral type for dwarf stars. V-I grows monotonically with spectral type until about M7 (V-I=4.5). For stars later than M7 V-I grows very slowly. At a given age, the PMS models of Baraffe et al. (1998) have T$_e$ determined by the mass of the model. Thus we may convert theoretical T$_e$ to spectral types which are linked to observable colors.

A major uncertainty is that the relationship between temperature and color depends on the surface gravity, which in turn depends on age. Luhman (1999) found that the models of Baraffe et al. (1998) could fit all 4 members of the GG Tau system at a single age if the stars have T$_e$ intermediate between dwarfs and giants (at a given spectral type).

Also, stellar models normally start with initial conditions which are somewhat arbitrary. According to Baraffe (this volume), models do not converge before an age of $\sim$1 Myrs. Models of very young stars (τ <10 Myrs) may still be affected by the choice of initial condition.

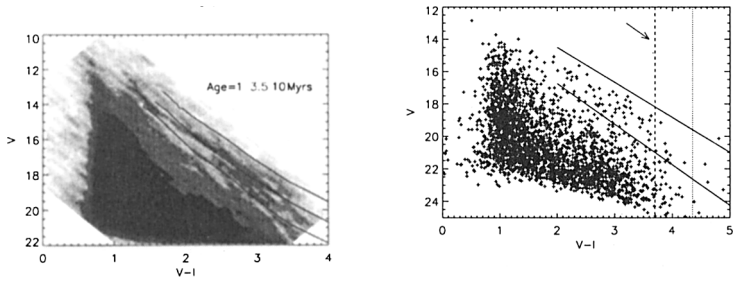

Figure 1. The left panel is a smoothed color-magnitude diagram (CMD) of 33,000 stars in the 2.7 deg^2 shallow survey of Orion's belt. The gray scale indicates the number of stars as a function of color and magnitude. Regions with more stars are darker. The PMS locus is the semi-detached dark band at the upper edge of the stellar distribution. The lines are (from top to bottom) 1, 3.5 and 10 Myr isochrones (Baraffe et al. 1998). The right panel is a CMD of 0.2 deg^2 from our deep images. Diagonal lines illustrate the rough boundaries of the PMS locus. Vertical lines mark the sub-stellar limit using dwarf (dashed) or Luhman's (dotted) T_e scale. The arrow is an A_v=1 reddening vector. Reddening is generally low, but a few candidate BDs may have $A_v \sim 1$.

Table 1. Predicted V-I Colors of 3.5 Myr old Brown Dwarfs.

Mass	Dwarf T_e	Luhman's T_e	Mass	Dwarf T_e	Luhman's T_e
0.075	3.70	4.35	0.055	4.15	4.45
0.070	3.80	4.40	0.050	4.25	4.45
0.060	4.05	4.45	0.040	4.35	4.50

We find 11 candidate brown dwarfs using the dwarf T_e scale. Follow up JHK photometry for some of our candidate BDs finds colors consistent with BDs (Walter, Sherry, & Wolk this volume). Finding 11 BDs is consistent with an IMF that is still rising for masses down to at least 0.06$M_\odot$. Using Luhman's T_e scale we find only 3 or 4 brown dwarf candidates. This is fewer than the 10-15 we expect, but the isochrone becomes nearly vertical near V-I$\sim$4.4. That could place most of the brown dwarfs below our completeness limit (V$\sim$22). Assuming the initial mass function of Kroupa (2002) there could be between 100 and 500 brown dwarfs (M>0.01$M_\odot$) in the 2.7 deg^2 of our shallow survey.

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