Brown Dwarfs
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The Substellar Members of the Pleiades

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Abstract. We have compiled the largest magnitude limited sample of candidate substellar Pleiads to date. We fit King profiles to their spatial distribution to determine the Pleiades brown dwarf core radius to be $r_c = 2.22^{+1.36\circ}_{-0.67}$. Subsequently we have used our improved spatial model to place stringent limits on the shape of the cluster mass function across and below the stellar/substellar regime. We find this to be a power law with index $\alpha = 0.41 \pm 0.08$ ($0.3M_\odot \geq M \geq 0.035M_\odot$). Extrapolation of this mass function to $M = 0.012M_\odot$ indicates that brown dwarfs contribute only $\sim 2\%$ to the total mass of the cluster hence we conclude that brown dwarfs do not contribute significantly to disk dark matter.

1. Introduction

The Pleiades has been recognised as an ideal hunting ground for low mass stellar and substellar objects for well over a decade. The cluster is both young ($\sim$ 125 Myrs) and nearby (m-M$\sim$ 5.53) placing its lowest mass members within easy reach of 2m class telescopes. Furthermore, theory suggests that at this age the cluster mass function (CMF) provides a reasonable measure of the IMF and therefore contains information on the star formation process. To provide a robust determination of the present day CMF we have combined the results of four large, deep, far-red CCD surveys of the Pleiades (i.e.,. the ITP survey - Zapatero-Osorio et al. 1999; the CFHT survey - Bouvier et al. 1998; the BPL survey - Pinfield et al. 2000; the INT WFC survey - Dobbie et al. 2002) to yield the largest magnitude limited sample of brown dwarf (BD) members to date (see Jameson et al. 2002 for details).

2. Substellar Pleiads: core radius and mass function

We adopt the lithium boundary at $I = 17.8$ as a suitable bright sample limit and as the working definition of a Pleiades BD. The least sensitive of the CCD

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surveys (the BPL and CFHT) enforce a faint completeness limit of $I \leq 19.5$. By imposing these selection criteria on the candidates from the four surveys we confine ourselves to a well defined and complete sample of 32 BDs. We fit King profiles to their spatial distribution to determine the cluster's substellar core radius to be $r_c = 2.22^{+1.36\circ}_{-0.67}$. This is consistent with a continuation of the $r_c \propto m^{-0.5}$ relationship found previously for the higher mass stellar members, but within uncertainties can also be consistent with a moderate flattening of the relationship at $M < 0.5M_\odot$.

We employ our improved model of the spatial distribution of Pleiades BDs to derive the form of the CMF across and below the stellar/substellar boundary. Also included in this calculation are 14 candidates from the two surveys which are complete to deeper magnitudes. The number of cluster members in a particular luminosity interval has been determined by integrating King profiles with $r_c = 2.22°$ and scaled to the observed number of BD candidates, out to the cluster tidal radius which we take to be at 5.54° (Pinfield et al. 1998). We estimate the mass boundaries of the luminosity bins using the 125Myr NEXTGEN model (Baraffe et al. 1998) and in this way determine the values of the mass function (MF) to be 417^{+46}_{-83} and 600^{+218}_{-218} n per $0.1M_\odot$ between $0.074M_\odot \geq M \geq 0.050M_\odot$ and $0.050M_\odot > M \geq 0.033M_\odot$ respectively. A χ^2 minimisation technique has been used to fit a power law to our MF points and the two lowest points from the study of Adams et al. (2001) to derive an index of $\alpha = 0.41 \pm 0.08$. We find this result to be largely insensitive to our choice of evolutionary model and uncertainties in the age and the distance of the Pleiades. Furthermore, it is only marginally sensitive to the low mass binary fraction. Extrapolating our power law model MF down to the $0.012M_\odot$, the deuterium burning limit, and integrating, we estimate the total mass of Pleiades BDs to be $13(+4/-3)M_\odot$ or $\sim 2\%$ of the total cluster mass. If this result is generally true for the Galactic disk, then BDs do not contribute significantly to the disk dark matter that is inferred from tracer populations in approximately equal quantities as the luminous matter (e.g Bahcall et al. 1992).

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