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Praesepe and the seven white dwarfs

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ABSTRACT

We report the discovery, from our preliminary survey of the Praesepe open cluster, of two new spectroscopically confirmed white dwarf candidate members. We derive the effective temperatures and surface gravities of WD0837+218 and WD0837+185 (LB5959) to be 17845^{+555}_{-565}K and log g $= 8.48^{+0.07}_{-0.08}$ and 14170^{+1380}_{-1590}K and log g $= 8.46^{+0.15}_{-0.16}$ respectively. Using theoretical evolutionary tracks we estimate the masses and cooling ages of these white dwarfs to be $0.92 \pm 0.05\mathrm{M}_{\odot}$ and 280^{+40}_{-30}Myrs and $0.90 \pm 0.10\mathrm{M}_{\odot}$ and 500^{+170}_{-100}Myrs respectively. Adopting reasonable values for the cluster age we infer the progenitors of WD0837+218 and WD0837+185 had masses of $2.6 \leqslant \mathrm{M} \leqslant \mathrm{M}_{\mathrm{crit}}\mathrm{M}_{\odot}$ and $2.4 \leqslant \mathrm{M} \leqslant 3.5$ $\mathrm{M}_{\odot}$ respectively, where $\mathrm{M}_{\mathrm{crit}}$ is the maximum mass of a white dwarf progenitor. We briefly discuss these findings in the context of the observed deficit of white dwarfs in open clusters and the initial mass-final-mass relationship.

Key words:
stars: white dwarfs; galaxy: open clusters and associations: Praesepe

1 INTRODUCTION

The common age, metallicity and distance of their members make galactic open star clusters favourable environments in which to examine fundamental issues in stellar and galactic astrophysics e.g. the shape of the initial mass function (IMF) or the form of the initial mass-final mass relationship (e.g. Weidemann 1987). The modestly rich and well studied Praesepe (NGC2632) cluster at a distance of 177pc, as determined from Hipparcos astrometric measurements (Mermilliod et al. 1997), appears particularly suited to such investigations. Its members share a distinct proper motion so it is comparatively straightforward to discriminate them from the vast majority of field objects along this line of sight. For example, Hambly et al. (1995) performed an astrometric survey of 19 sq. degrees centered on the cluster and found the proper motions of members tightly clumped around $\mu_{\alpha} cos\ \delta = -30$ mas yr^{-1} and $\mu_{\delta} = -8$mas yr^{-1}. A more recent Hipparcos based study of Praesepe finds mean values of $\mu_{\alpha} cos\ \delta = -35.7$ mas yr^{-1} and $\mu_{\delta} = -12.7$mas yr^{-1} (van Leeuwen 1999).

A spectroscopic study of F type members indicates the cluster is slightly metal rich with respect to the Sun ([Fe/H]=0.038, [C/H]=0.01; Freil & Boesgaard 1992). This is consistent with the conclusions reached by previous investigations of this type (e.g. Boesgaard & Budge 1988). However, there is still uncertainty as to the age of the cluster, with estimates ranging from 0.4-2 Gyrs (e.g. Allen 1973; Mathieu & Mazeh 1988). Those determinations based on isochrone fitting generally support an age of between 0.7-1.1 Gyrs (e.g. Anthony-Twarog 1982; Mazzei & Pigatto 1988), although Claver et al. (2001), hereafter C01, favour a value closer to that of the Hyades (625Myrs), on grounds that the two clusters have similar metalicity and, kinematically, Praesepe is part of the Hyades moving group (Eggen 1960).

To date, five white dwarf members of Praesepe have been identified: LB390, LB5893, LB393, LB1847 and LB1876 (Luyten 1962; Eggen & Greenstein 1965; Anthony-Twarog 1982, 1984; C01). This is fewer than the 7-20 observable degenerates predicted from the extrapolation of the present day cluster luminosity function, allowing for reasonable assumptions about the form of the IMF, the maximum progenitor mass ($\mathrm{M}_{\mathrm{crit}}$) and the binary fraction (Williams 2004, hereafter W04). Several explanations have been put forward to account for this shortfall and the deficit of white dwarfs observed in other open clusters such as the Hyades. For example, if $\mathrm{M}_{\mathrm{crit}} \sim 4\mathrm{M}_{\odot}$ there would have been fewer white dwarf progenitors in the first place (e.g. Tinsley 1974). However, the presence of the white dwarf LB1497 in the Pleiades with an estimated progenitor mass M$\gtrsim 6\mathrm{M}_{\odot}$ argues against this (C01). It has recently

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Table 1. Details of the six new candidate WD members unearthed (top) and the four previously known WD members recovered (bottom) by our preliminary survey of Praesepe.

Designation	Other ID	RA	DEC	O	E	B_J	R_F	$\mu_\alpha cos\ \delta$	μ_δ
		J2000.0		USNO-B		SuperCOSMOS		mas yr^{-1}	
candidate 1	-	08 36 10.01	19 38 19.1	17.60	18.17	18.44	18.30	-36±2	-2±3
WD0837+185	LB5959	08 40 13.30	18 43 26.4	17.81	18.20	18.28	18.24	-32±0	-12±7
WD0837+218	-	08 40 31.47	21 40 43.1	17.87	18.64	18.04	18.17	-30±5	-6±5
candidate 4	-	08 42 58.03	18 54 35.5	17.86	18.44	18.34	18.43	-34±3	-8±2
candidate 5	-	08 43 22.00	20 43 30.5	18.34	18.39	18.44	18.54	-30±4	-8±2
candidate 6	LB8648	08 46 01.91	18 30 48.5	18.04	18.25	18.11	18.25	-36±5	-14±5
WD0836+201	LB393, EG61	08 39 45.57	20 00 16.0	17.54	18.24	17.98	18.15	-32±2	-10±4
WD0836+199	LB1847, EG60	08 39 47.20	19 46 12.1	17.64	18.31	18.73	18.25	-38±3	-10±2
WD0837+199	LB390, EG59	08 40 28.09	19 43 34.8	17.28	17.78	17.48	17.59	-34±2	-2±3
WD0840+200	LB1876	08 42 52.32	19 51 11.3	17.27	18.00	17.75	18.02	-30±3	-10±4

been shown that asymmetry at a level of only 1% in the post main sequence mass loss process is sufficient to lead to the rapid loss of a significant fraction of the white dwarf population from an open cluster (Fellhauer et al. 2003). Alternatively, for Praesepe at least, it may be that no investigation to date has included a sufficient fraction of the total area the cluster projects on the sky. The surveys of Anthony-Twarog (1982, 1984) and C01 have both concentrated on the central ~ 2 sq. degrees of the cluster but Adams et al. (2002) determine the tidal radius to be $\sim 5^\circ$ (see Figure 1).

There have been a number of studies of the five previously known Praesepe white dwarfs. Reid (1996) have used high resolution spectroscopy of the H$-\alpha$ line cores to derive gravitational redshift based mass estimates of 0.42, 0.91 and 0.67$M_\odot$ for LB390, LB5893 and LB393 respectively. C01 fit synthetic line profiles to moderate resolution, high S/N spectra of the H$-\eta$ to H$-\beta$ members of the Balmer series in each white dwarf, to measure effective temperatures ($T_{\rm eff}$) and surface gravities (log g). Subsequently, they derived the mass of each, in the order listed in the above paragraph, to be 0.82, 0.91, 0.62, 0.82 and 0.75$M_\odot$. They also noted the anomolously low mass Reid determined for EG59 likely stemmed from his neglect of the Zeeman splitting of the H$-\alpha$ line core caused by a magnetic field with a strength of $\sim$ 3MG. Reid and C01 have estimated the mass of the progenitor star of each degenerate, comparing the difference between the age of the cluster and the cooling time for the white dwarf to the predictions of stellar evolutionary models. For four of the white dwarfs studied the progenitor mass is consistent with the existence of a monotonically increasing relationship between the initial mass and the final mass (see Figure 11 of C01). However, in both investigations LB5893 is found to be “too young” for its comparatively high mass. C01 speculate that it may be the outcome of binary evolution, perhaps a double degenerate merger. Alternatively, taking into account both this white dwarf and his mass estimate for LB390, Reid suggests that a simple relationship between initial mass and final mass may not exist.

To move towards a resolution of these issues we are embarking on a comprehensive search for additional white dwarf members of Praesepe. Here we report the discovery, from a preliminary version of this survey, of two new white dwarf candidate cluster members. For each object we present an optical spectrum, determine $T_{\rm eff}$ and log g and by comparing these measurements to evolutionary models estimate mass and cooling time. We conclude by briefly discussing our findings in the context of the reported deficit of white dwarfs in Praesepe and the initial mass-final mass relationship.

2 A PRELIMINARY SEARCH FOR PRAESEPE WHITE DWARFS

We have utilised the USNO-B1.0 catalogue to undertake a survey of a $5^\circ \times 5^\circ$ region centred on the Praesepe open cluster ($\alpha = 08\ 40$ $\delta = +19\ 40$, J2000.0). The USNO-B catalogue contains astrometric information and photographic magnitudes for over a billion objects, gleaned from digitally scanned photographic plates spanning a baseline of ~ 50 years. The internal astrometric accuracy and the dispersion in the photometry are estimated to be $\sim 0.2''$ and ~ 0.3 magnitudes respectively (for details see Monet et al. 2003).

In this preliminary effort we have extracted all sources with $19 \geqslant$ O $\geqslant 17$, O-E $\leqslant 0$ and with proper motions $-25 \geqslant \mu_\alpha cos\ \delta \geqslant -45$ mas yr^{-1}, $0 \geqslant \mu_\delta \geqslant -20$ mas yr^{-1}. This encompasses the magnitude range of known cluster white dwarfs and is virtually coincident with the astrometric range sampled by Hambly et al. (1995). Further, the survey should be near complete for O-E $\gtrsim -1$ (Hambly et al. 1995). Subsequently, the POSS II J and F images of each candidate have been inspected to eliminate extended sources, blended objects and spurious detections originating in the diffraction spikes of bright stars. As an additional check, candidates have been cross referenced against the 2MASS Point Source Catalogue (Skrutskie et al. 1997), keeping only those which are either non-detections or have blue near-IR colours within the photometric errors. Finally, we have used photographic photometry measured by SuperCOSMOS to compare the location of our new candidates to the locus of cluster white dwarfs in the B_J, R_F colour-magnitude diagram (Figure 2). The external accuracy of individual passband magnitudes in the SuperCOSMOS Sky Survey is quoted as 0.3 magnitudes, but this uncertainty is dominated by drifts in zeropoints as a function of magnitude and position on the sky. These systematic errors do not appear when using colours as they are the same in all passbands, so indices like $B_J - R_F$ are accurate to ~ 0.1 magnitudes (Hambly et al. 2001). This is not the case in USNO-B where the scatter in colours is > 0.3 magnitudes.

To enhance the white dwarf sequence which is rather loosely defined by the five known degenerate members (the photometry for LB5893 appears to have been adversely affected by the proximity of the bright stellar cluster member KW195) we have used suitable objects drawn from the 20pc sample of Holberg et al. (2002) with trigonometric parallax determinations and SuperCOSMOS B_J and R_F photometry, scaling these to the cluster distance of 177pc. Of the seven new candidates the locations of six are deemed consistent with them being white dwarf members of Praesepe, the remaining object lying $\sim$ 1 magnitude below the sequence (see Figure 2).

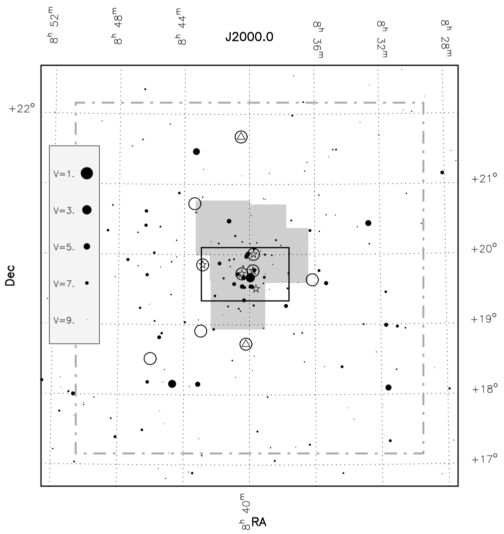

Figure 1. A schematic plot of the Praesepe cluster showing stars down to V $\approx$ 9 and the areas surveyed by Anthony-Twarog (1982, 1984; solid outline) and C01 (grey shading). The region included in this investigation is outlined (dashed grey line). All objects listed in Table 1 (open cricles) and the known white dwarf cluster members (open stars) are also overplotted. The locations of the two new spectroscopically confirmed white dwarf candidate members are highlighted (open triangles).

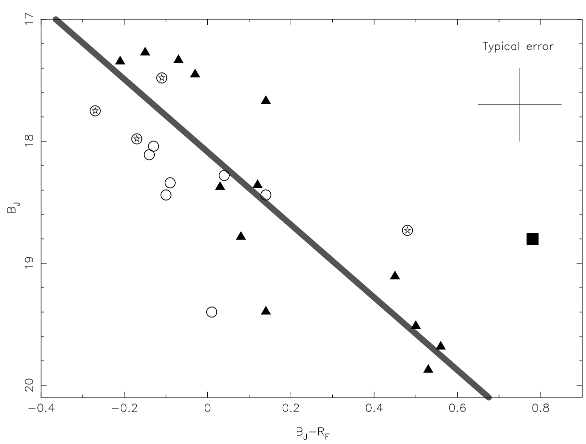

Figure 2. A B_J, $B_J - R_F$ colour-magnitude diagram of the eleven objects remaining after cross referencing against the 2MASS PSC (open circles). The thick line represents a linear least squares fit to SuperCOSMOS photometry of the known degenerate members (open circles+stars) and objects drawn from the 20pc sample of Holberg et al. (2002) with trigonometric parallax determinations (filled triangles). The magnitudes of the latter have been scaled to correspond to a distance of 177pc. Note that LB5893 (filled square) has been excluded from the fit.

Details of these six candidates and the four previously known white dwarf members recovered here are given in the top and the bottom of Table 1 respectively. Although C01 recognise LB5893 to be an astrometric member, it is not recovered here as its proper motion is listed in the USNO-B1.0 catalogue as $\mu_\alpha cos\ \delta = -56$ mas yr^{-1}, $\mu_\delta = -14$ mas yr^{-1}. This astrometry also appears to have been affected by the proximity of KW 195.

We have obtained optical spectra of two candidates in the sample (LB5959 and WD0837+218) using the William Herschel Telescope and the double armed ISIS spectrograph on 28/01/2001. Sky conditions were fair on this night with clear skies but with seeing $\sim$ 2”. For the course of the run ISIS was configured with the 5700 dichroic and the EEV12 and TEK4 detectors on the blue and red arms respectively. The data were obtained using the R158B and R158R gratings and a slit width of 1” to provide a spectral resolution of $\approx$ 6Å. Total exposure times were 60 and 120 minutes for LB5959 and WD0837+218 respectively. The CCD frames were bias subtracted, flat fielded and cosmic ray hits removed using the IRAF routines CCDPROC and FIXPIX. Subsequently the spectra were extracted using the APEXTRACT package and wavelength calibrated by comparison with the CuAr+CuNe arc spectra. Our observed spectral standards (G191-B2B and Feige 67) were drawn from the catalogues of Oke (1974,1990) and used to remove the instrument signature and telluric features from the science spectra.

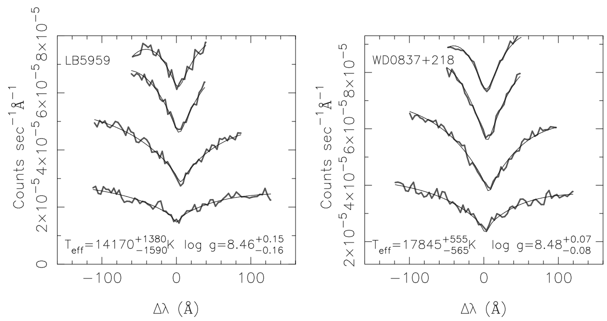

Figure 3. The results of our fitting of synthetic profiles (thin black lines) to the observed Balmer lines (thick grey lines).

3 ANALYSIS OF THE DATA

3.1 Model white dwarf spectra

A glance at Figure 3 reveals broad hydrogen Balmer lines consistent with both objects being DA white dwarfs. Therefore, we have generated a grid of pure-H synthetic spectra covering the T_{eff} and surface gravity ranges 14000-20000K and log g=7.0-9.0 respectively. We have used the latest versions of the plane-parallel, hydrostatic, non-local thermodynamic equilibrium (non-LTE) atmosphere and spectral synthesis codes TLUSTY (v200; Hubeny 1988, Hubeny & Lanz 1995) and SYNSPEC (v48; Hubeny, I. and Lanz, T. 2001, ftp:/tlusty.gsfc.nasa.gov/synsplib/synspec). We have employed a state-of-the-art model H atom incorporating the 8 lowest energy levels and one superlevel extending from n=9 to n=80, where the dissolution of the high lying levels was treated by means of the occupation probability formalism of Hummer & Mihalas (1988), generalised to the non-LTE situation by Hubeny, Hummer & Lanz (1994). All calculations were carried out under the assumption of radiative equilibrium, included the bound-free and free-free opacities of the H^- ion and incorporated a full treatment for the blanketing effects of HI lines and the Lyman $-\alpha$, $-\beta$ and $-\gamma$ satellite opacities as computed by N. Allard (e.g. Allard et al. 2004). During the calculation of the model structure the lines of the Lyman and Balmer series were treated by means of an approximate Stark profile but in the spectral synthesis step detailed profiles for the Balmer lines were calculated from the Stark broadening tables of Lemke (1997).

Table 2. Details of the two new spectroscopically confirmed white dwarf candidate cluster members. Masses and cooling times are derived from the “thick H-layer” evolutionary calculations of Wood (1995).

WD	$T_{\rm eff}$(K)	log g	M($M_\odot$)	τ_c(Myrs)
0837+185	14170^{+1380}_{-1590*}	$8.46^{+0.15}_{-0.16}$	0.90 ± 0.10	500^{+170}_{-100}
0837+218	17845^{+555}_{-565}	$8.48^{+0.07}_{-0.08}$	0.92 ± 0.05	280^{+40}_{-30}

* extrapolated.

3.2 Determination of effective temperatures and surface gravities

We carried out comparisons between models and data using the spectral fitting program XSPEC (Shafer et al. 1991). XSPEC works by folding a model through the instrument response before comparing the result to the data by means of a χ^2-statistic. The best fit model representation of the data is found by incrementing free grid parameters in small steps, linearly interpolating between points in the grid, until the value of χ^2 is minimised. Errors are calculated by stepping the parameter in question away from its optimum value until the difference between the two values, $\Delta\chi^2$, corresponds to 1σ for a given number of free model parameters (e.g. Lampton et al. 1976). The errors in the $T_{\rm eff}$s and log g s quoted here are formal 1σ fit errors and may underestimate the true uncertainties.

Preliminary fitting of our model grid to the observed Balmer line profiles (H$-\epsilon$ - H$-\alpha$) in both spectra revealed that our efforts to remove the effects of the wiggles in the response of the ISIS dichroic around 4400Å had not been entirely successful. Therefore, we excluded the Balmer$-\gamma$ line from our subsequent analyses, determining $T_{\rm eff}$s and log g s from the four remaining profiles. The results are given in Table 2 and shown overplotted in Figure 3.

4 DISCUSSION

4.1 Cluster membership and the white dwarf deficit

A steep powerlaw ($\Gamma = 2$) was the only shape of IMF of the four investigated by W04 consistent with his assumption of seven white dwarf members of Praesepe, for reasonable values of the maximum progenitor mass ($6M_\odot \leqslant M_{\rm crit} \leqslant 10M_\odot$). The “Naylor” IMF, a broken powerlaw with index $\Gamma = 0.2$ (M$\leqslant 1M_\odot$) and $\Gamma = 1.8$ (M$> 1M_\odot$) was found to be consistent only for $M_{\rm crit} = 6M_\odot$. However, in a subsequent paper, Williams, Bolte & Liebert (2004), show LB6037 and LB6072 to be QSOs, reducing the number of bona fide white dwarf members of Praesepe unearthed to date to only five. In this case, only the steep powerlaw form with $M_{\rm crit} \leqslant 8M_\odot$ can be considered consistent with the observations.

Nevertheless, we have presented evidence here the number of Praesepe white dwarfs is at least seven. As a further check of the membership status of our two new spectroscopic candidates we constrain their distances using the measured $T_{\rm eff}$s and log g s and radii derived from evolutionary tracks. From the “thick H layer” models of Wood (1995) we determine R$= 0.0093 \pm 0.0020R_\odot$ and R$= 0.0091 \pm 0.0009R_\odot$ for LB5959 and WD0837+218 respectively. Subsequently,we estimate the absolute visual magnitude of LB5959 to be $M_V = 12.0 \pm 0.5$ and that of WD0837+218 to be $M_V = 11.7 \pm 0.2$. Refering to the synthetic photometry of Bergeron et al. (1995; private comm.), we estimate B-V $\approx +0.15$ and +0.05 for the cooler and hotter degenerate respectively. Thus from the SuperCOSMOS data, $B_J = 18.3\pm0.3$ and $B_J = 18.0\pm0.3$, we determine V magnitudes of 18.15 ± 0.3 and 18.0 ± 0.3. Hence, we estimate these white dwarfs to reside at 170^{+45}_{-40}pc and 180^{+40}_{-30}pc respectively.

Indeed, the favourable success rate of our preliminary survey in unearthing cluster white dwarfs suggests several of the remaining four new candidates will also prove to be degenerate members. However, as confirmation of this must await further spectroscopy, for now we consider the observed number of Praesepe white dwarfs, N, to lie in the range $7 \leqslant N \leqslant 11$. Based on the Williams simulations we find the steep powerlaw form of the IMF is consistent with the observed number for any reasonable value of $M_{\rm crit}$. Similarly, if N$\geqslant 8$ the “Naylor” form can be considered consistent for any reasonable value of $M_{\rm crit}$. We note, one requires to detect at least ten white dwarf members for the Salpeter form of the IMF to be regarded at best, in Williams scheme, as mildly inconsistent with the observed number (P≈ 0.07). As our preliminary results indicate white dwarf members are to be found beyond the well studied inner regions of the cluster (Figure 1 shows WD0837+218 lies at a projected separation of $\sim 2^\circ$) more likely await discovery. A detailed survey extending out to at least the tidal radius should be undertaken before any firm conclusions are drawn regarding the form of the IMF.

Prior to this work only the “Naylor” form of the IMF was found to be consistent with the non-detection of cluster white dwarfs residing in unresolved binary systems (W04). However, there is no evidence to suggest that either of the two new confirmed white dwarfs resides in a binary. We find a white dwarf with $T_{\rm eff} = 17000$K and log g $= 8.0$, typical of the Praesepe population, has M_V=11.0, M_B=11.0 and M_U=10.2 (Bergeron et al. 1995) and a young disc M3 dwarf has M_V=10.7, M_B=12.3 and M_U=13.4 (Leggett et al. 1992). An unresolved binary consisting of these two objects has U-B$= -0.6$, B-V$= 0.6$. It thus lies on the fringes of the W04 criteria for being “observable” (U-B $\leqslant 0.0$, B-V $\leqslant 0.6$), which were chosen to approximate the limits of the UBV surveys of C01 and Anthony-Twarog. White dwarfs with more massive main sequence companions are unlikely to have been identified by these surveys. Similarly, since both Luyten's and the current work utilised blue and red photographic plates, selecting objects with colours I.C.$\leqslant 0.2$ ($\approx$ B-V$\lesssim 0.5$) and O-E$\leqslant 0$ respectively, these too are likely biased against finding white dwarfs residing in binaries with stars of spectral type earlier than mid-M.

Farihi et al (2003) report a deficit of objects of spectral type later than mid-M paired to field white dwarfs at separations of $\sim$ few 100AU. Further, radial velocity surveys point towards a drop in the relative frequency of main sequence binaries with mass ratios $M_2/M_1 \lesssim 0.2$, at separations $\lesssim 5$ AU (Halbwachs et al. 2003; Marcy & Butler 2000). Hence, it seems plausible, particularly as the progenitors of the Praesepe and Hyades white dwarfs had M$\gtrsim 2.5M_\odot$, that by including a population of zero age binaries consisting of randomly paired stars, the simulations of W04 overpredict the number of detectable white dwarfs in unresolved binaries with main sequence companions. This assumption was acknowledged by W04 as a possible shortcoming in their modelling. Our forthcoming GALEX survey of Praesepe will expand the parameter space in which we are able to search for white dwarfs to include those in unresolved systems with K, G, and F type companions. It will reveal important additional information on the form of the IMF and the binary fraction of this cluster.

Table 3. Progenitor lifetimes and corresponding masses for various adopted cluster ages.

Progenitor	8.80 ($\log_{10}$ Myrs)		8.92 ($\log_{10}$ Myrs)		9.04 ($\log_{10}$Myrs)	
of WD	$\tau_{\rm prog}$ (Myrs)	$\rm M_{prog}$ ($\rm M_\odot$)	$\tau_{\rm prog}$ (Myrs)	$\rm M_{prog}$ ($\rm M_\odot$)	$\tau_{\rm prog}$ (Myrs)	$\rm M_{prog}$ ($\rm M_\odot$)
0837+185	130^{+100}_{-170}	$4.9^{\lesssim \rm M_{crit}}_{-1.0}$	330^{+100}_{-170}	$3.4^{+1.1}_{-0.3}$	600^{+100}_{-170}	$2.8^{+0.3}_{-0.2}$
0837+218	350^{+30}_{-40}	$3.3^{+0.2}_{-0.1}$	550^{+30}_{-40}	$2.9^{+0.0}_{-0.1}$	820^{+30}_{-40}	$2.5^{+0.0}_{-0.1}$

4.2 White dwarf masses and the initial mass-final mass relationship

We have estimated the masses of the two new white dwarfs by comparing their measured $\rm T_{eff}$s and log g s to the predictions of evolutionary calculations (Wood 1995). As expected for their progenitor masses, $\rm M \gtrsim 2.5M$, these two objects have masses greater than the canonical white dwarf value of $\rm M \approx 0.6M_\odot$ (see Table 2). We have also used the evolutionary tracks to estimate the cooling times of these objects, determining 500^{+170}_{-100}Myrs and 280^{+40}_{-30}Myrs for LB5959 and WD0837+218 respectively. As the age of the cluster is rather uncertain we have used three different estimates encompassing the likely value ($\log\, \tau_{\rm cluster} = 8.80, 8.92$ and 9.04) to derive the progenitor lifetimes. Using cubic splines to interpolate between the lifetimes calculated for stars of solar composition by Girardi et al. (2000), we constrain the masses of the progenitors of LB5959 and WD0837+218 to be $2.6 \leqslant \rm M \leqslant M_{crit}$ $\rm M_\odot$ and $2.4 \leqslant \rm M \leqslant 3.5$ $\rm M_\odot$ respectively.

Examining the location of these objects in Figure 11 of C01 we find while LB5959 fits in comfortably with a monotonic relationship between initial mass and final-mass, like LB5893, WD0837+218 appears to be too hot and hence too young for its high mass. We note there are five blue straggler members of Praesepe (e.g. Andrievsky 1998). The evolution of these objects appears to have been delayed, either through binary interaction or another as yet unidentified mechanism. We suggest that LB5893 and WD0837+218 may be related to this population. Alternatively, as suggested by Reid (1996), perhaps, at least some stars, do not subscribe to a simple monotonic relationship between their mass and the mass of their resulting white dwarf remnant.

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