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Abstract

The MACHO microlensing experiment's time-sampled photometry database contains blue and red lightcurves for nearly 9 million stars in the central bar region of the Large Magellanic Cloud (LMC). We have identified known LMC Planetary Nebulae (PN) in the database and find one, Jacoby 5, to be variable. We additionally present data on the "parent populations" of LMC PN, and discuss the star formation history of the LMC bar.

The Variable LMC Planetary Nebula, Jacoby 5

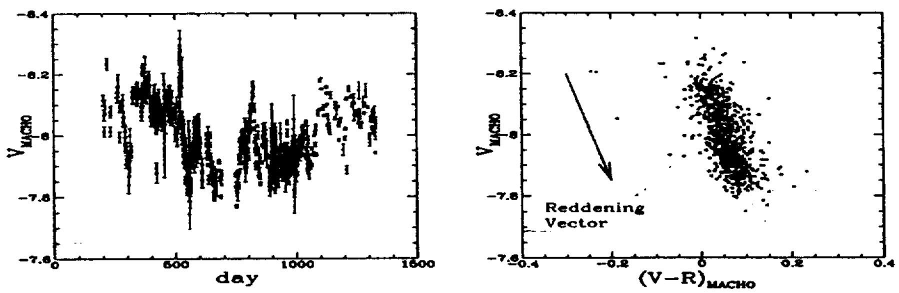

Fig. 1 - MACHO lightcurve for J5 starting Jan 2, 1992 and CMD

Fifty LMC PN from the catalogs of Jacoby [1] and SMP [2] have been identified in the MACHO database. One PN, Jacoby 5 (J5), is found to be variable on short timescales, of order tens of days, with an amplitude up to 0.4 mag in the MACHO instrumental system [3]. The V_{MACHO} lightcurve and locus of points in the color-magnitude diagram (CMD) are presented in Fig. 1. Note that the points in the CMD lie parallel to the reddening vector. This may imply extinction as the source of variability. The point spread function of J5 is stellar. There is no correlation of brightness with seeing, and no periodicity is found. Boroson and Leibert [4] confirmed J5 as a PN via spectrophotometric observations and remark on the presence of Fe emission lines. Broad-band photometric variability attributed to changes in emission line strengths has been seen in the galactic D-type symbiotic star, HM Sge [5]. Systems such as HM Sge are characterized by extremely high electron densities [6], and may be similar to J5.

Parent Populations

MACHO has identified approximately 1500 Cepheids in the LMC bar [7]. Using photometry calibrated to V and R_{KC} and the pulsation models of Chiosi et al. [8] we derive a pulsation mass histogram (PMH) for metallicity appropriate to the LMC. Core He-burning "clump giants" have been counted with luminosity functions yielding 9.5×10^5 in the bar, or a surface density of 24 per arcmin^2 in agreement with Hardy et al. [9].

We seek a "plausible" star formation history (SFH) constrained by the number of clump giants and Cepheid PMH. Our model uses the main sequence lifetimes of Iben and Laughlin [10], a Salpeter IMF, and a flat enrichment history. Cepheid lifetimes as a function of initial mass are derived from evolution tracks [11] and a theoretical instability strip [8]. We fit only the high mass end of the PMH. Clump lifetimes are derived from Vassilidias and Wood [12]. We count only stars of $M_i \leq 2\ M_\odot$ passing through the clump. We find that a constant SFH is improbable, as is a single (10 Gyr ago) burst. Almost regardless of past SFH, we find that a burst 50 Myr ago (σ_{FWHM} = 50 Myr) is required by the Cepheid PMH.

We estimate a total of 300 $\pm$ 50 PN in the bar of the LMC using observational data [1,4] and predict only 150 for a lifetime of 2×10^4 years with our "plausible" present day mass function. Either the average LMC PN lifetime is disturbingly long (4×10^4 yr), the incompleteness of the surveys was overestimated, or a short duration burst of star formation took place a few Gyr ago. A modification to our SFH consistent with the Cepheid and clump giant constraints, favors the latter.

MACHO has also found 19,000 AGB red variables [3] where 87 % have R-band amplitudes less than 0.5 mag, below the limits of previous surveys [13]. We find general agreement between our model predictions and the observed number of AGB variables, although pulsating lifetimes are highly uncertain [14]. We note that the gross disagreement between Mira deathrates and PN birthrates [13] is alleviated considerably by the large number of low amplitude AGB red variables found if they are all counted as "parents" of the LMC PN.

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