THE AGE DISTRIBUTION AND AGE-METALLICITY RELATION OF STAR CLUSTERS IN A NORTHERN REGION OF THE LMC

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ABSTRACT. CCD images and UBV integrated photometry of 31 clusters comprising a magnitude limited sample in a remote northern region of the LMC have provided reliable ages and consistent abundances using isochrone 'fits' to deep color-magnitude (CM) diagrams for the 15 clusters with CCD data. Ages for the remaining clusters have been inferred from their integrated colors. The resulting LMC cluster age distribution is markedly different from the age distribution of Galactic clusters suggesting a significant 'burst' in the cluster formation rate in the outer LMC 2 – 4 Gyr ago. The age-metallicity relation (AMR) for our LMC cluster sample is also presented.

1. INTRODUCTION

Many studies have used LMC star clusters as probes of that galaxy's star formation and metal enrichment history (*e.g.*, Elson and Fall 1985). Such studies have suffered from large uncertainties in the ages of middle-aged and old clusters. With the advent of CCDs, the time is ripe for a re-examination of the LMC cluster age distribution (CAD) and age-metallicity relation (AMR). This paper describes such a study for a sample of remote LMC clusters. Analysis of this sample allows us to a) obtain a CAD and AMR subject to understandable selection effects, and b) address the puzzling questions of how and why the remote LMC clusters formed where there is now no gas or apparent star formation.

2. OBSERVATIONS AND PROCEDURES

The sample consists of 31 clusters located in a region centered about 6° NNE of the optical center of the LMC and is essentially complete to $V \sim 14.0$ ($M_V \sim -4.5$). The data include integrated UBV photometry of 29 clusters and BVR CCD photometry of 15 clusters using the CTIO 0.9m and 4m telescopes. All but one of the clusters are located beyond the limit of detected LMC HI (McGee and Milton 1966).

The analysis of these data include a) the subtraction of field stars from the cluster CM diagrams (Mateo and Hodge 1986), b) determining ages and metallicities via 'fits' of the CM diagrams to the isochrones of VandenBerg (1985), and c) using the integrated colors and ages of the clusters with CM diagrams to assign ages to the remaining clusters. Our analysis is 'self-contained' and involves no observations or age calibrations from other sources.

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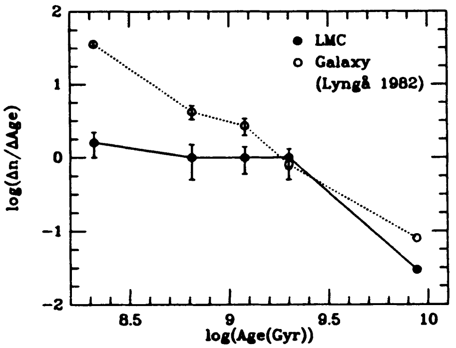
3. DISCUSSION

The normalized cluster frequency ($\equiv \frac{n}{\Delta t}$, where n is the number of clusters formed in the period Δt) is shown in Fig. 1. Comparison with the Galactic CAD (Lyngå 1982) suggests very different cluster formation histories in the two galaxies. A constant LMC cluster formation rate (CFR) implies excessively long cluster dissolution times (Wielen 1985) and implies that Fig. 1 is more consistent with a non-uniform CFR in the outer LMC with $CFR_{2Gyr}/CFR_{200Myr} \sim 20$. The AMR for the LMC clusters in our sample (Fig. 2) shows that a) the youngest clusters have abundances consistent with those of LMC Cepheids (Harris 1983), and b) the chemical enrichment of the LMC has been slower than in the Galaxy, but the present-day abundances of the two galaxies are quite similar.

Our data suggest that after forming the oldest clusters (*e.g.*, NGC 2010, H11), the LMC was relatively inactive. Then, about 2 – 4 Gyr ago, a sudden 'burst' in the CFR occurred throughout the LMC; the inner LMC is still forming stars. This picture is supported by a) the rarity of LMC clusters with accurate CCD CM diagrams with ages between 3.0 to 15 Gyr and b) the LMC field star data (Butcher 1977) suggesting a similar rise in the star formation rate 3 – 5 Gyr in many regions of the LMC.



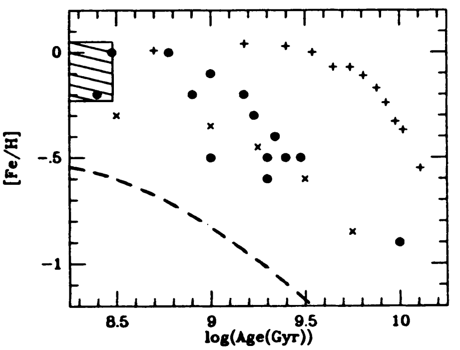


FIG. 1 (*left*) – The LMC and Galactic cluster age distributions. FIG. 2 (*right*) – The AMR for clusters in our sample (closed circles). Other AMRs – x's: Cohen (1982); line: Hodge (1981); +'s: Galactic (Twarog 1980); hatched: LMC Cepheids (Harris 1983).

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