INTERMEDIATE-AGE MAGELLANIC CLOUD STAR CLUSTERS

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Ages of six intermediate-age Large Magellanic Cloud star clusters have been estimated using the time dependent behavior of the luminosity of stellar interior models of red giants. All clusters studied, NGC 1783, NGC 1868, NGC 1978, NGC 2121, NGC 2209, and NGC 2231, were found to have ages < 10^9 yr. It is concluded that there is currently no substantial evidence for a major cluster population of large, populous clusters > 10^9 yr in the Large Magellanic Cloud.

The distributions of red giants on the six cluster color-magnitude diagrams were compared to a grid of 33 stellar evolutionary tracks, evolved from the main sequence through core-helium-exhaustion and up the asymptotic giant branch, spanning the expected mass range (2-3 solar masses) and metallicity range ($-0.2 \leq$ [Fe/H] ≤ -1.2) for intermediate-age Large Magellanic Cloud clusters. The faintest model core-helium-burners clearly decreased in luminosity with decreasing mass; thus, model red giant luminosities decreased with age.

Although Cannon (1970) indicates that the mean M_V of the red "clump" giants reaches a limiting magnitude of +1, many galactic intermediate-age clusters exhibit red clump giants much fainter; e.g., the faintest red giants in NGC 559 reach $M_V = +2.5$, in NGC 752, NGC 1245, NGC 2477, and NGC 3496 they reach $M_V \simeq +2$. These clusters clearly substantiate the age-luminosity trends of the model core-helium-burning red giants.

Since the current main sequence photometry is generally still too inaccurate to obtain reliable Magellanic Cloud cluster ages with main sequence turnoffs, the red giant models have been used to estimate cluster ages (the red giant photometry is more accurate than the necessarily fainter main sequence photometry). These red giant ages are compared in Table 1 to the main sequence termination ages of Hodge (1982), Olszewski (1983), and Flower et al. (1983), the AGB ages of Mould and Aaronson (1982), and the integrated spectra ages of Rabin (1982). The red giant ages agreed with the main sequence termination ages; both techniques are based on cluster color-magnitude diagrams (CMD).

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TABLE 1 LMC CLUSTER AGE ESTIMATES (10^9 yr)

Cluster	Red Giants	MS Termination	Mould and Aaronson	Rabin	[Fe/H] Estimate	SWB Type
NGC 2209	0.8	0.7	3	1.5-2.5	-1.1	III-IV
NGC 1868	0.75	0.3	-	-	-1.2	-
NGC 2231	0.55	1.2	-	-	-1.3	V
NGC 1783	0.46	>0.2	3	4	-0.5	V
NGC 1978	0.45	0.7	2	>6	-0.5	VI
NGC 2121	0.39	0.4	4	5	-1.0	VI

In every instance of an age estimate for a cluster by both CMD and AGB dating techniques, the CMD ages are always significantly (factor of 3 or more) lower. The AGB ages are, however, very sensitive to the choice of the mass loss parameter used in the AGB evolutionary models. Increasing it from 0.45 (Mould and Aaronson 1982) to 1.0 will reduce all AGB age estimates to less than 10^9 yr. The AGB ages are also susceptible to statistical fluctuations in the luminosity function (in many clusters only one star defines the age).

Because the integrated spectra ages (Rabin 1982) are based on integrated light models that ignore the contribution of red clump giants, the extremely large ages (based on the strengths of the Balmer lines) are probably entirely unreliable. The large number of red giants in the clusters may contribute enough flux on the blue to fill in the H-line contribution by the fainter main sequence stars, thus mimicking the effects of a weakening main sequence contribution in the blue due to cluster aging.

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