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The Star Formation History and IMF in the LMC and SMC from Deep HST Imaging

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Abstract. We present deep photometry to $V \sim 27.5$ obtained with the HST in several fields in the LMC and the SMC. We derive luminosity functions for the faintest stars which are *consistent with* an initial mass function similar to that of the solar neighborhood, although moderate variations are not excluded. We discuss implications of these observations for the star formation history in these regions of the LMC and SMC.

1. Observations and Results

Four fields have been observed in the LMC with the WFPC2 for several thousand seconds in F555W and F814W. Three of the fields are several degrees from the LMC center; one is located in the bar. In the SMC, two separate fields have been observed which are just adjacent to the bar.

Color-magnitude diagrams in all of the fields are roughly similar, showing broad upper main sequences which imply roughly constant star formation over the past few Gyr. There is no evidence for discrete bursts of star formation within the past few Gyr. The giant branches are bluer than expected from the Padova stellar models for metallicities expected for the LMC; Geneva isochrones predict *even redder* giant branches. The main sequence around the oldest turnoff is relatively blue as well. One would need field stars which have lower metallicity than clusters of a comparable age to populate this region if the stellar models and photometry are correct.

The luminosity functions for the fields are similar, after correction for differing levels of completeness which arise from different exposure times, crowding, and image quality.

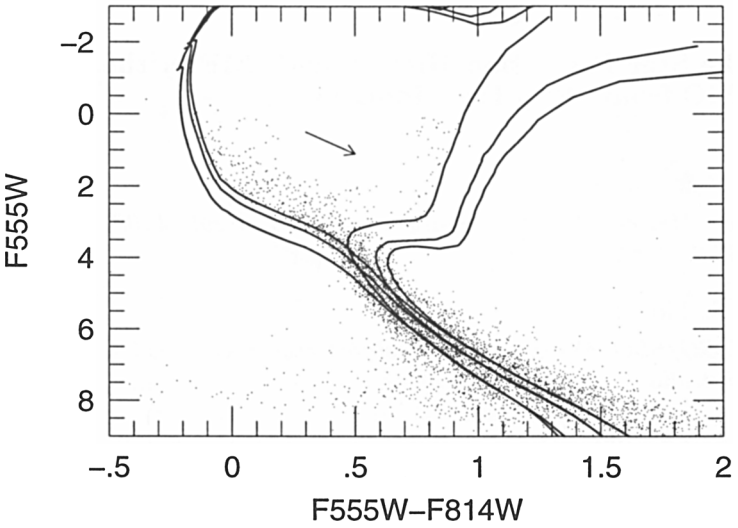

Figure 1. The color-magnitude diagram of one outer LMC field. Isochrones are for 1 and 10 Gyr with Z=0.0004, 0.004, and 0.008.

2. Discussion

Various techniques have been discussed to derive star formation histories from the distribution of stars in a color-magnitude diagram. However, in the presence of systematic errors in either the stellar models or the observations, it is difficult (and dangerous) to infer the star formation history using this method. This is especially true if areas in the CMD are weighted by the number of stars; errors in densely populated regions will drive the derived star formation history parameters. In addition, one must insure that results derived from the color-magnitude diagram are consistent with known information about the stellar metallicity distribution and the age-metallicity relation.

As an example, if the full LMC color-magnitude diagram is fit, the blue mid-main sequence requires the existence of a significant quite metal-poor component of the population, which is unlikely to be real.

Fitting the luminosity function alone bypasses some of the potential problems, because systematic errors in the magnitudes (not colors) are likely to be relatively small. Clearly, however, information is lost when only fitting the luminosity function! We compensate for this somewhat by constraining the models to use the age-metallicity relations of Pagel & Tautvaisiene (1998, MNRAS 299, 535) for the Clouds, which match observations rather well. We find that, if a solar neighborhood IMF is assumed, a moderate component of "older" stars is required, with $\geq$ 40% of LMC stars having ages older than 3-4 Gyr. This would imply a different star formation history for field stars than for LMC clusters.

We have also compared the predicted luminosity function from the star formation histories derived by Pagel & Tautvaisiene with our observations. These predicted LFs match the observed LMC LF reasonably well, but appear to have too many young stars for the SMC.

Discussion

Johannes Andersen: Results will certainly depend on your choice of models; for example, the published colours of the Padova models are redder than others for the same models, which would lead you to fit more metal poor models.

How do you deal with reddening in the CMD fit?

Holtzman: I have been adopting single values of the reddening for all of the fields.

Carme Gallart: What would you think would be the effect of including binaries in the models on the amount of star formation that you find in the epoch between about 3 and 10 Gyr?

Holtzman: If you assume that binaries are drawn independently from the same IMF, it makes little difference for the relatively massive stars (> 0.8 $M_\odot$) seen in the LMC. If binaries preferentially have mass ratios near unity, it can make a significant difference.

Knut Olsen: Are your solutions of star formation histories derived from the luminosity function? If so, there seem to be problems with degenerate effects of all of the parameters that are allowed to vary.

Holtzman: I have fit both the Hess diagram and the luminosity function. Fits to the former appear to be affected by systematic differences between the models and observations, which led me to just fit the luminosity functions. Clearly, however, you are correct that this throws away a lot of information and may lead to degenerate solutions.