

## Young Populous Clusters in the Magellanic Clouds - Implications for Stellar Evolutionary Models

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**Abstract.** We present new UV, visual and H $\alpha$  photometry obtained with the WFPC2 of NGC 330, NGC 1818, NGC 2004 and NGC 2100, four young populous clusters in the MCs. We present observational evidence for a degree of convective core overshoot in excess of that currently applied in standard models.

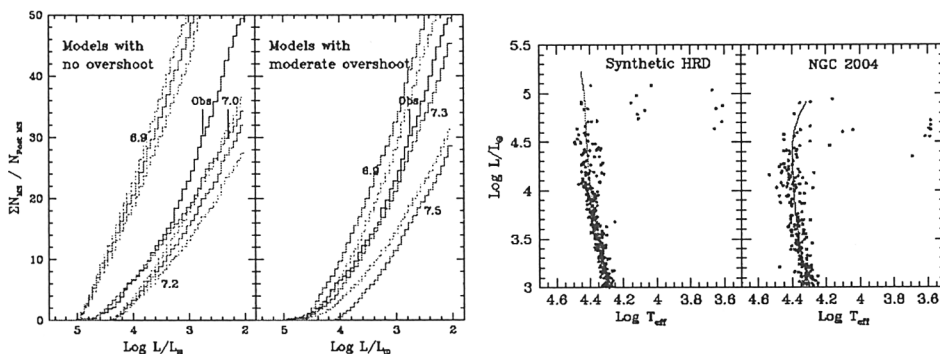
### 1. Introduction

One of the most important and actively debated issues in stellar evolution is that of the presence and amount of extension of the convective core due to internal mixing. A sizable number of studies have revealed the need for some degree of core extension (Langer & Heger, in this volume). The present study focuses on four young populous clusters in the mass range 10–20  $M_{\odot}$ .

### 2. Discussion

We have imaged the clusters in F160BW, F555W and F656N. The F160BW-F555W color provides an excellent temperature discriminator for the bright MS members. The clusters are known to be rich in Be stars (Keller et al. in preparation), given the discordant photometric characteristics of Be stars we obtained a F656N image to distinguish those stars with significant H $\alpha$  emission. Further details can be found in Keller et al. (1999, A&AS, 134, 489).

It is within the mass range of 10–20  $M_{\odot}$  that the effects of internal mixing are most apparent as evolution progresses. The mechanism for core extension that we consider here is that brought about by convective core overshoot (CCO). CCO brings more H to the central core, the MS lifetime is increased and the star evolves further to the red and is more luminous. Subsequent evolution occurs at a more rapid pace, that is the ratio of core H to core He burning lifetimes ( $t_H/t_{He}$ ) is reduced. It is only through observational studies that the degree of overshoot within theoretical models can be constrained. To ascertain the degree of CCO present we compare our sample to that produced synthetically from SEMs incorporating varying degrees of CCO. We test how well the models match the data in two ways: by examination of the normalized integrated luminosity function (nILF) and the morphology of the MS.



**Left - Figure 1.** The left panel shows the nILF for NGC 2004 and models without overshoot. The dotted bounding lines represent  $1\sigma$  uncertainties estimated from repeated trials. Ditto in the right panel from Padua models. **Right - Figure 2.** The left panel shows the population synthesized from the best fitting model of Fig. 1a. The curve represents cubic spline fit derived from repeated trials. The right panel shows the observed HR diagram for NGC 2004.

Figure 1 shows the ILF for MS stars normalized to the number of post-MS stars in NGC 2004. The nILF reflects the  $t_H/t_{He}$  which is a function of the amount of CCO. Overlaid in figure 1 are the nILF predicted from models of various ages containing no overshoot. All fail to match the observations. These models predict too many evolved stars from the number of MS progenitors, i.e.  $t_H/t_{He}$  of no overshoot models is too high to match the observations. nILFs derived from the "moderate" overshoot SEM of the Padova and Geneva groups present a much better fit to the observed nILF with the omission of the brightest portion. To achieve a better match with the bright tail of the nILF we include a slight age spread. This tells us that the  $t_H/t_{He}$  of these models is appropriate for the population.

As we have accurate  $T_{\text{eff}}$  for these stars we examine the morphology of the MS band. We see that the model with moderate overshoot and age spread described above fails to match the shape of the MS band. The inclusion of an age spread produces the observed number of stars at high luminosities but at higher temperatures than observed. The observations show a distinct turnover to the red consistent with extended MS evolution. The amount of extension of the MS to the red is seen to increase with increasing turnoff mass amongst the sequence of four clusters.

### 3. Conclusions

The present study has highlighted a number of problems for standard SEMs. We find strong evidence for a degree of CCO in excess of that incorporated in standard models. In addition, increasing amounts of CCO are required in higher mass stars.