Formation, evolution, and survival of massive star clusters
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Modeling Small Stellar Populations Using Starburst99

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Abstract. In this work, we have developed a new approach to form stars from clusters first, where massive stars are formed from fractions of mass of small stellar clusters. This new approximation is based on the empirical power law found in recent years and the maximum stellar mass that can be formed in a cluster. To produce the new models we have used the most recent version of Starburst99 that incorporates the most recent stellar evolution models with rotation. At the verge of solving nearby stellar populations and observing small stellar populations across the universe, this new approach brings a new scope on trying to disentangle the nature of hyper and supermassive stars in small stellar populations. Models for NGC 3603 and NGC 604 are presented. Our most important result is a strong ionizing power from small clusters by forming enough supermassive stars in a cluster of $\sim 10^4$ $M_\odot$.

Keywords. supermassive star clusters, stellar population synthesis, galaxy evolution

1. Theory

We have used the empirical mass function of clusters ($MF_C \sim M_c^{-2}$) from 20 - 1100 $M_\odot$ found by Lada & Lada (2003). As the total mass of the system M_T decreases, this mass function will form fractions of clusters of the more massive clusters. A condition to form at least one cluster of the upper mass limit for the MF_C is used to form the fractions of clusters. When only fractions of those massive clusters are formed, it means that smaller clusters, low mass stars, massive stars, and multiple stellar systems are formed. The maximum mass of a star formed in each cluster depends on the mass of the cluster as it was found by Pflamm-Altenburg, Weidner, & Kroupa (2007).

Clusters are formed in cells defined by the mass function of clusters. A change in scale occurs when the mass of the cell increases above or equal to the maximum mass of the mass function of clusters ($\sim$ 1100 $M_\odot$.) Then, the mass of the cluster becomes the mass of the cell.

2. Results

All models in Figure 1 used an IMF (0.1 to 100 $M_\odot$) from Kroupa (2001) using the new evolutionary tracks with rotation (V40, Maeder & Meynet 2012) with solar metallicity and the new version of Starburst99 (Leitherer *et al.* 2014.) Models shown in Figure 1 correspond to different M_T for the system: 1.0 (1), 2.0 (2), 5.0 (3), 8.0 (4), 11.0 (5), and 14.0 (6) $\times 10^4$ $M_\odot$ as shown by the conventional models (black dashed lines) and models in colors using the new approach of cluster star formation. In the figure, it is possible to observe the increase of the ionizing photons when M_T is small compared with the regular

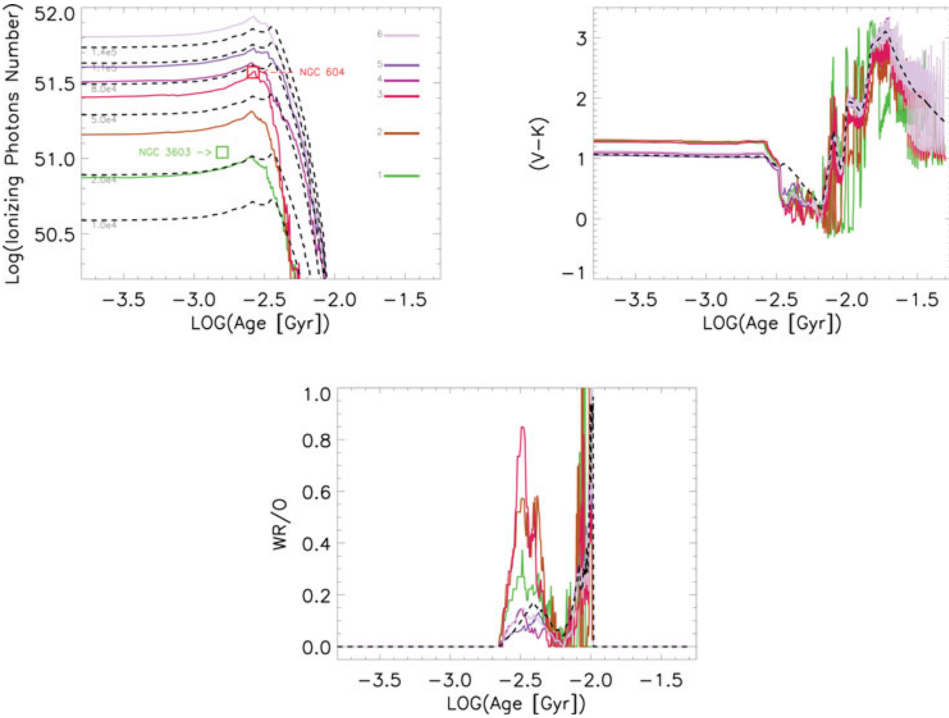

Figure 1. Color models were generated with this new approach. Dashed models are from the current version of Starburst99 with rotation.

models as in the case for a total mass of $\times 10^4$ $M_\odot$. As M_T increases the new models converge to the regular models. It is clear that there is now a dependence on M_T for the WR/O ratio and the color index $(V-K)$. The reason for this is that the number of massive stars does not scale with M_T.

3. Concluding Remarks

We have found an empirical relation between the M_T and the number of cells to produce the clusters. This relation is proportional to the number of supermassive stars generated. This new approach has allow us to generate a number of supermassive stars in small clusters that match the amount of *UV* energy seen in some of these small clusters such as NGC 3603 and NGC 604 (Kennicutt 1984) as seen plotted in Figure 1. Using these new models, we have found a new determination for the mass of NGC 604 between $5-8\times10^4$ $M_\odot$. Our most important result is a strong ionizing power from small clusters by forming enough supermassive stars in a cluster of $\sim 10^4$ $M_\odot$.

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