Investigation of the origin of mass segregation in NGC3603

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Introduction

NGC 3603 is one of the most massive, compact young star clusters of the Milky Way at a distance of about 7 kpc from the Sun. We have analyzed deep imaging data obtained with an epoch difference of 10 years using the Wide Field and Planetary Camera 2 on board of the Hubble Space Telescope. Our photometric and astrometric data permit us to determine its present-day mass function, to quantify the amount of mass segregation, and to evaluate the dissolution time scale of NGC 3603. Since NGC 3603 is only 1 Myr old, it may allow us to establish whether mass segregation is likely to be primordial or evolutionary.

Analysis

The color-magnitude diagram of NGC 3603 shows an extended, well-defined main sequence as well as a prominent group of pre-main-sequence stars. Isochrones confirm a likely age of about 1 Myr with a true age spread of possibly 3 Myr (Fig.1). One of the obstacles in deriving a mass function is the contamination by foreground stars. We used the deep imaging data from the two different epochs to select only those stars with a high membership probability. Artificial star experiments permit us to correct for magnitude- and radius-dependent incompleteness, which is particularly high in the crowded inner regions of the cluster.

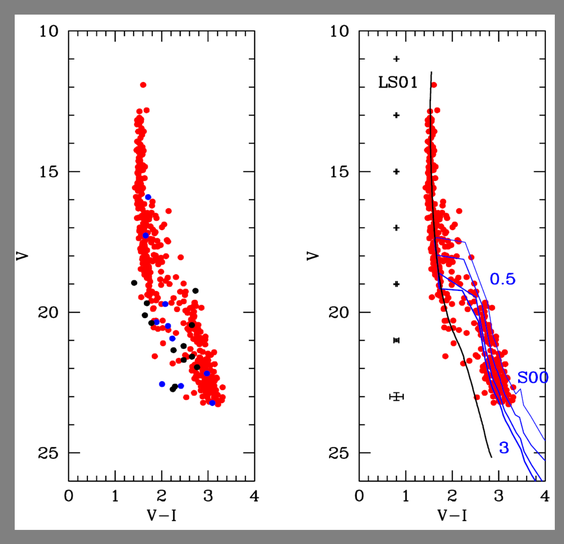

Fig. 1 : Left panel: common stars on the PC chip. Right panel: member stars after application of the proper motion criterion.

Results & Discussion

The NGC 3603 cluster shows pronounced mass segregation. In Fig. 2 we show the combined mass function for member stars on the PC chip (r~20”), which is more shallow than the canonical Salpeter slope. In Fig. 3 we show the dependence of the mass function on cluster radius. The change of slope as a function of radius and the decrease in massive stars as one moves outwards are clearly visible.

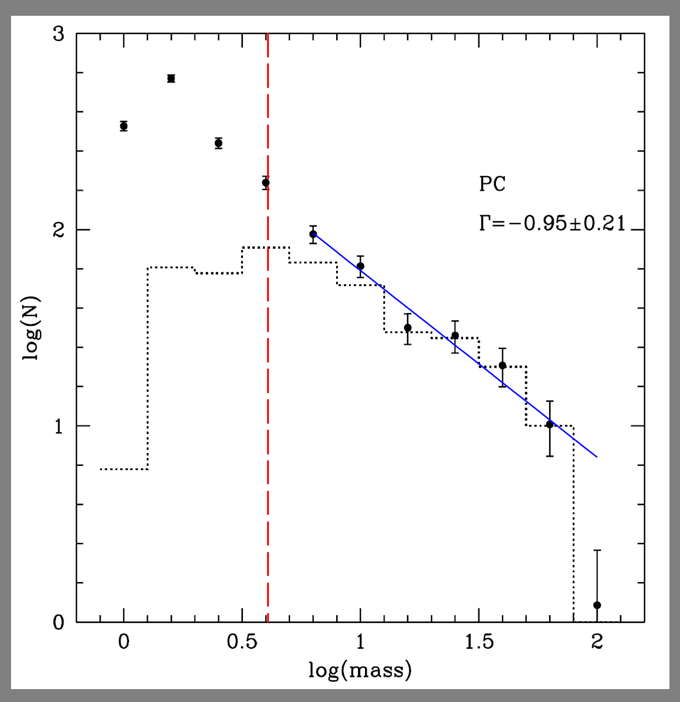

Fig. 2

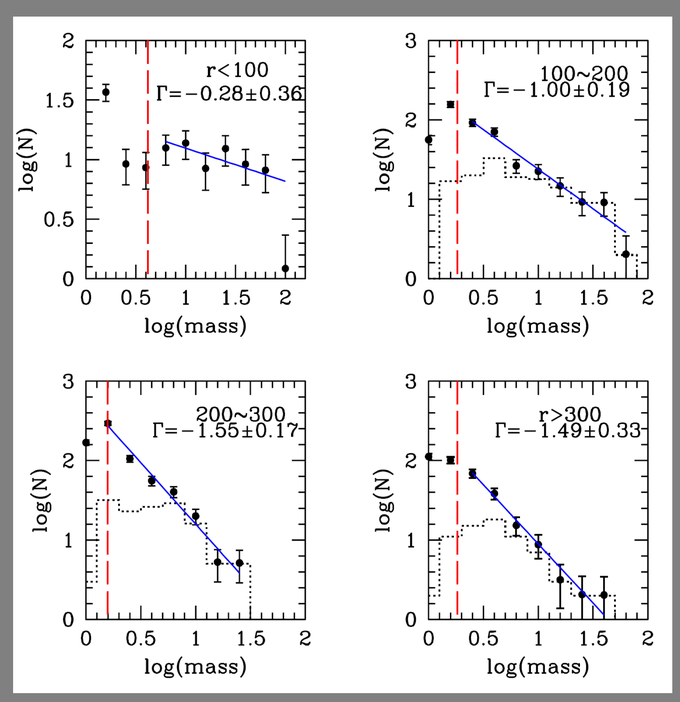

Fig. 3

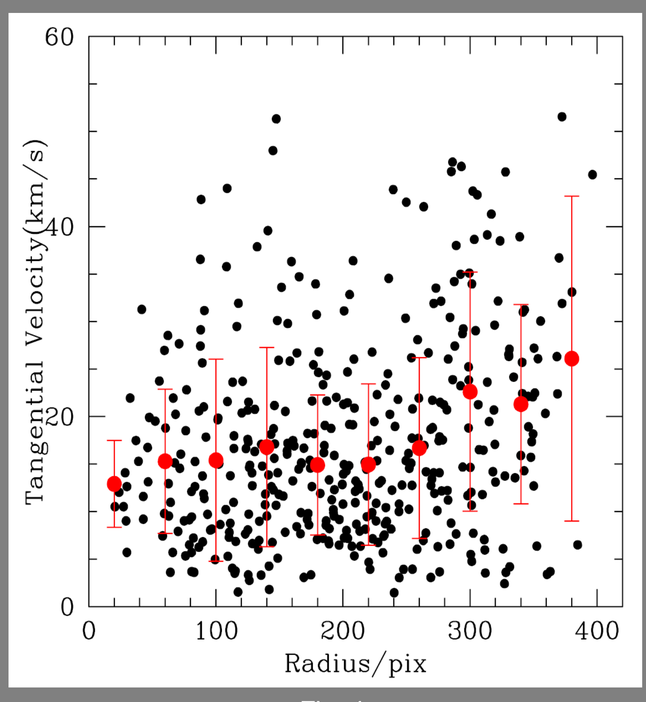

Fig. 4

Fig. 2 (left panel): The combined mass function of member stars on the PC chip. The resulting mass function is less steep than a Salpeter function.

Fig. 3 (right panel): The radial mass function variation for member stars. The histograms show star counts without completeness correction; the black points are corrected. Left of the dashed red line the incompleteness exceeds 50%. Note the steepening of the mass function as one moves outwards, and the increasing lack of high-mass stars.

Fig. 4 : Velocity distribution along radius for member stars on PC chip. There is a slight indication for increasing velocities beyond a radius of 280 pixels, but considering the size of the error bars this may not be significant.

Mass segregation origin?

Assumed isotropic distribution of velocity:
σ= 4.9 km/s
Core radius: ~0.14pc (Harayama et al. 2008)

t_{cross}= 3·10^4 yr

Bonnell & Davies (1998)
Initial condition: Plummer sphere.
Heavy mass segregation can create a high-mass dominated core after 10 t_{cross} .

For NGC3603: age ~ 30 t_{cross}
The cluster is already shaped by heavy dynamical evolution.

Allison et al. (2009)
Initial condition: Substructure and subvirial.
The most massive stars in the dense cores of clusters can mass-segregate within ~ 0.1 Myr.
Clusters can dynamically segregate stars above 2 - 4 Solar masses.

For NGC3603: Age is ~ 1 Myr, hence we expect that massive stars in the cluster are dynamically segregated.

→ evolutionary

Conclusion

1. Isochrone fitting of NGC 3603 member stars on the PC chip results in an age of 1 Myr for both MS and PMS stars, with an age spread of 3 Myr.
2. We find a top-heavy mass function with Γ = –0.95 ± 0.21.
3. We find a radially varying MF that is flat and top-heavy near the centre of the cluster and becomes increasingly steeper with larger distance from the cluster centre. There is very pronounced mass segregation with the most massive stars being strongly centrally concentrated.
4. The observed mass segregation is consistent with early dynamical evolution, but primordial mass segregation cannot be excluded.