

The complex lives of Open Clusters: Extended halo of NGC 2682 (M 67)

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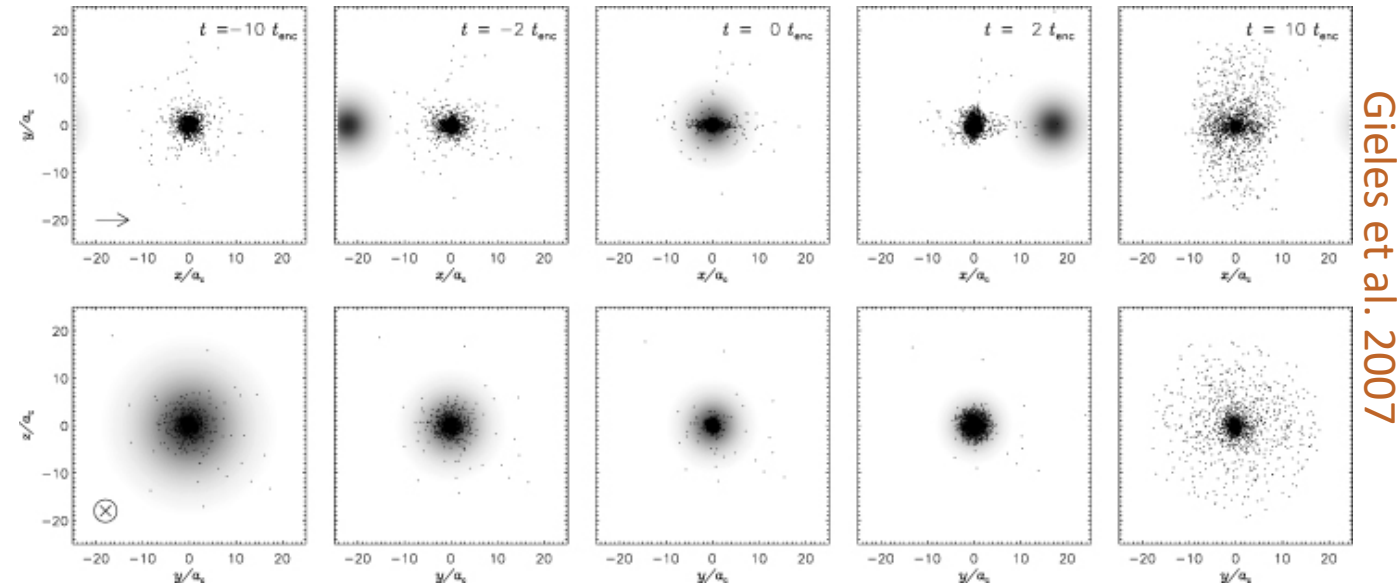
The internal collisional dynamics and external interactions are so effective that Open Clusters would be dissolved on a timescale of 1 Gyr. Although they are a minority systems older than 1 Gyr are key to investigate the dynamical evolution of stellar clusters.

NGC 2682 (M 67) is one of the nearest old OCs (3.6 Gyr) and is located at about 860 pc from the Sun. Evidence of substantial dynamical evolution in this cluster has been reported previously such as mass segregation. Using Gaia DR2 we investigate the spatial distribution of the stars in NGC 2682 to constrain its focus on the marginally bound stars in the cluster outskirts.

Background: Dynamical evolution of stellar clusters

Theoretical predictions

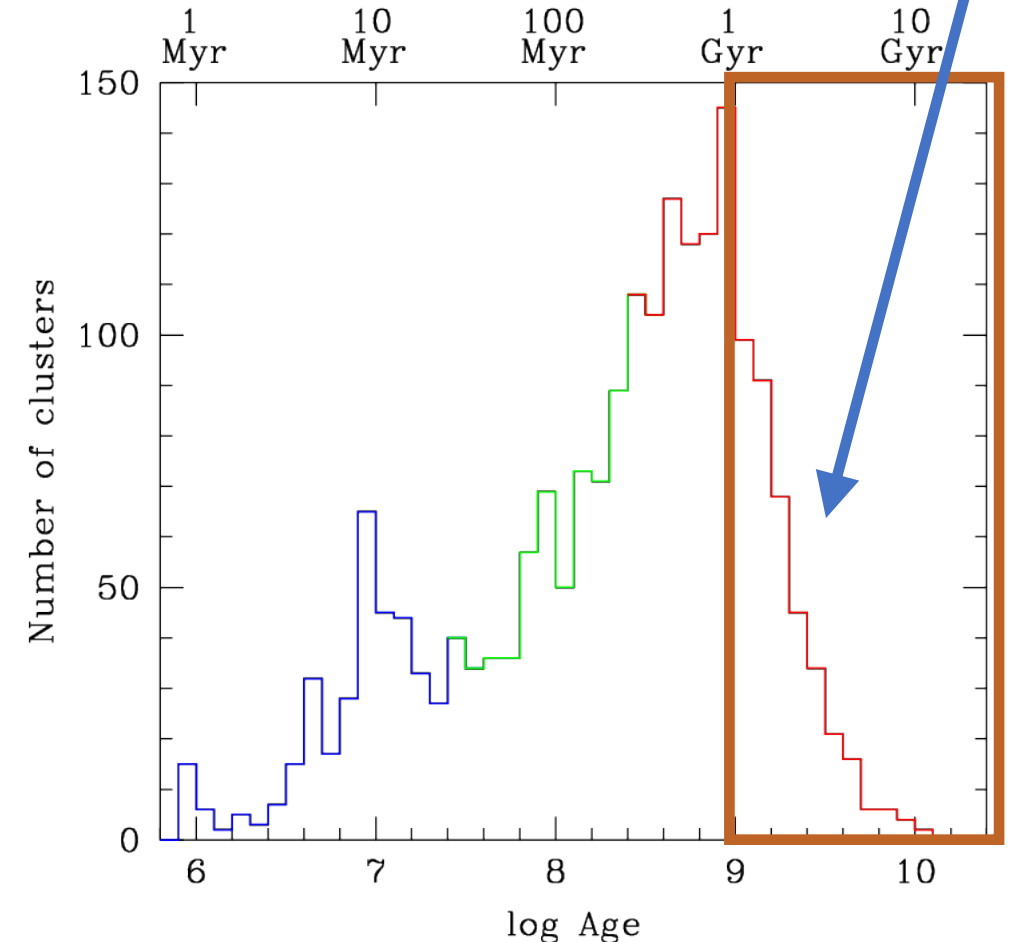
- Internal collisional dynamics: interactions between stars
 - Dynamical relaxation (Spitzer 1987)
 - Stellar-wind mass loss (Gieles et al. 2009)
- External interactions: giant molecular clouds, spiral arms



A typical OC ($10^4 M_{\odot}$) may not survive more than 1 Gyr

Observational facts

Clusters older than 1 Gyr are observed



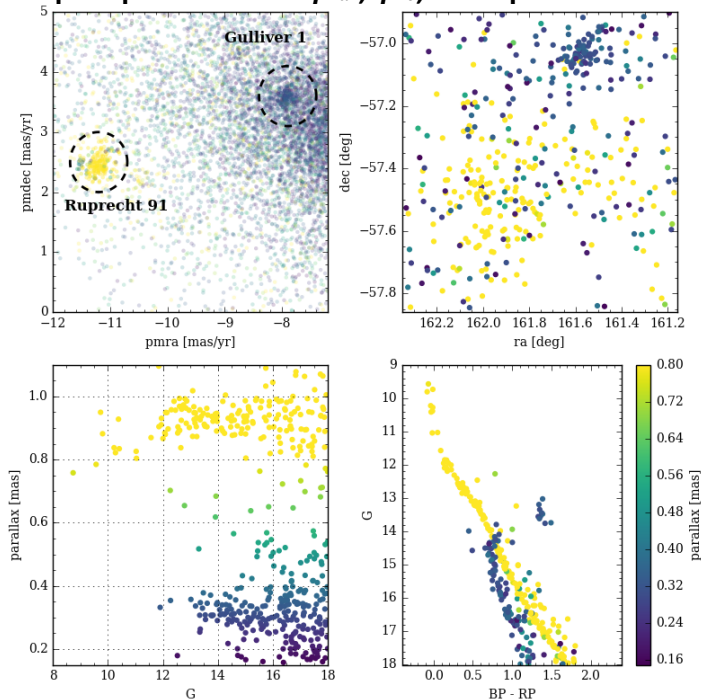
Observational Material

Gaia DR2: five-parameter astrometric solution: positions (α , δ), proper motions (μ_{α^*} , μ_{δ}), and parallaxes (ϖ)
magnitudes in three photometric bands (G , G_{BP} , and G_{RP})

Membership probabilities

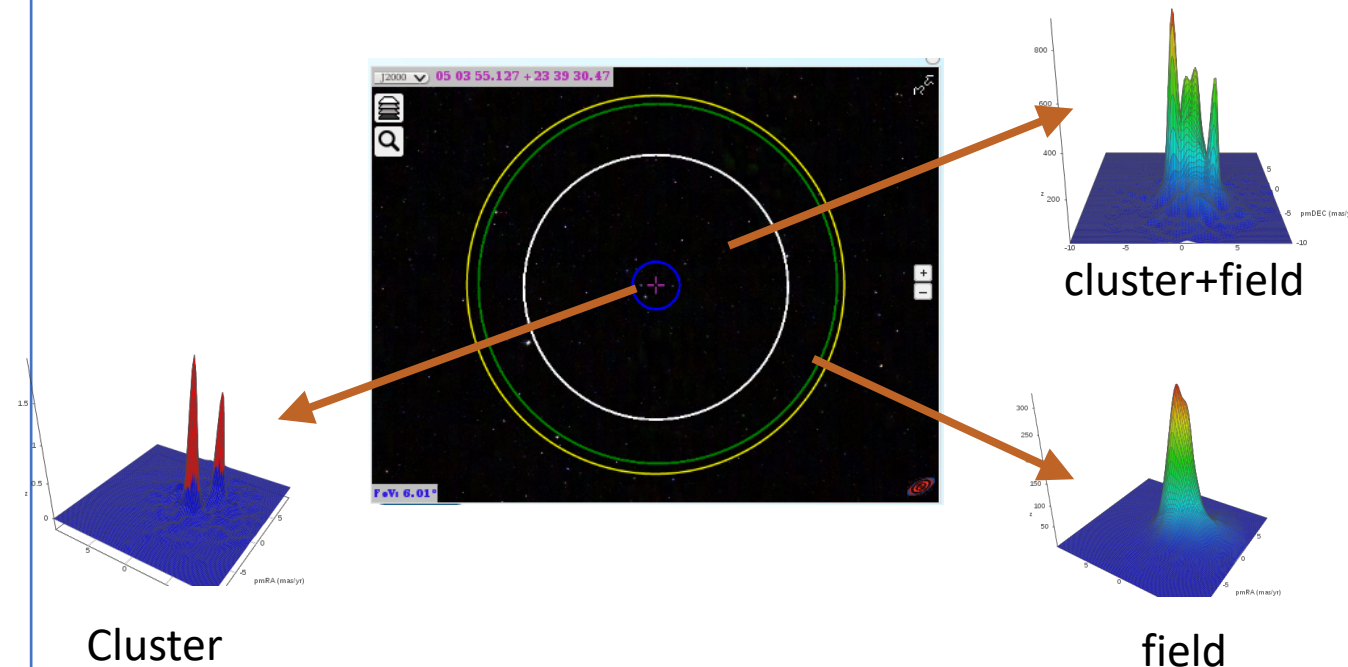
UPMASK (Cantat-Gaudin et al. 2018)

K-means clustering algorithm to detect stars that share common properties in μ_{α^*} , μ_{δ} , ϖ space.



Clusterix (Balaguer-Núñez et al. 2020)

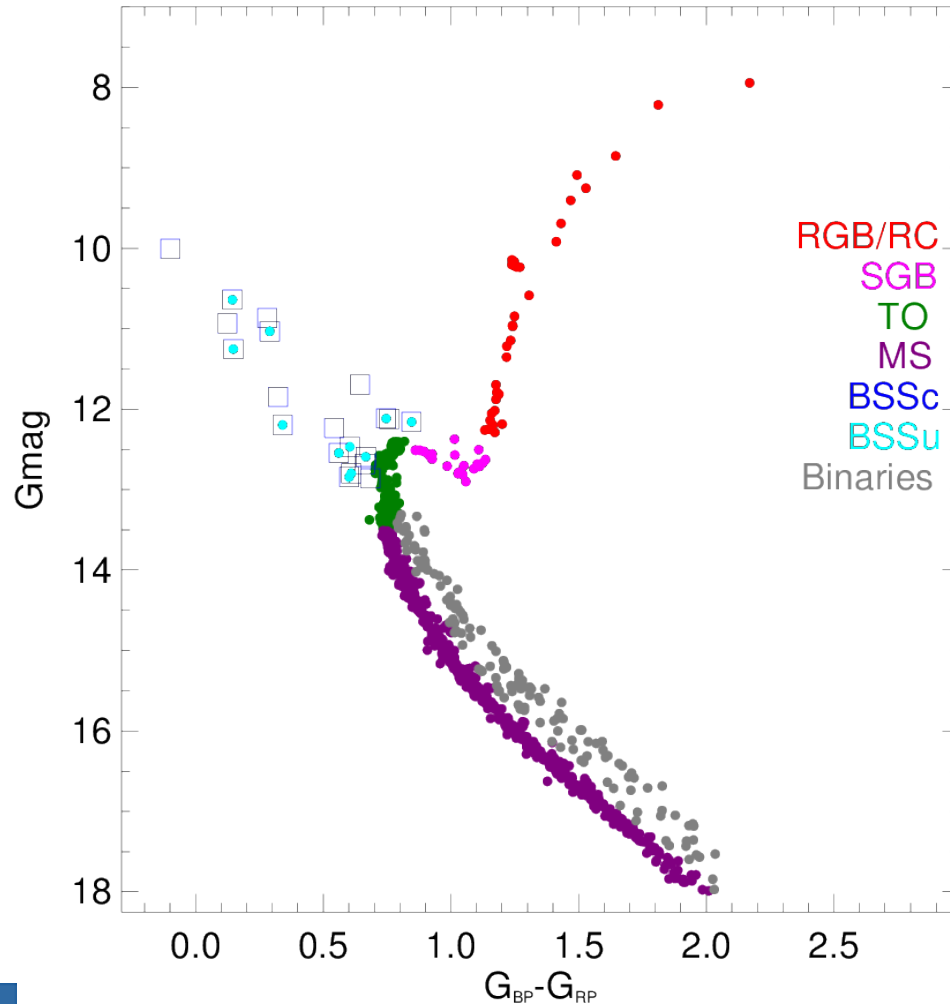
Two non-parametric overlapping populations in the 2-D proper motion vector point diagram (VPD): *cluster* and *field*.



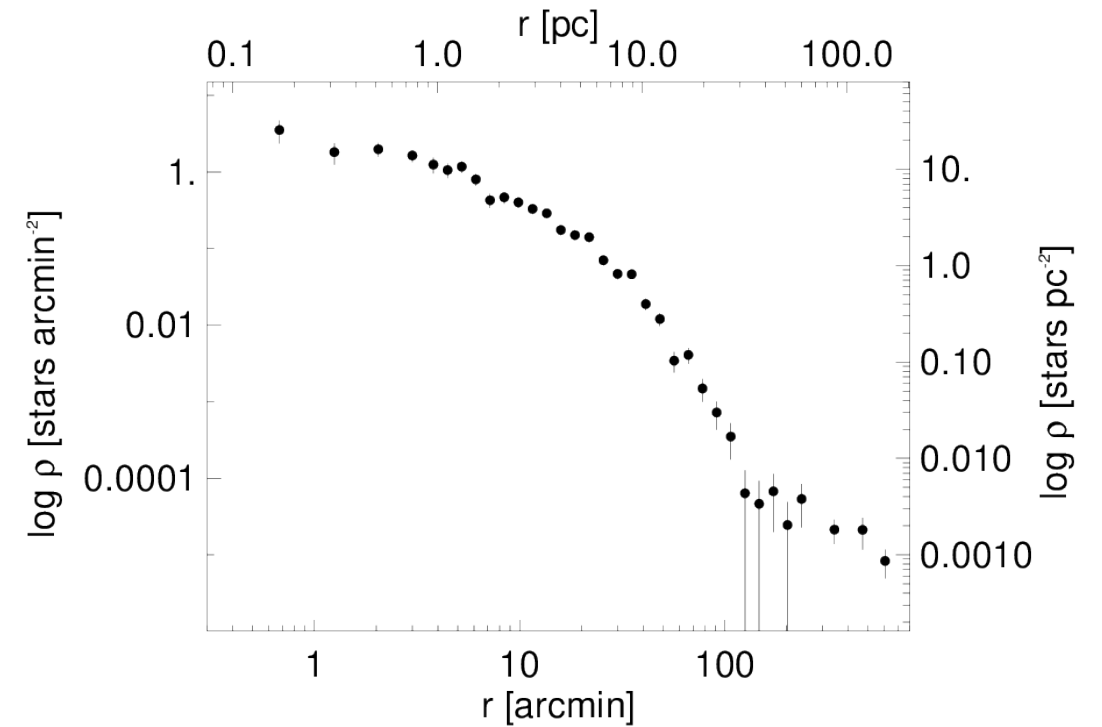
Results

Carrera et al. 2019

Color-magnitude diagram



Radial density profile



Members at $r > 25$ kpc (100')!

2MASS: 6 pc (24') [Bonatto & Bica 2003](#)

SDSS: 15 pc (60') [Davenport & Sandquist 2010](#)

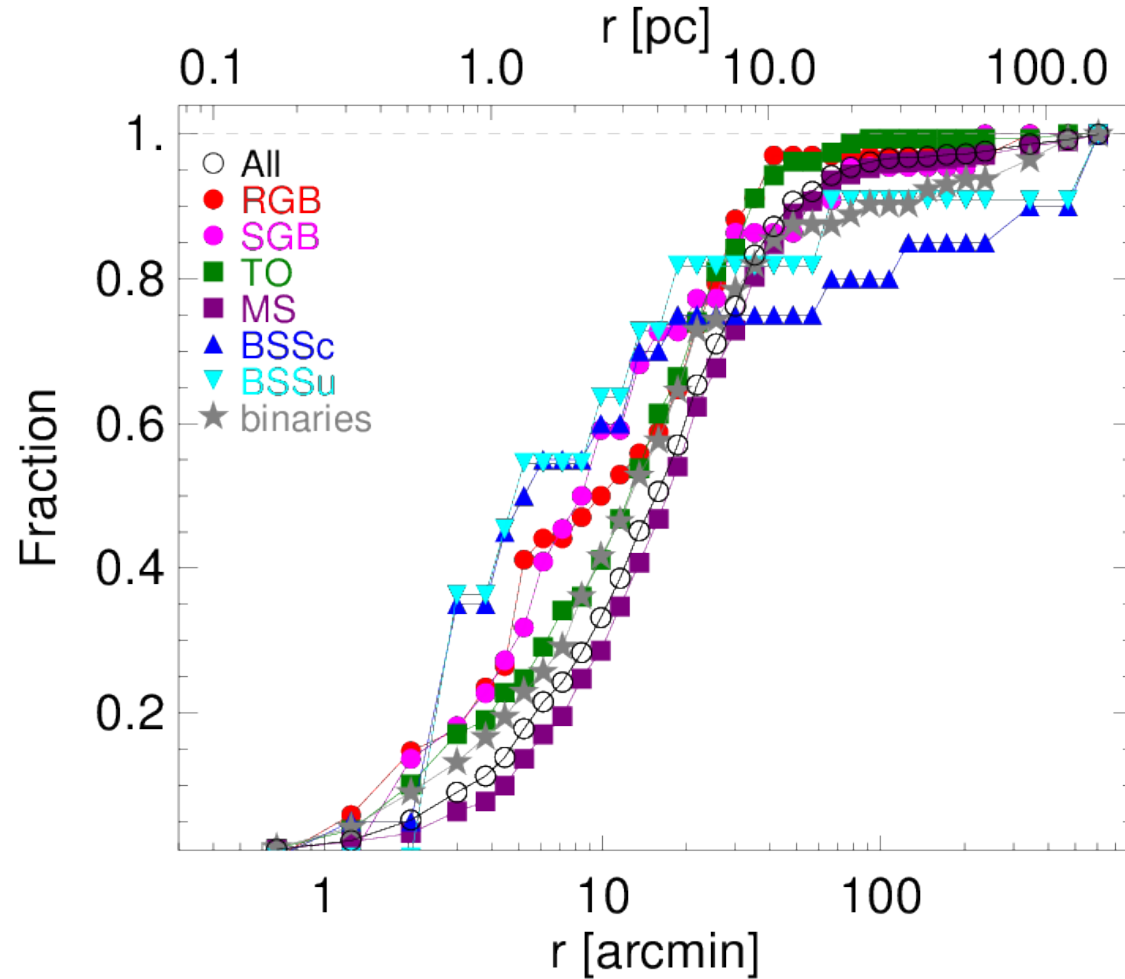
Gaia DR2: 15pc (60') [Gaia collaboration et al. 2018](#)

Gaia DR2: 16 pc (62') [Gao 2018](#)

Results

Carrera et al. 2019

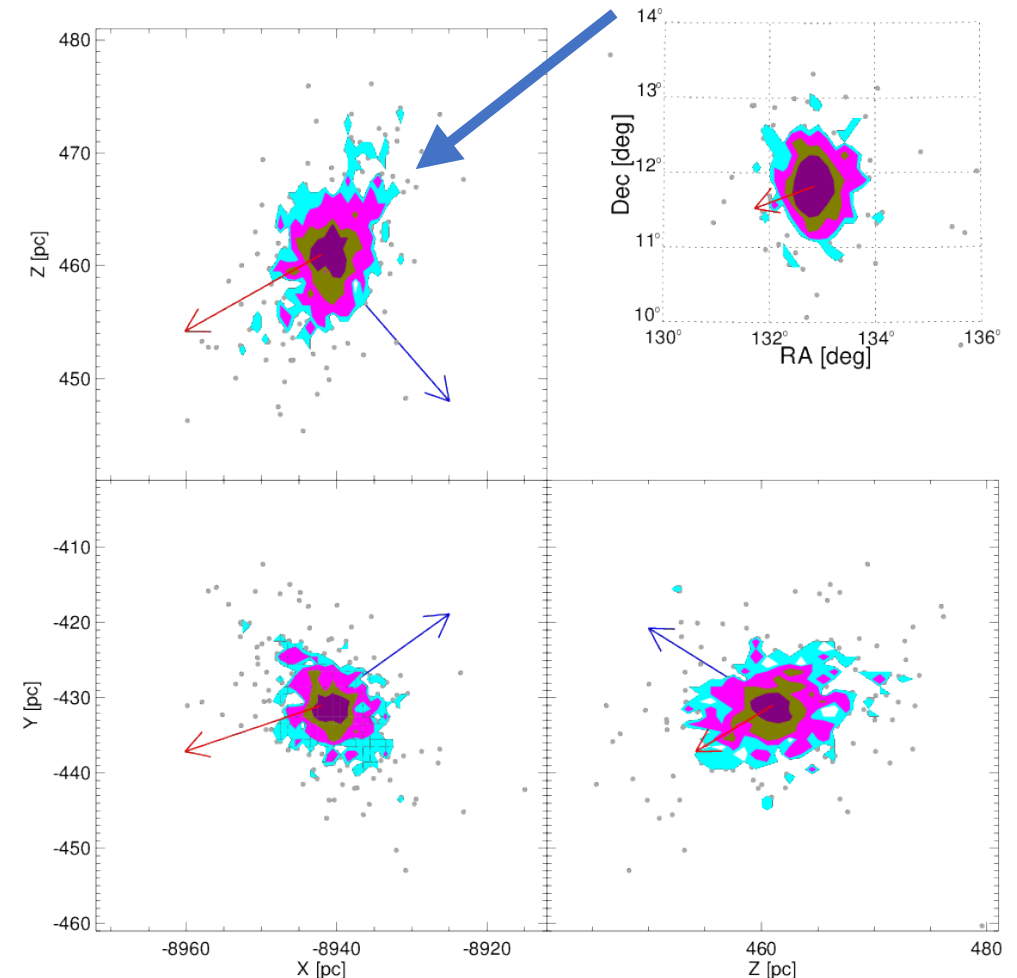
Mass segregation



The cluster is mass-segregated: most massive objects are concentrated in the central regions.

3D spatial distribution

A small tail in the opposite direction to that of the movement.



Conclusions

- The cluster extends up to 200' (50 pc)
- Complex radial density profile: power-law cusp core + logarithmic decline.
- There are stars outside the tidal radius.
- The cluster is mass-segregated: most massive objects in the central regions.
- Blue stragglers distribution: majority of the objects in the core, several objects in the outskirts.
- NGC 2682 crossed the Galactic disk several times in the last 200 Myr.
 - The cluster is never relaxed
 - Extra-tidal stars in NGC 2682 may be due to disk shocking.

Similar analysis must to be performed in the other old Open Clusters.