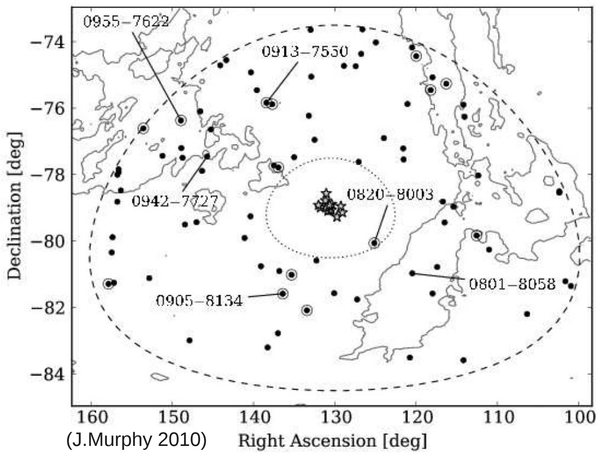
Dynamical evolution of Eta Chamaeleontis

C.Becker, E. Moraux
LAOG, Grenoble, France



Eta Cha is a **young and sparse association**, 8 Myr old, situated at ~ 97 pc, discovered in 1999 by Mamajek et al.
It is composed of **18 systems** (0.15 – 4 Msun) in a 1 pc radius, with an IMF consistent with other rich open clusters in higer mass range.
Despite its youth it presents unusual features : - **Deficit of very low mass stars** (no object with m<0.1 Msun found up to 1.5 deg)
- Mass segregation (50% of the mass is in the inner 6')
- Lack of wide binaries (no separation greater than 30 AU)

Can dynamical simulation reproduce these properties?

First investigation, done by E.Moraux, W.Larson & Clarke (2007), found that in the simple case where no binaries are considered, it was possible to reproduce Eta Cha with a log-normal IMF.
However, the most favorable case was providing a high initial density (10^8 stars/pc³)

What is the impact on these results if we consider binaries?

Numerical simulation

Cluster dynamical evolution	Initial conditions
Code : Nbody3 (Aarseth, 1999)	20 – 60 systems following log-normal IMF
Object located outside tidal radius, escape the cluster, removed from the calculation	Initial radius Rbar between 0.003 and 0.1 pc
Position, speed of the systems written every 0.1 Myr	100% binaries, with gaussian separation distribution (Duquennoy & Mayor 1991) **No gas, virialized system**

Analysis

We used 4 cuts to select the configurations which best reproduce Eta Cha observationnal features.

(1) Number of systems within 1pc

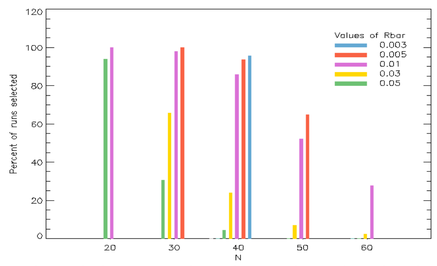
Observationnal constraint:

- 18 systems were found within 1pc from cluster center
- No binary with separation > 30 AU found

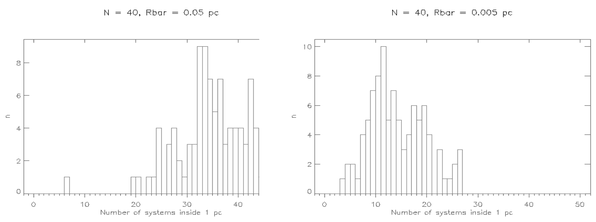
Associated selection cut:

- **14≤Nsystems{1pc}≤22**
- When counting systems, do not consider as binairies those with separation greater than 30 AU

- As a last check we will verify that no wide binairies are present in selected runs



Overview of the proportion of runs (out of 100) selected on the number of systems
N is initial number of binairies, distributed in radius rbar.



Distribution of number of systems for 2 configuration, at the time when selection is passed or at end time of simulation if failed. Statistic is over 100 runs for each configuration

Results

- This first cut was used as a guideline to find the best value of initial N and radius rbar.
- Configuration with large N (N=40, and more) tend to favor very small value for rbar, needing high density to eject its members.
- Smaller value for N seem to be best for larger rbar (0.03-0.05 pc) as they start with a number of systems close to selection cut.

(2) Low mass stars inside 2.6 pc

Observationnal constraint:

- No star m<0.1 Msun has been detected within 2.6 pc radius

- Detection of low mass companions has been done down to a separation of 20 AU

Associated selection cut:

- **Within 1.5 deg, N {m<0.1 Msun}≤1**
- We do not count star of mass m<0.1 if in tight binairies

Result:

- Such cut removes most of the runs
- Need enough massive stars to eject those less massive stars

(3) Solar masses within 1pc

Observationnal constraint:

- 4 objects of mass 1<M<4 Msun in the association

Associated selection cut:

- **Within 1 pc, N {m<1.5 Msun}≥3**

Result:

- This selection does not favour any particular configuration, but ensure that the core is dense enough to keep a few massive stars.

(4) Outside 1 pc radius

Observationnal constraint:

- Only a few members with m>0.5 can be between 1 and 8.75 pc
- 4 new members found recently with mass in range [0.08, 0.3]
(J.Murphy 2010)

Associated selection cuts:
Between 1 and 8.75 pc,

- **N{m>0.5 Msun} ≤2**
- **2≤N{0.08≤m≤0.3} ≤6**

Result:

- Not very stringent, but very few selected runs remain (2% at best)

Preliminary results

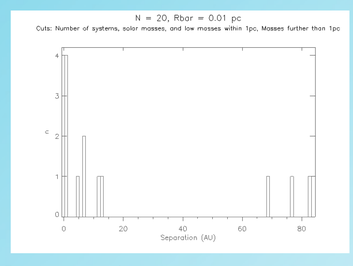
- A few configurations seem to reproduce Eta Cha, but in very small proportion (about 1%): N=30 and N=20, for Rbar=0.01 pc

- Taking binaries into account seem to allow better match for smaller density but still close to the one obtained previously (10^8 stars/pc³)

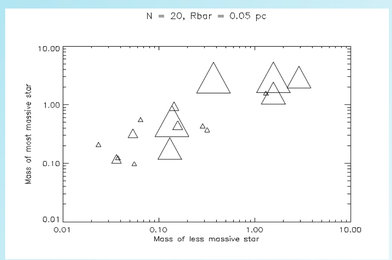
Binaries

How are distributed separation and masses within the binairies ?

Study of the binary ratio shows that after a short (< 1 Myr) period of decrease, it remains approximately constant.
Denser configurations (Rbar=0.05 pc) tend to start with small bin ratio (around 50%), whereas large Rbar gives higher initial bin ratio (around 80%)



Distribution of binary separation, in the case N=20, Rbar=0.01 pc.
Even though this was the bast results, there are still are a few wide binaries (3 have separation around 80 pc)



Mass of primary versus mass od secondary. The symbol size is bigger for bigger separation. Here we can see that the ratio stays relatively close to 1.

Time constraint

Age is estimated around 6-9 Myr

Simulations start with a time offset of a few Myr, corresponding to the time of gas depletion and relaxation into virial equilibrium.

Thus we require that the condition be satisfied in the **time range [4-8 Myr]**

Don't hesitate to ask some questions, or make remarks, I should be around.

Christophe Becker