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Possible reason for the higher binarity of massive stars in the ONC

Capture-induced binarity in young clusters

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1. Introduction

Most stars are born in a cluster environment.

Model cluster here: Orion Nebula Cluster (ONC).

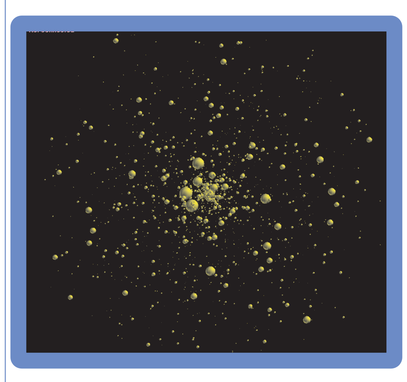
Observations show

Binarity of massive stars (> 70%) is higher than for solar-mass stars (~50%).

Possible reasons:
▶**Binary rate primordially higher for massive stars.**
▶**Dynamics lead to rapid formation of massive binaries.**

Here we investigate the latter.

2. Method



Why ONC?

well observed
limits parameters

high stellar density
encounters likely to be important

Cluster simulations of the ONC using N-body6^{++}.
~4000 stars
Mass distribution (Kroupa, 2001)

Simplifying assumptions: * no primordial binaries
* no gas
* no disc effects

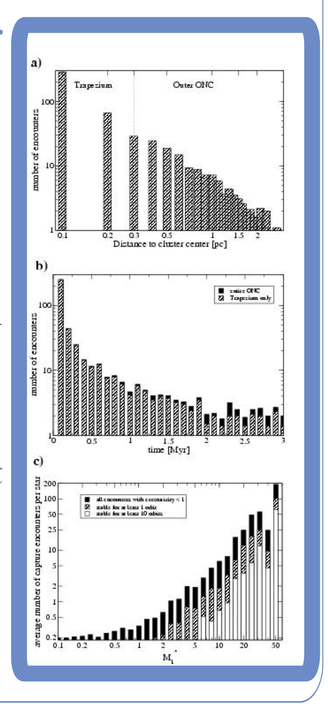
Quality checked by comparison with observationa results (see Poster Olczak)
▶ 40 simulations pass test ▶> 10000 events

As to be expected capturing encounters mainly

▶**early on in the cluster development**
> 300 in first 0.3 Myr, afterwards
<15 in every 0.1Myr bin

▶**close to cluster center**
~350 in central Trapezium region compared to ~150 in the rest of the cluster

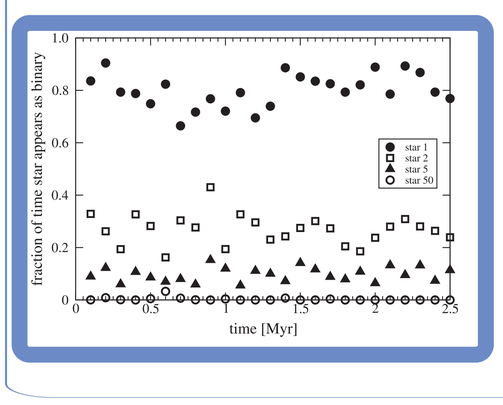
▶**Involving one of the most massive stars**
over 200 for most massive star, < 1 for solar-mass star



3. Binarity of Massive Stars

Capture-formed systems → **transient bound systems (TBS)**, but would appear as long-lived binaries

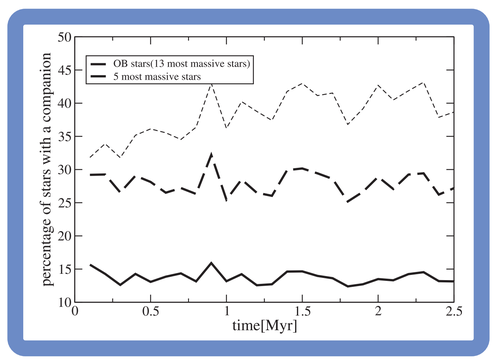
Massive stars ▶ mainly in high-density centre of ONC. ▶ function as gravitational foci
▶ fastest in loosing their discs



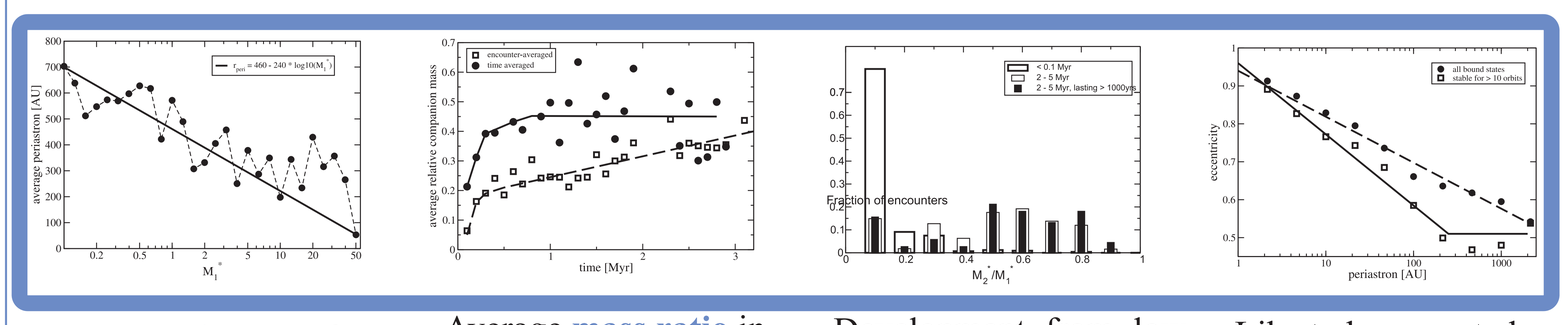
◀Most massive star is most probable to become a TBS (> 50%).

◀For other massive stars likelihood to be a TBS decreases for lower masses.

OB stars have at least 10-15% increase in binarity trough capture. ▶



4. Properties of Capture-formed Binaries



Average periastron of TBS decreases with increasing mass of primary.
Most likely **periastron** for most massive star: **50-100AU**.

Average **mass ratio** in TBS
~ 0.5, if time-averaged
~ 0.3, if encounter-av.
These mass ratios are achieved within ~0.5 Myr.

Development from low to high mass ratios.

Two populations simultaneously: a low- and a high-mass population

Like to be expected, the larger the periastron the lower the excentricty in the TBS.

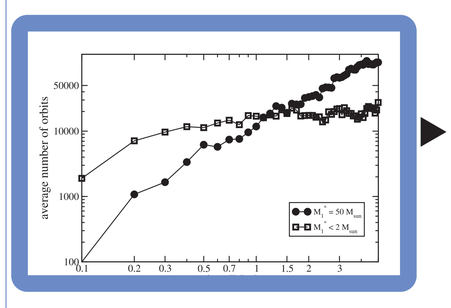
Steeper decline, if only stable systems.

5. Cluster Age Dependence

How sensitive are the results to the assumed cluster age?

Fast development in the first 0.1-0.3 Myrs.

During that time-interval: ▶Rapid succession of short- lived TBS.



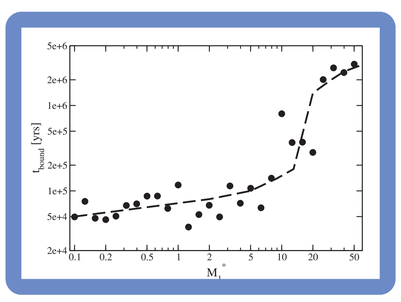
▶ Initially massive stars form less stable systems than lower mass stars

▲ After ~1 Myr the massive stars have formed the more massive systems.

At times > 1 Myr much slower development.

So result is not very sensitive to cluster age in the 1-2Myr range

Then duration of TBS strong function of primary mass.



For primary mass larger than 10-20 solar masses much more stable TBS form,

i.e. TBS with smaller periastra larger mass ratios.

6. Discusssion & Conclusions

Capture processes are frequent enough to explain difference in binarity in massive and solar-mass stars.

Capture-formed binaries have average
periastron: 50 - 200 AU
mass-ratio: 0.4 - 0.5
eccentricity: 0.6

Do these values fit with ONC observations?
Difficult to say with just 15 OB stars, of which at least 2-4 would be capture-formed.

Possible explanation for overabundance in this periastron range in young clusters in comparison to field stars.

At age of ONC approximately equal amounts of high and low mass ratio binaries.

Future simulation should contain:
* primordial binaries
* gas
* disc effects
* clusters with larger number of massive stars

References:
C.Olczak, S.Pfalzner, R.Spurzem, ApJ 642, 1140 (2006).
P. Kroupa, MNRAS 322, 231 (2001).

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