The Dynamical Evolution of Exoplanet Systems

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Focus today:

Close fly-bys and exchanges into binaries occur in young clusters and star-forming regions.

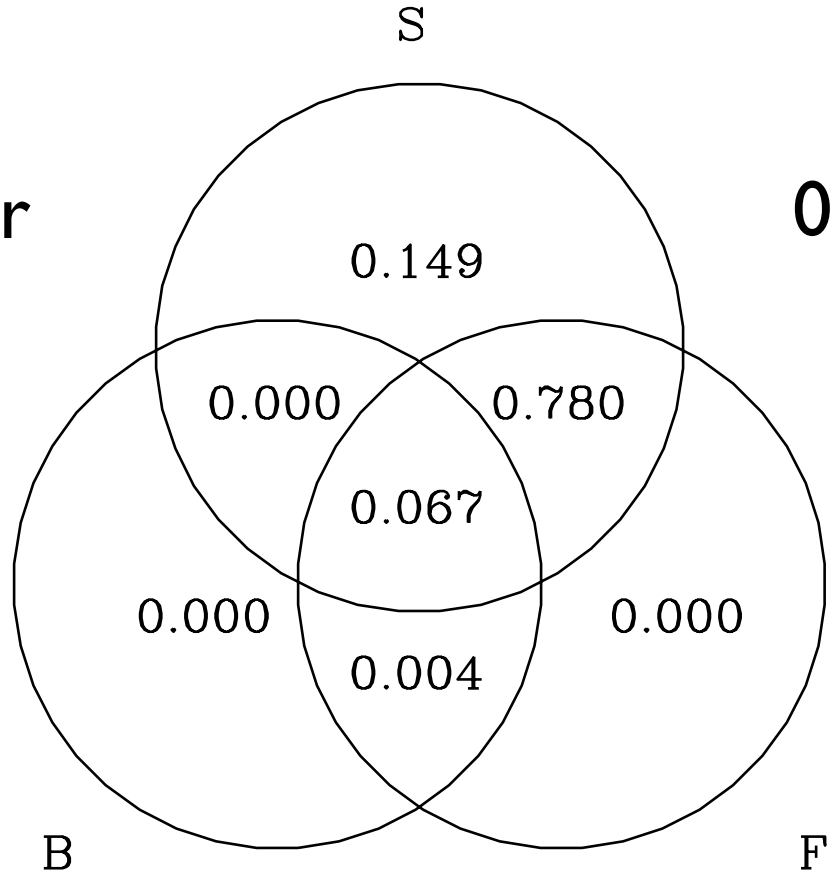
Planetary systems similar to our own solar system can then be turned into systems with planets on tight, eccentric orbits.

Idea one:

Close encounters happen interestingly often in young clusters and star-forming regions.

How common are singletons?

Entire cluster lifetime

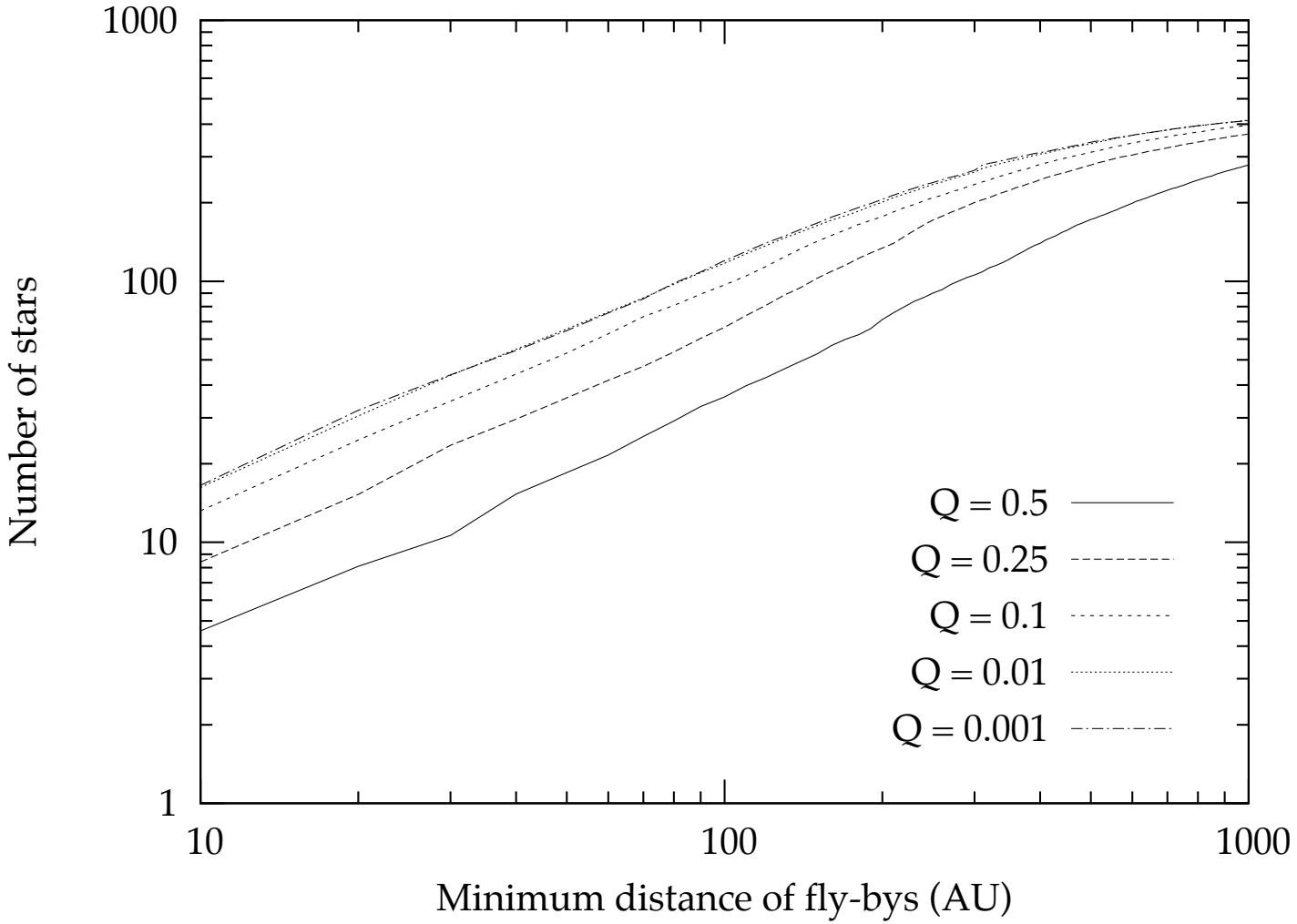


0.8-1.2 msol

N=700 stars, R=2-4 pc

(Malmberg, De Angeli et al 2007)

Distribution of close encounters (first 10 Myr)



Out of 466 stars

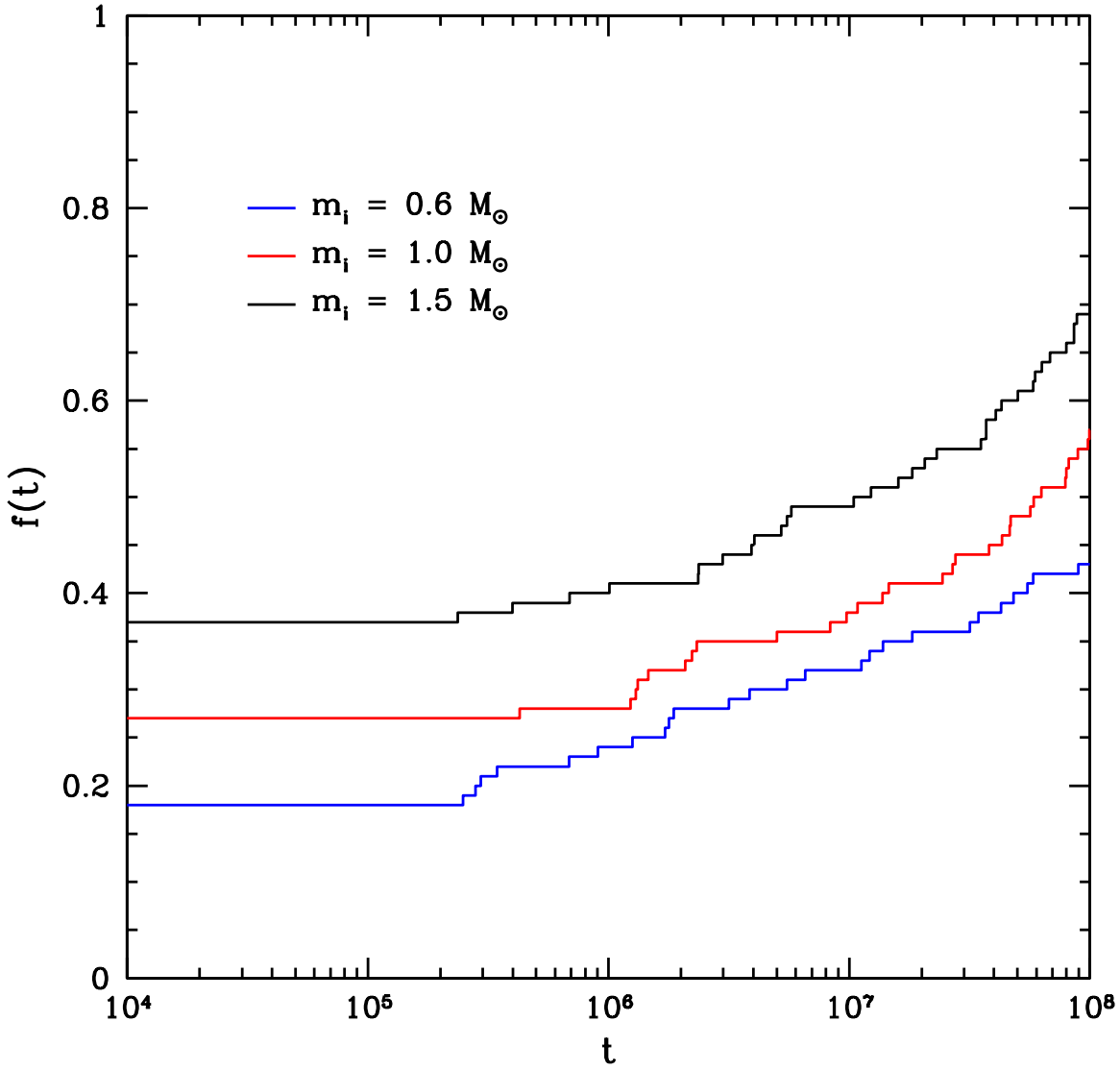
(Church et al, in prep.)

(see also Parker et al, in prep.)

Idea two:

Fly-bys in clusters de-stabilise planetary systems. Some planets are scattered on to wide orbits and later ejected.

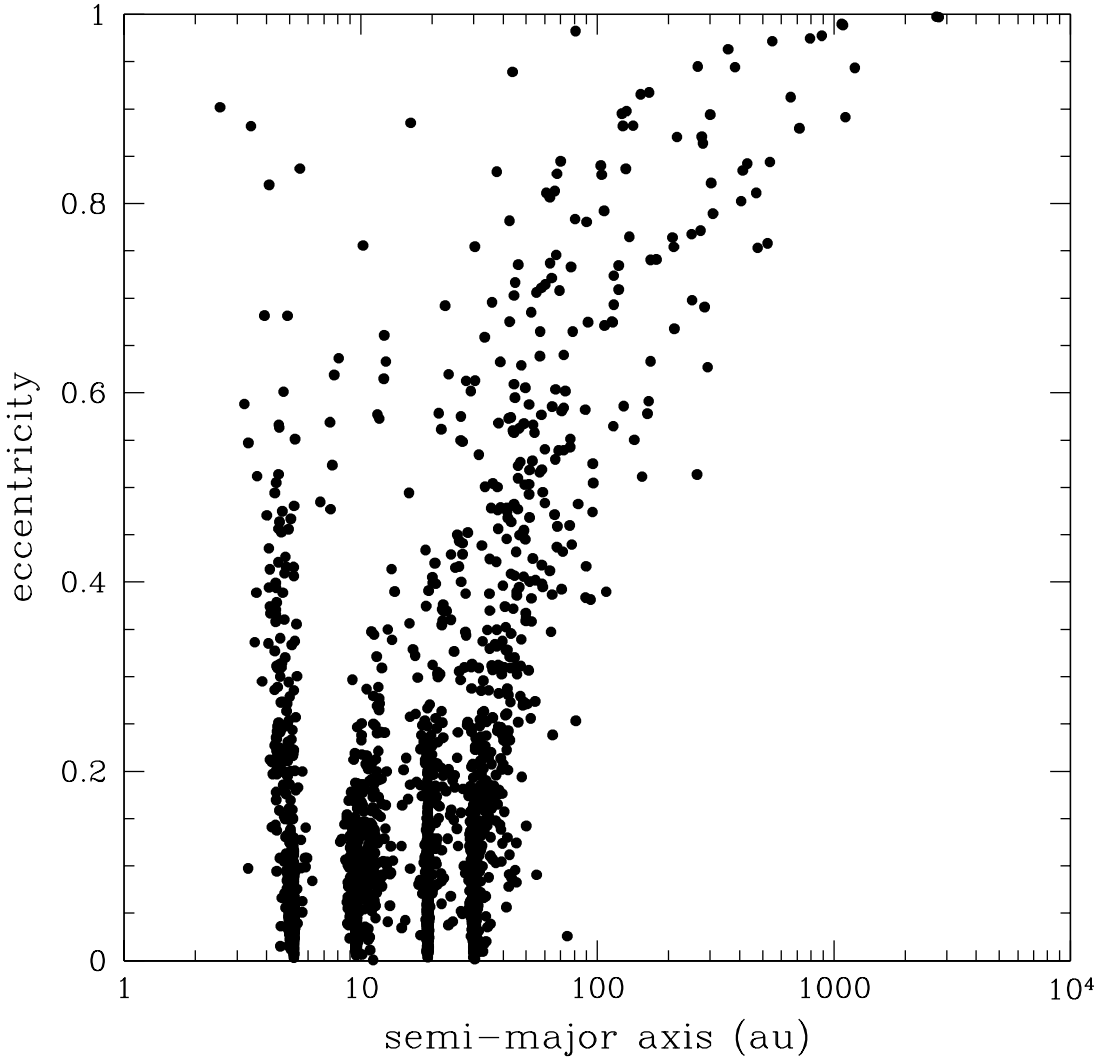
The long term effect of fly-bys (within 100 AU)



The fraction of solar-mass stars with four gas giants in a cluster of 700 stars that lose at least one planet within 100 million years of a close fly-by: 0.15

(Malmberg, Davies & Heggie, 2011)

The four gas giants 10^8 years after fly-by (r_{Min} < 100 AU)



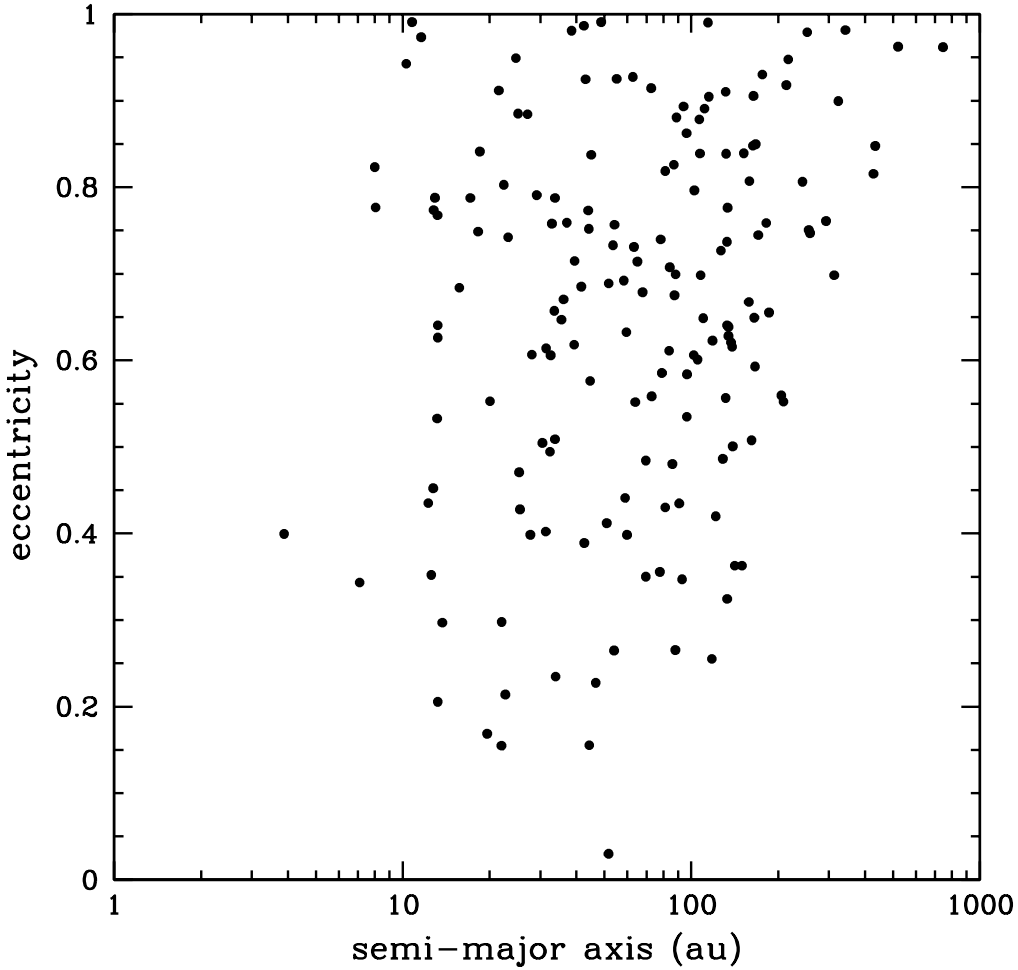
Fraction of solar-mass stars with initially four gas giants in a cluster of 700 stars having a planet with a>100 au 100 million years after fly-by: 0.02

(Malmberg, Davies & Heggie, 2011)

Idea three:

Intruding stars can pick up planets.

Post fly-by systems consisting of a single planet bound to the intruder star immediately after the fly-by

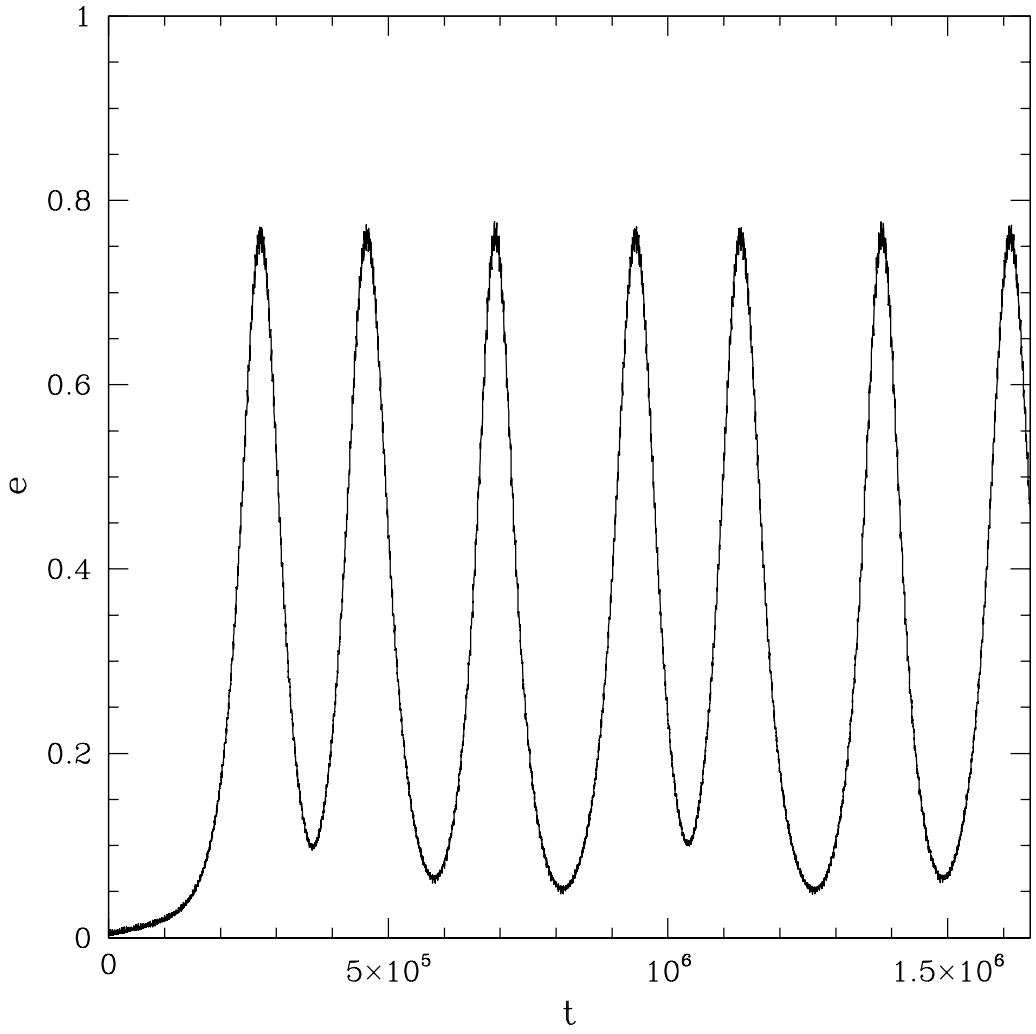


(Malmberg, Davies & Heggie, 2011)

Idea four:

Exchanging into a binary is bad for you.

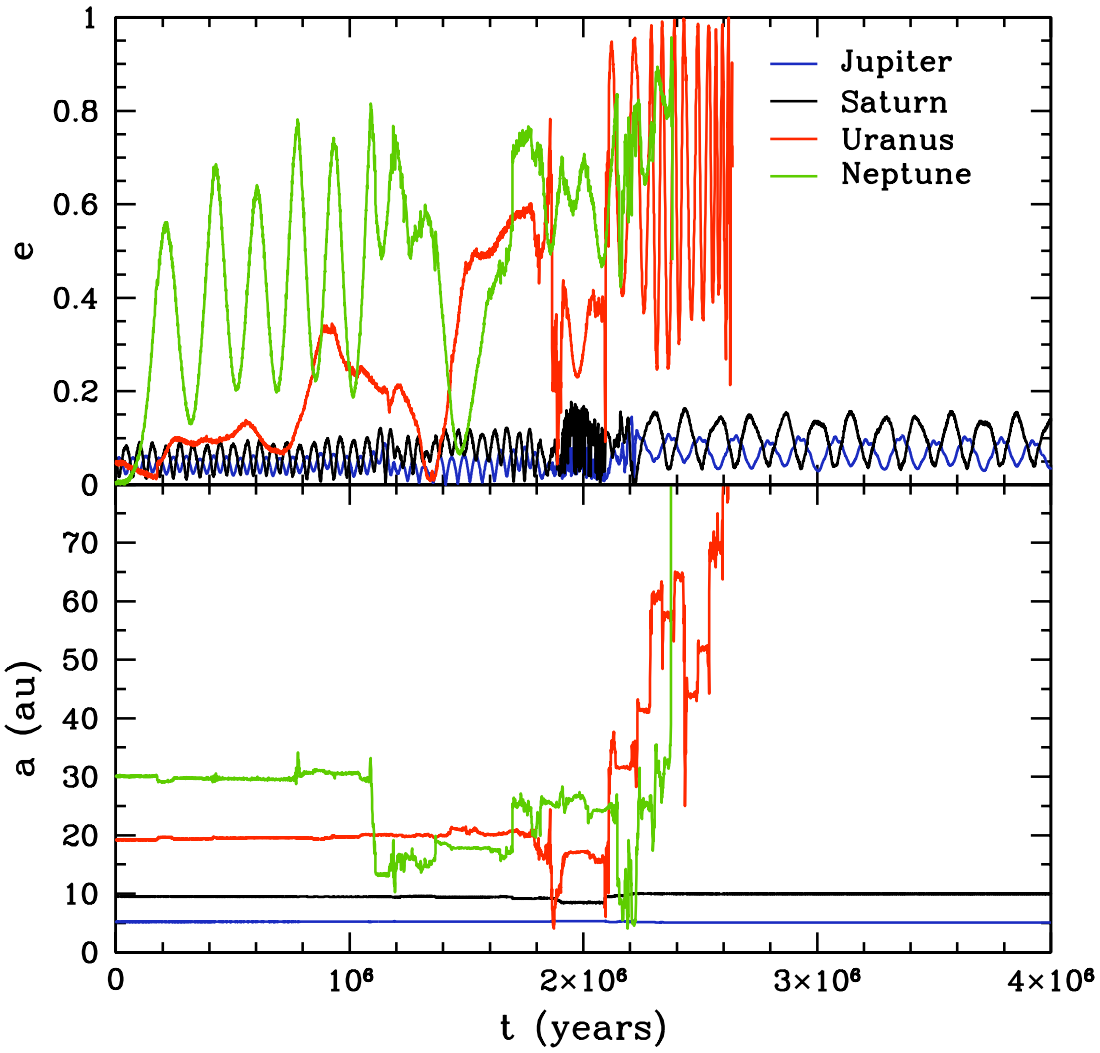
Evolution of a planet within a stellar binary



i=60 degrees

Kozai cycles

The four gas giants in a binary



(Malmberg, Davies & Chambers, 2007;
Malmberg & Davies 2009)

Summary

1) Close encounters happen interestingly often.

2) Fly-bys de-stabilise planetary systems.

3) Intruding stars can pick up planets.

4) Binaries are bad for you: Kozai kills.