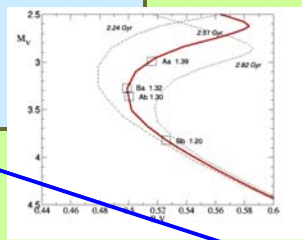
Measurement of tidal dissipation in multiple stars

Andrei Tokovinin (CTIO)

3. The circularization begins!

The primary component increases its radius to the point where the tidal dissipation at periastron starts to shorten the period.

Example: 41 Dra (HD 166866), F7V
***P*=1247.8d, *e*=0.9754, masses 1.39+1.30 M_{sun}**
Age 2.5 Gyr
Tertiary Bab at 800 AU, 1.32+1.20 M_{sun}, *P*=10.5d



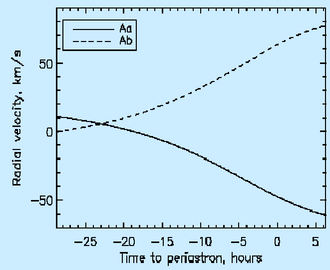
2. Quiet lifetime on the MS

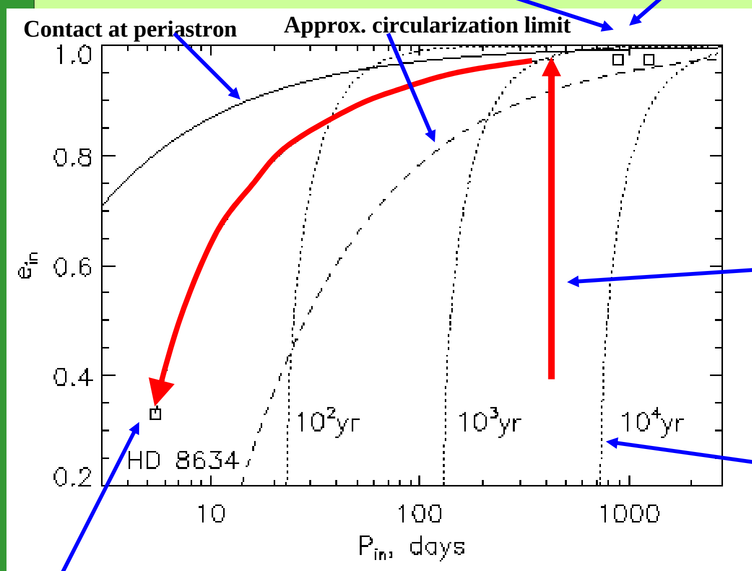
The eccentric binary with Main-Sequence components is not circularized during its lifetime because the tidal force at periastron is reduced (compared to a circular orbit).

Example: Gliese 586A (HD 137763), K2V
***P*=889.6d, *e*=0.9752, masses 0.74+0.49 M_{sun}**
Tertiary B at 1000 AU, 0.74 M_{sun}
Distant compaion C at 24000 AU

Is the orbit evolution in 41 Dra detectable?

The radial velocity of 41 Dra at periastron changes by 3 km/s per hour. Periastron timings accurate to 0.1h are done in 1994 and 2001. Timing to 0.01h or better is possible now.
Next periastron: April 1, 2008
Detectable T_P ~ 3 Myr
Estimated T_P ~ 6 Myr





1. The origin

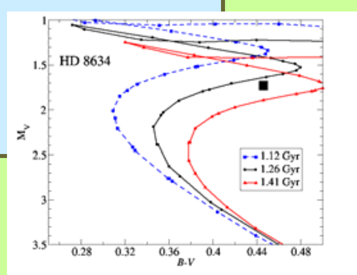
The inner binary in a multiple system with highly-inclined orbits becomes *very* eccentric through Kozai cycles. The eccentricity reached is likely determined by the balance between the Kozai effect and the tidal dissipation or relativistic apsidal motion.

The dotted lines show the e_{in} where the periods of Kozai cycles and relativistic AM are equal, for orbital periods of the tertiary companion of 100, 10^3, 10^4 years

4. The orbit is being circularized NOW

A late-type binary with a short period yet eccentric orbit, in apparent contradiction with the established circularization limit of P=10d.

Example: HD 8634 (HR 407), F5III
***P*=5.429d, *e*=0.327, masses 1.82+0.20 M_{sun}**
Age 1.3 Gyr
Tertiary at 100 AU, 0.3 M_{sun} discovered in 2004.



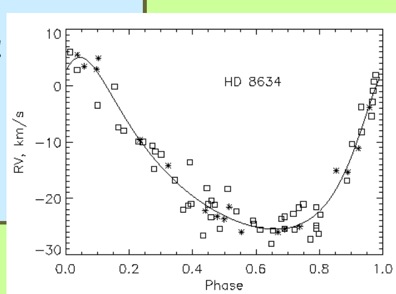
5. The end product

A detached binary with a circular orbit is formed, to become later a contact system.

Examples: many!
e.g. Capella, Algol

Two orbits were published for HD 8634:
→Wright & Plugh (1954): ***P*=5.42908d, *e*=0.378 +- 0.023**
→ Mayor &Mazeh (1987): ***P*=5.4264d, *e*=0.28 +- 0.03**
Do we really see an ongoing circularization here?

That is too fast, implying T_P ~ 80 000yr !
In fact the orbit did not change:
***P*=5.42922 +-0.00001 *e*=0.327+-0.014**
Data hint on period increase T_P ~ 1Myr
Estimated T_P ~ 4 Myr
Detectable with a modern orbit!



Conclusion:

Direct detection of the orbit changes caused by the tidal dissipation are within the reach of modern observational capabilities.

Selected binaries must be monitored with precise radial velocity techniques!