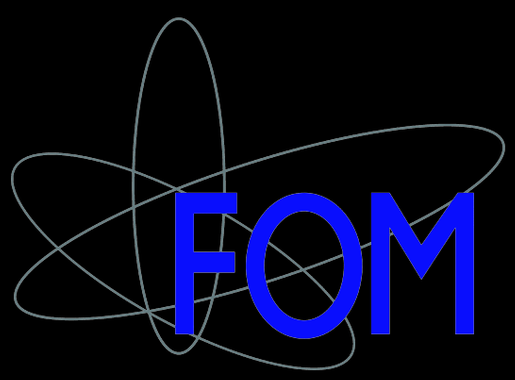
Population, He novae, late time evolution and the link with UCXB

... in a nutshell...

Gijs Nelemans
Radboud University Nijmegen

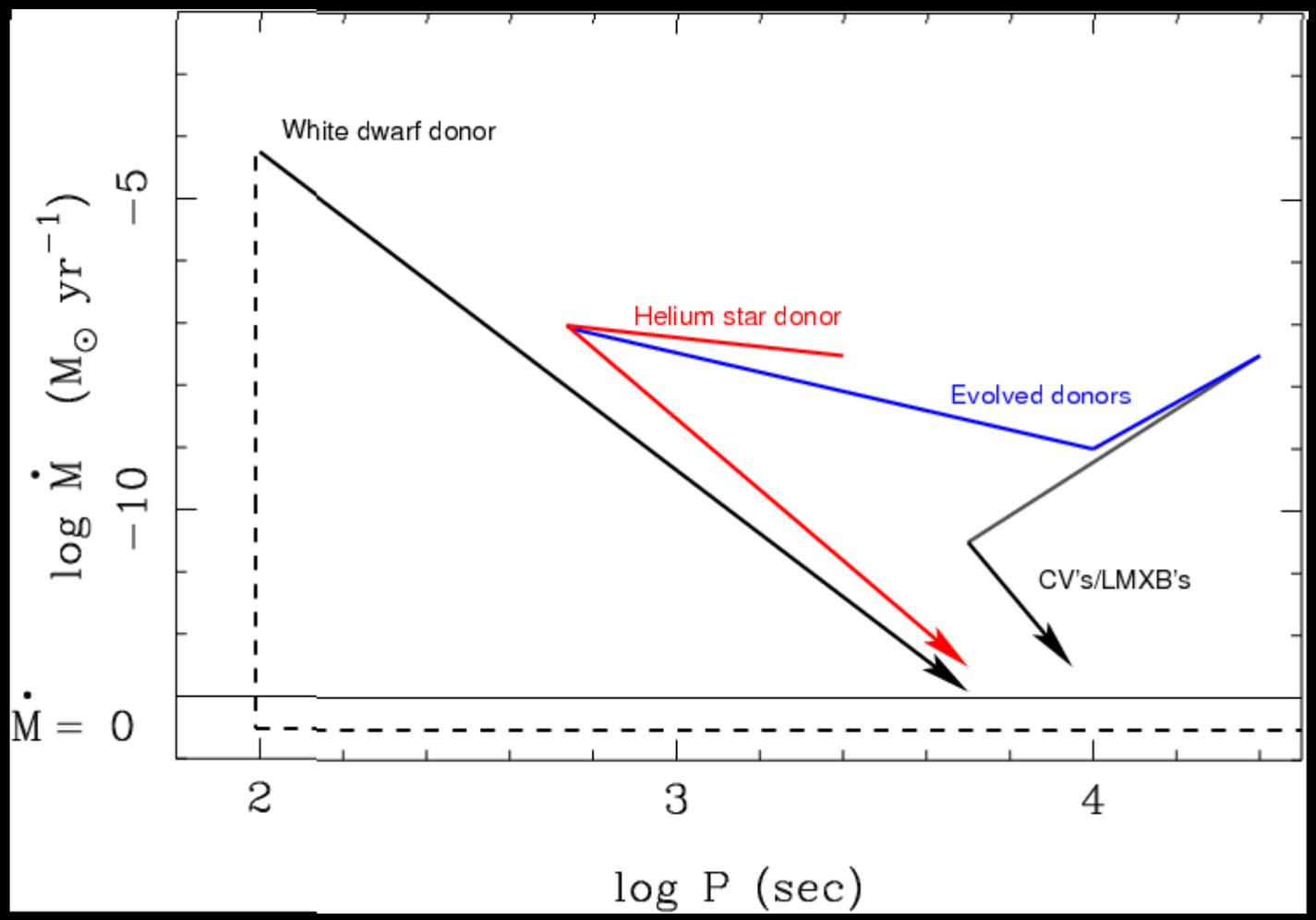


Radboud Universiteit Nijmegen

Outline

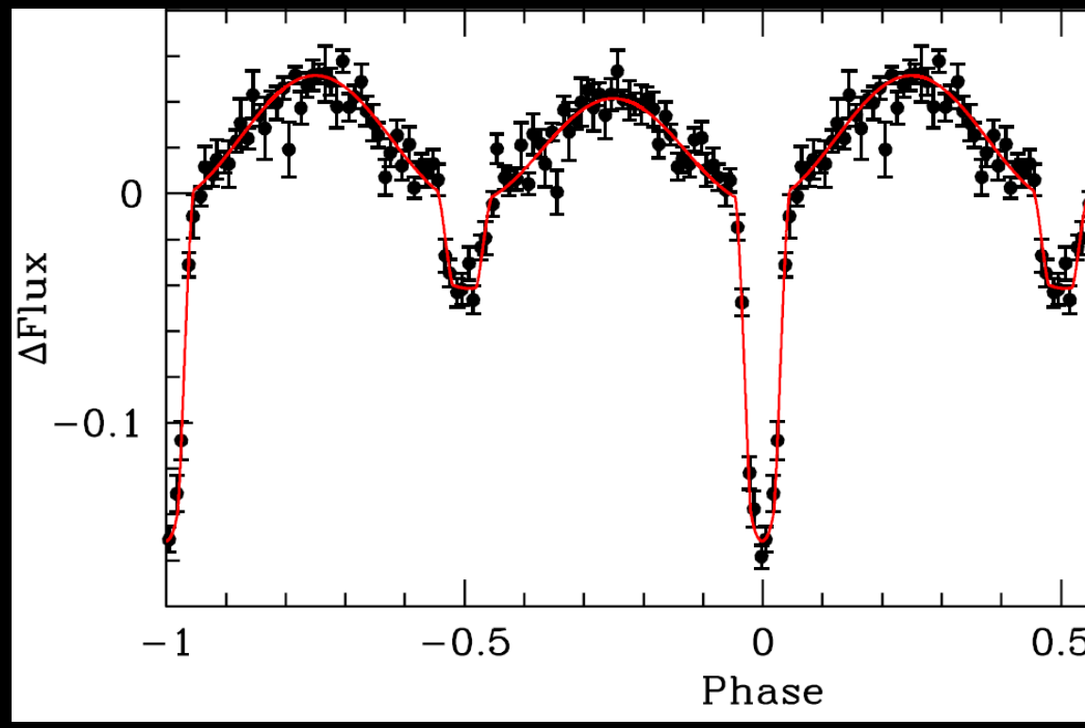
- Formation
- Population synthesis (any updates?)
- Stability of mass transfer
- Helium novae and .Ia (.Ib?) supernovae
- Late time evolution: the link with UCXBs
  - Final fate of UCB: disruption?
  - Late time (i.e. low q) accretion disks
  - Average accretion rate UCXBs
  - What about AM Cvn systems?
  - Companion to MSP J1719...

Formation



- Common envelope (1 or 2)
- Three possible donors
  - White dwarf
  - Helium core burning star (sdB)
  - "Evolved MS"

- Progenitor double WD exist, He channel not
- "Evolved MS" very unlikely
  Van der Sluys+ 2005, Yungelson+ in prep
- Key: detailed composition donor
  Nelemans, Yungelson, vd Sluys 2010



SDSS J0651 12m double WD! Brown et al. 2011

What is special about periods < 1 hour?

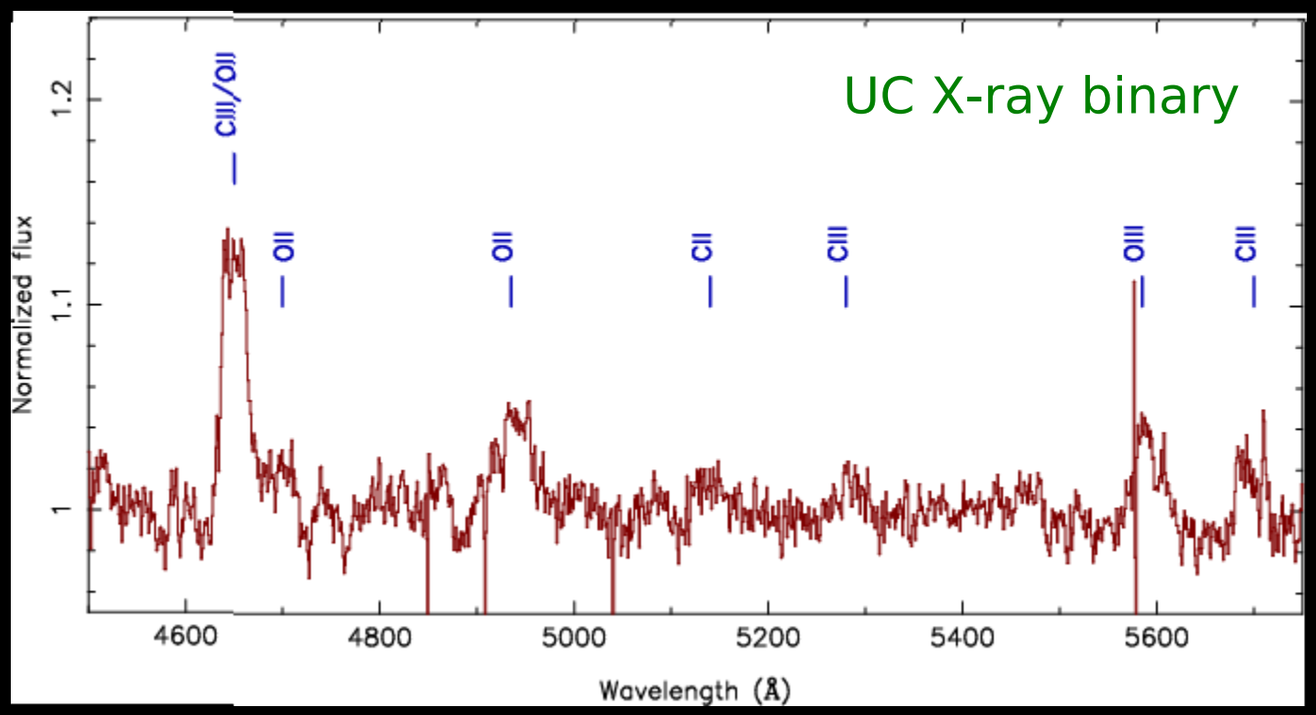
$$R < R_L = 0.46\ a\ \frac{M^{1/3}}{(M+M_2)^{1/3}} \qquad a \propto P^{2/3}(M+M_2)^{1/3}$$

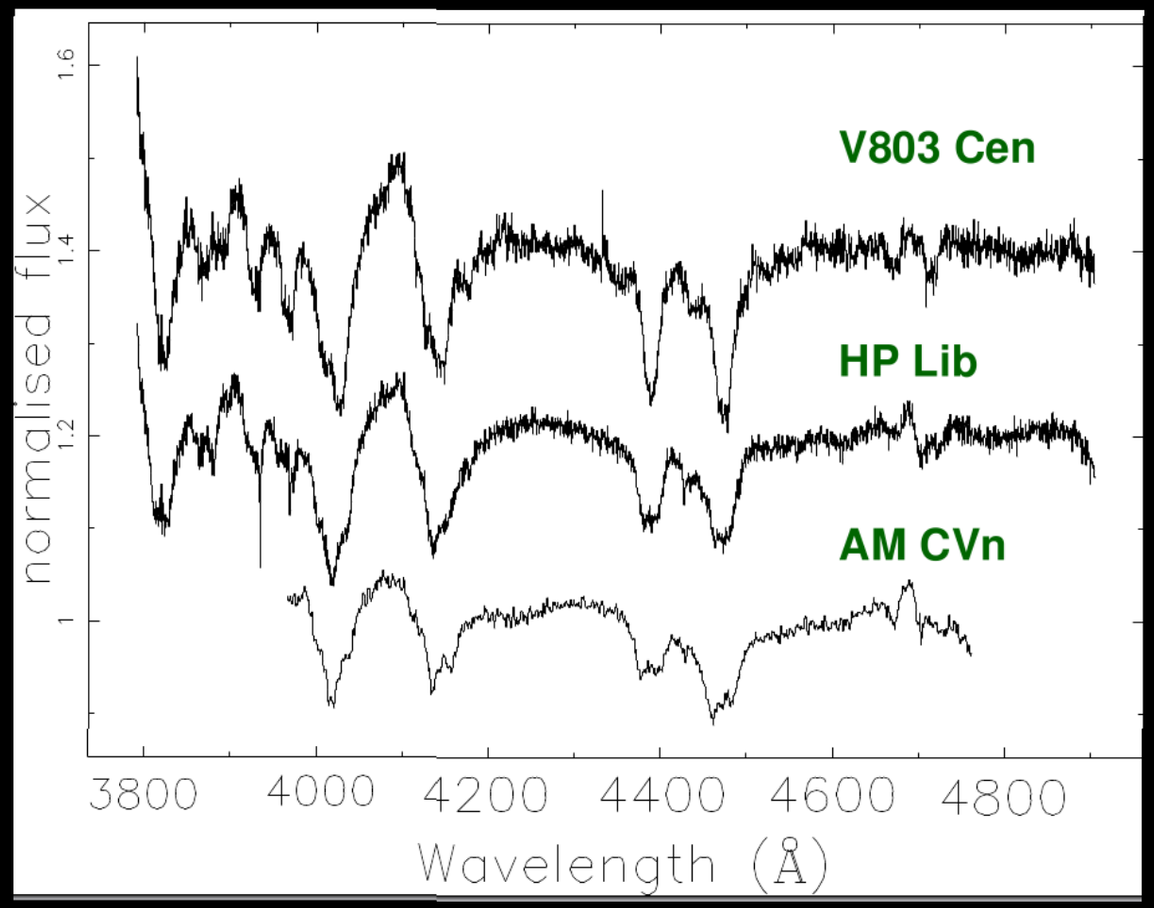
$$P^{2/3} \geq \ldots \frac{R}{M^{1/3}} \qquad P_{min} = 9\ hr\ \left(\frac{\rho}{\rho_{sun}}\right)^{-1/2}$$

Main sequence stars ρ < 100 gr/cm3 i.e P > 1 hr!

→ All stars in ultra-compact binaries are evolved

(indeed no H in spectra!)





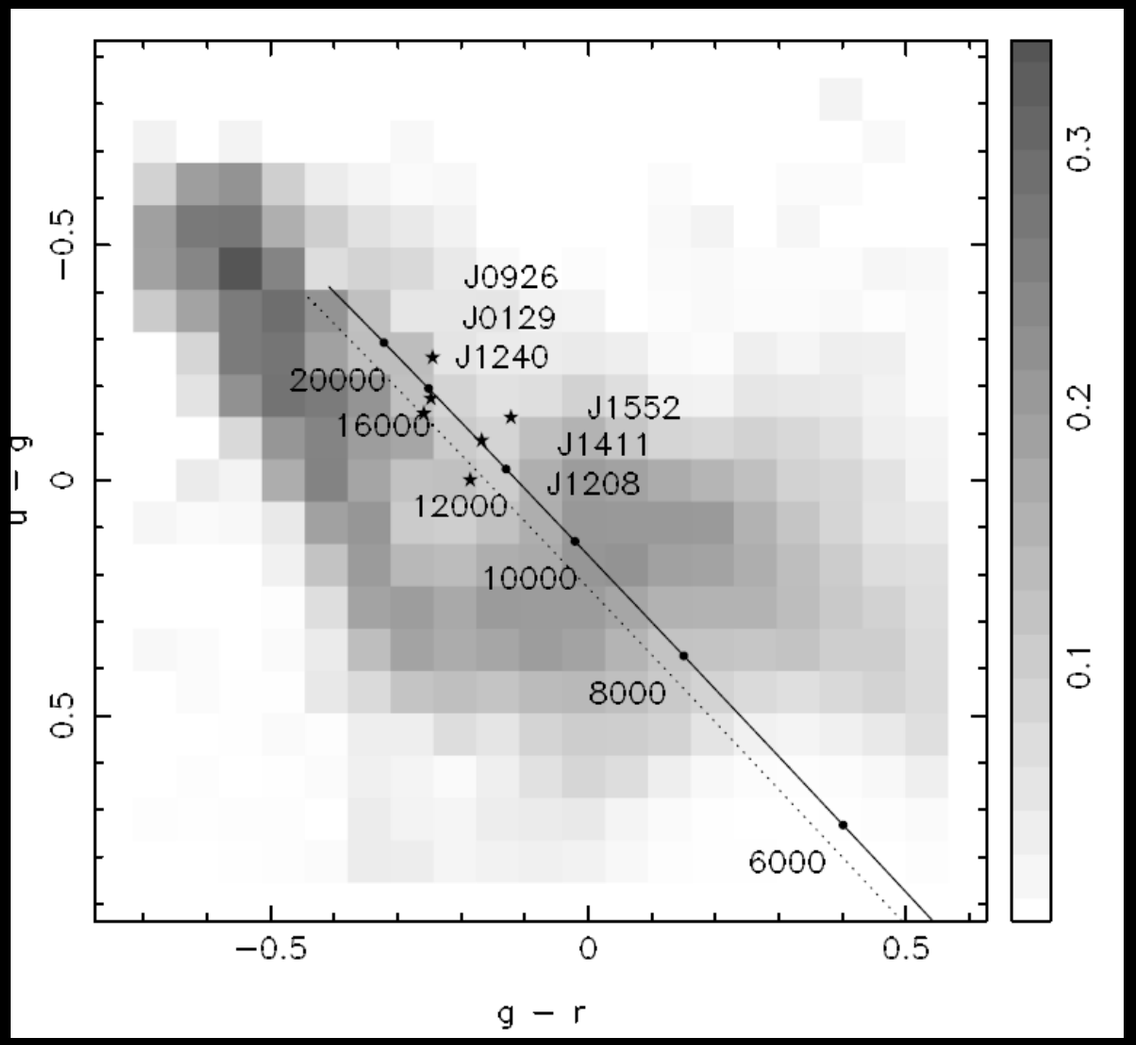
Nelemans et al. 2004, 2006

Population synthesis

- Population synthesis
  - Similar contributions WD and He channel
  - BUT space denstity overestimated!
- Latest (?) results still similar

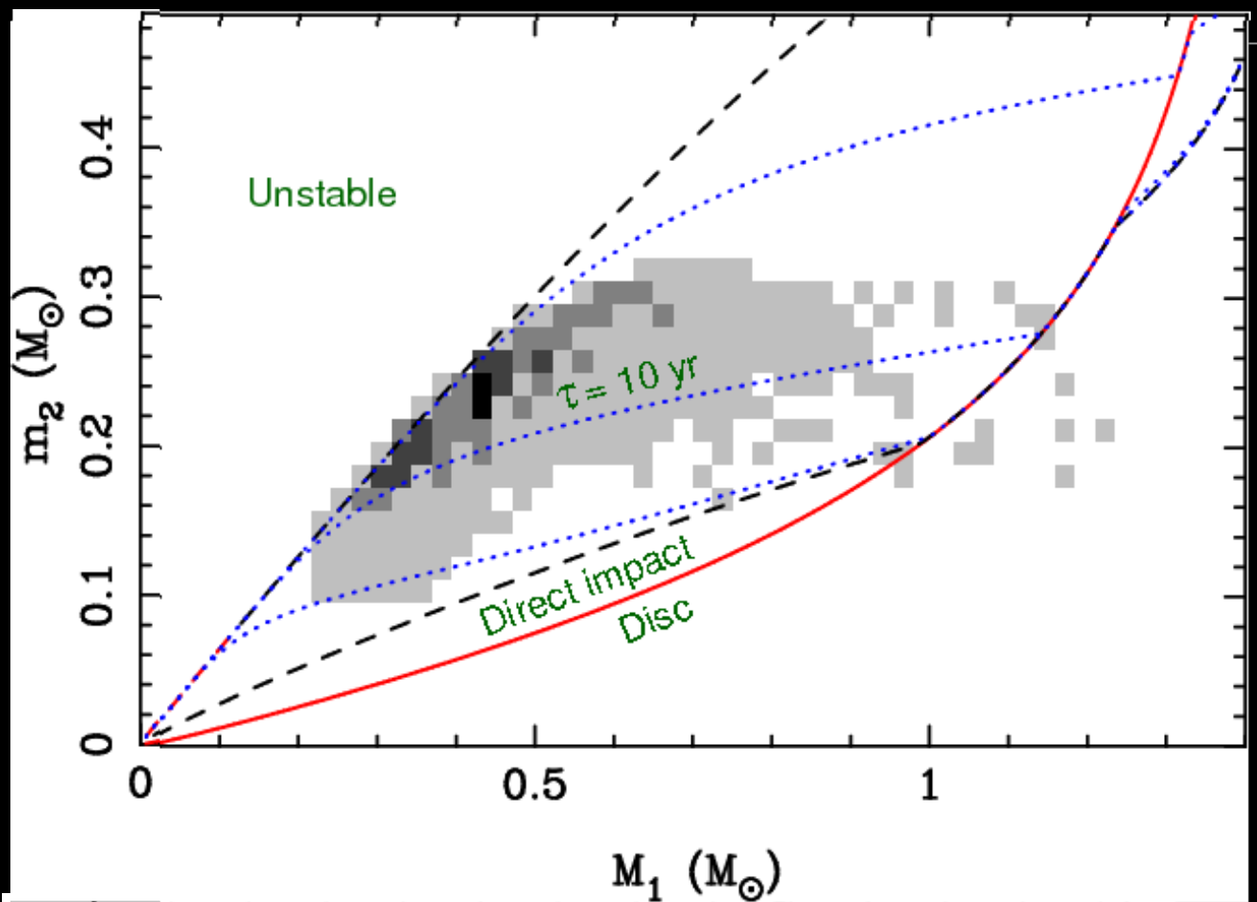
Ruiter et al. 2010,2011

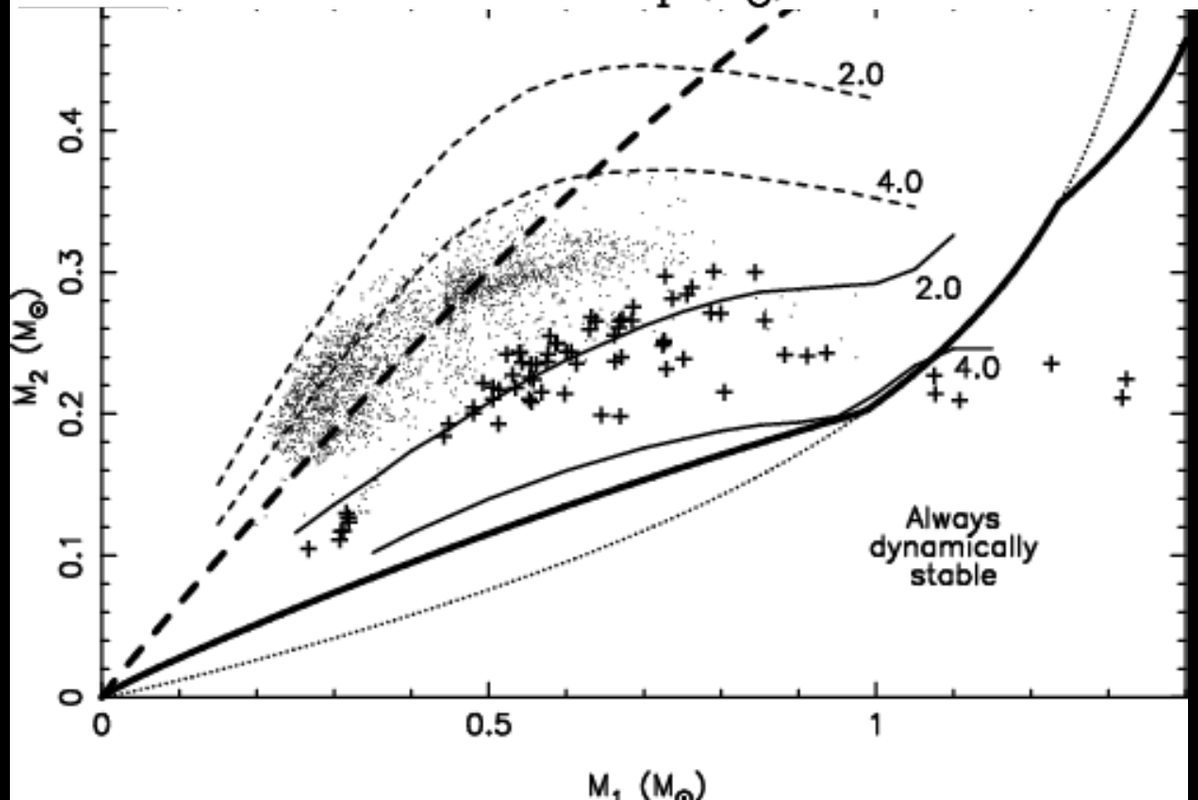
- Possible solutions
  - Double WD population wrongly simulated (mass ratio?)
  - Less WD donors survive (i.e. merge)
  - Somthing happens during evolution
  - Systems become detached



Roelofs et al. 2007, MNRAS

Stability of mass transfer





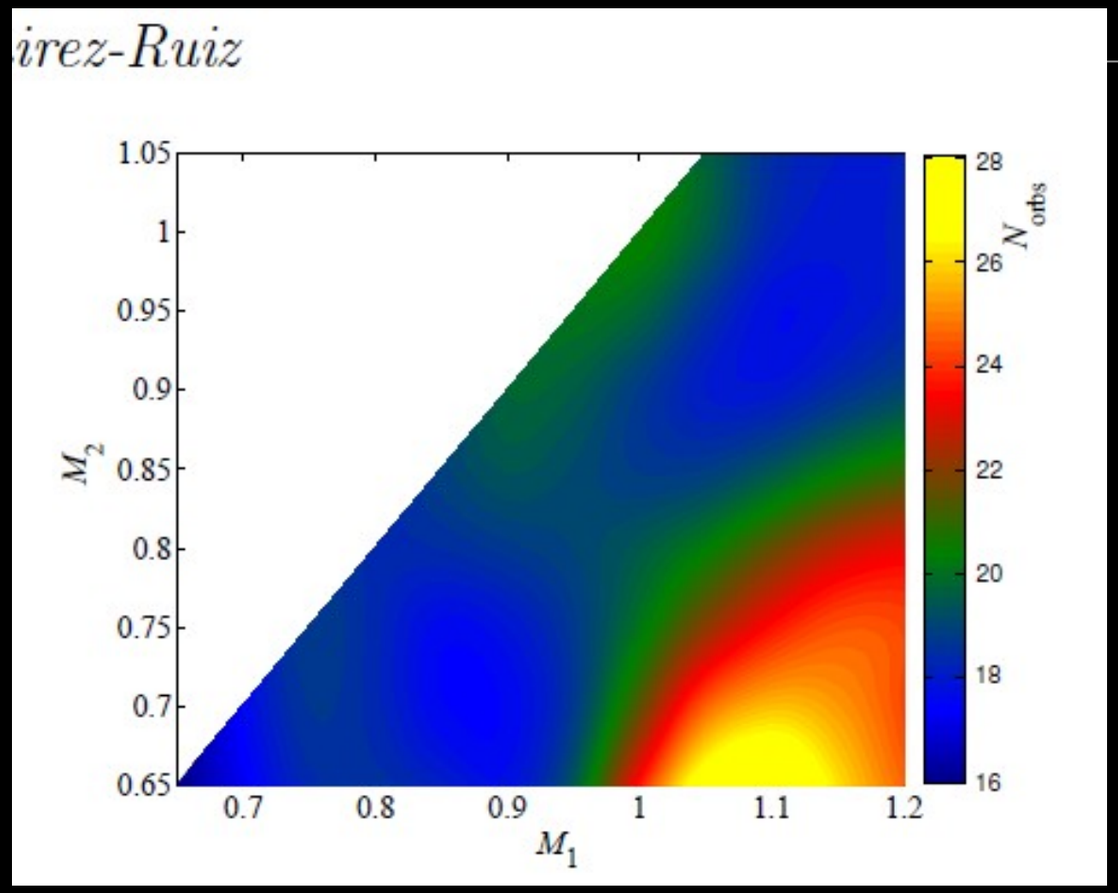
- GW angular momentum loss+mass transfer: stable if q < ~2/3
- Additional problems
  - Resulting Mdot highly super-Eddington
  - Direct impact
  - Extra angular momentum loss, destabilise

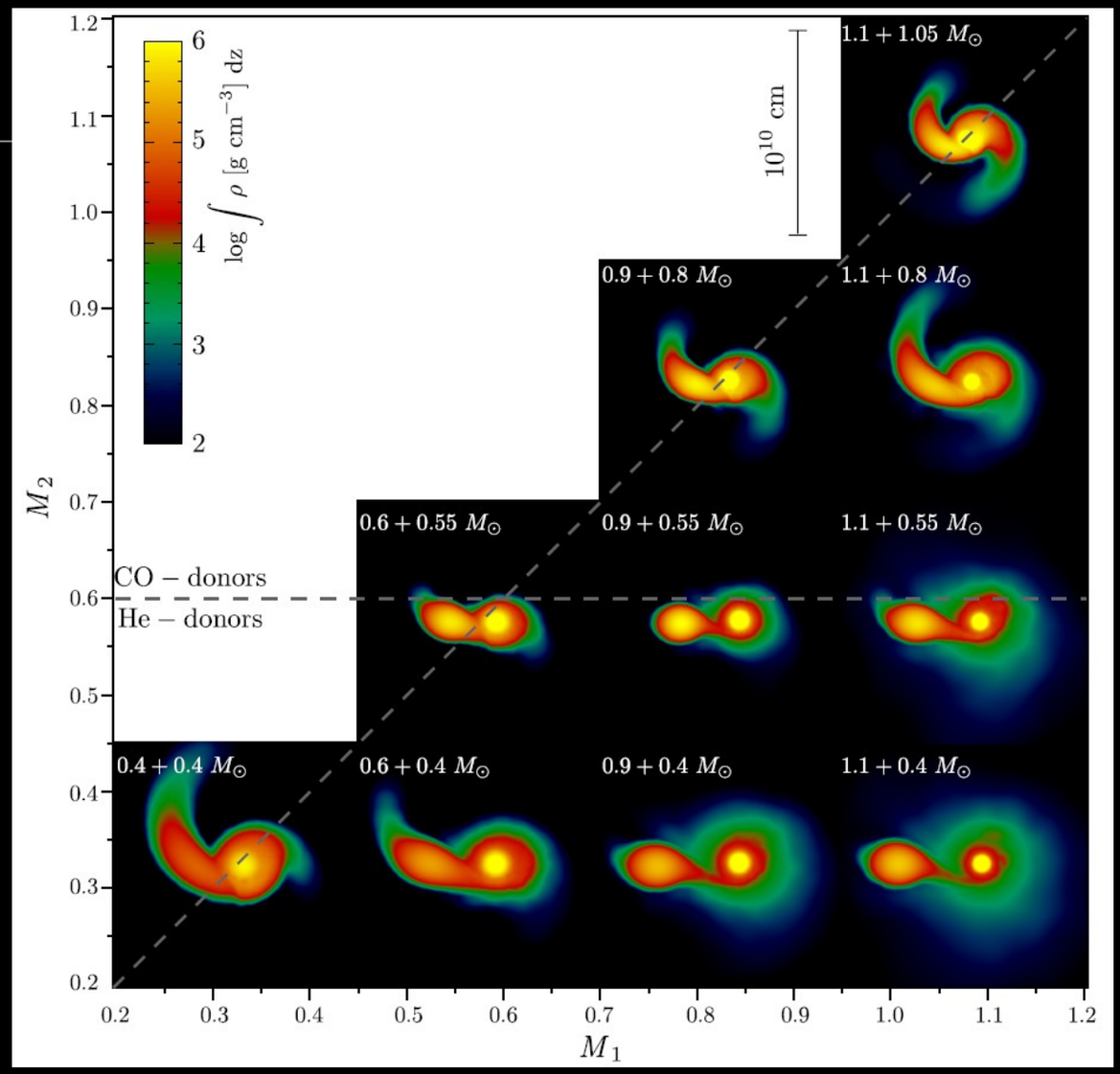
Marsh et al. 2004

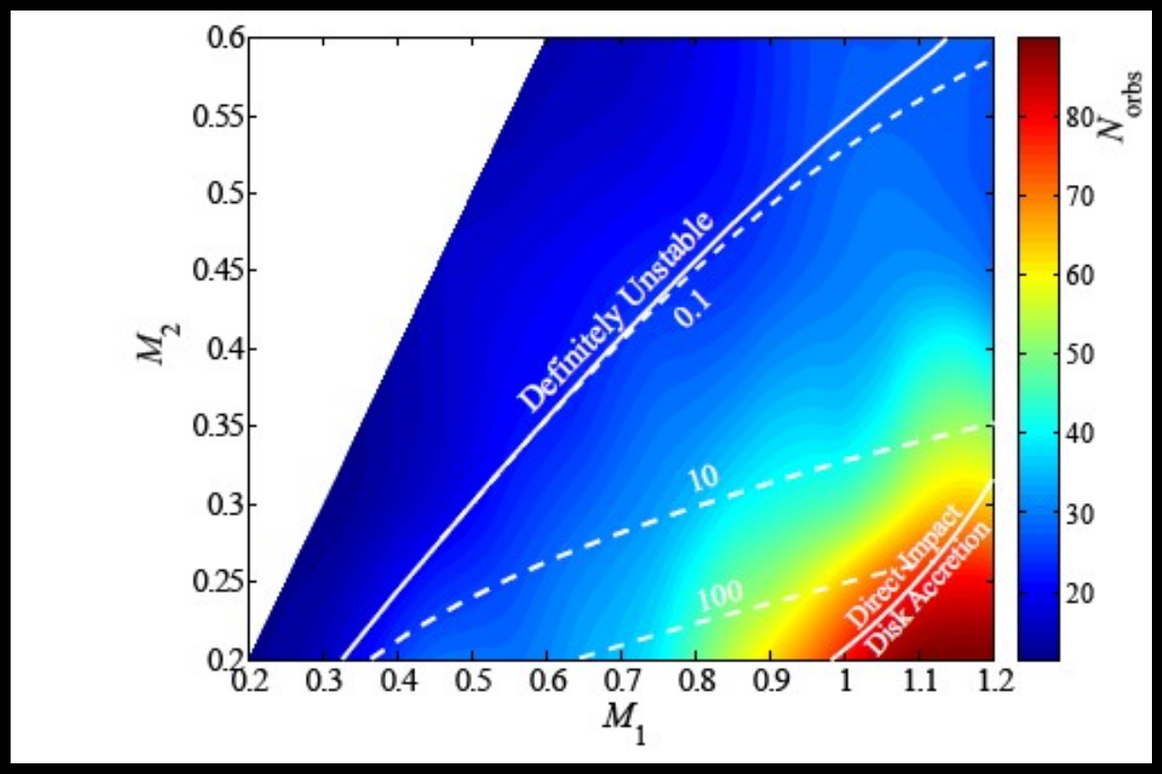
- But influence radius donor (i.e. entropy)
- Could make more stable

Roelofs & Deloye never published

SPH calculations

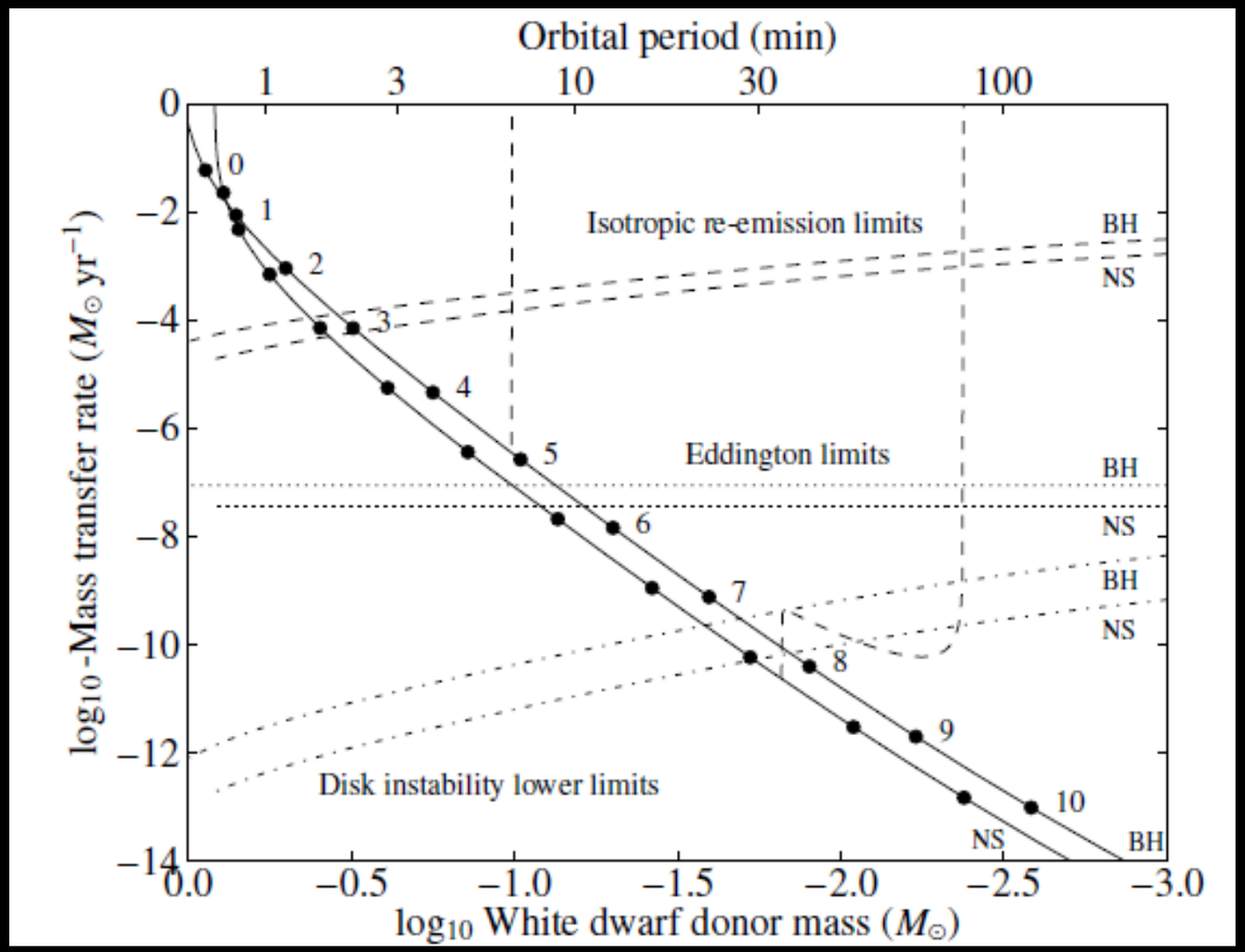






- Mergers “slow”, i.e. not in 1 orbit
- “Stable” systems even slower
- But beware of limitations method (cannot resolve τ_{GW} by many orders!)

What is different for UCXBs?



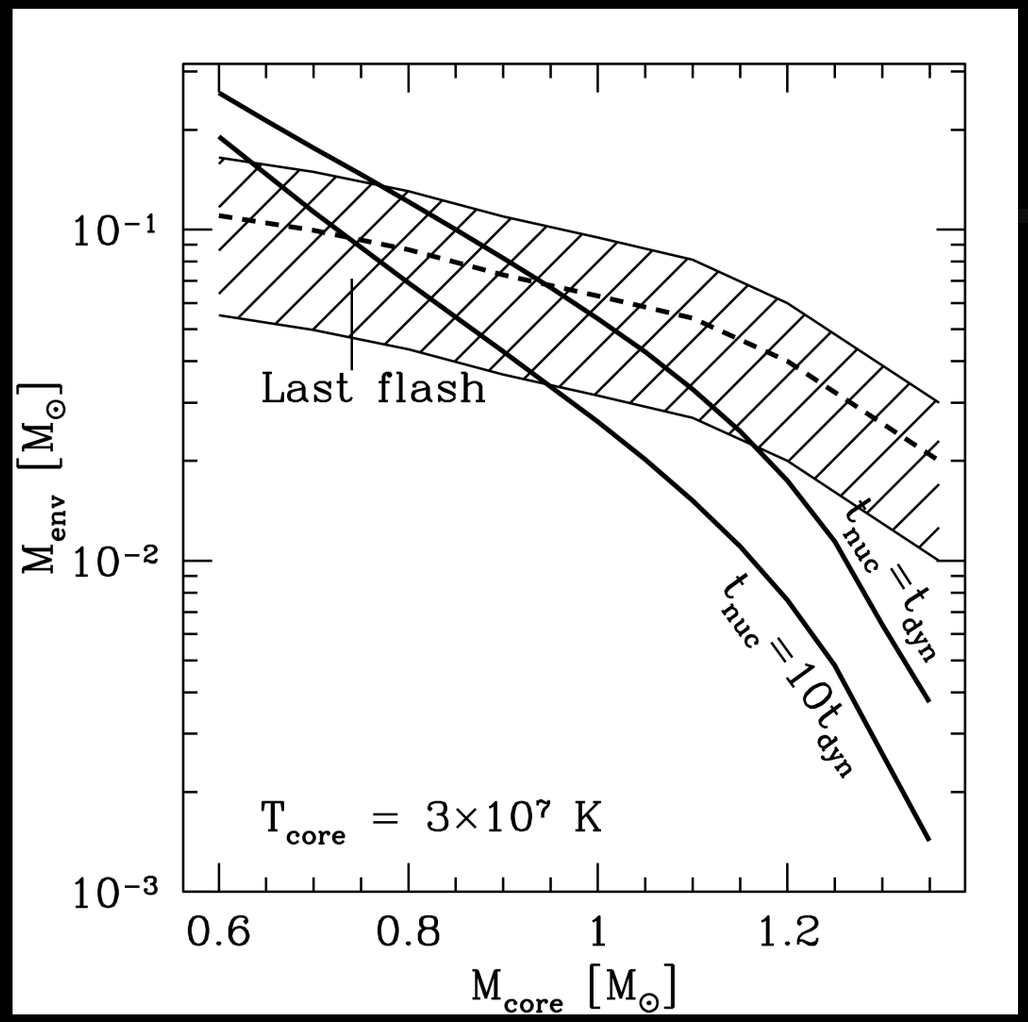
- No direct impact, i.e. always efficient coupling
- But what happens to super-Eddington mass transfer?
- Optimistic max Mdot: Eddington luminosity used to eject material from L1 (isotropic re-emission)

Van Haaften+ 2012

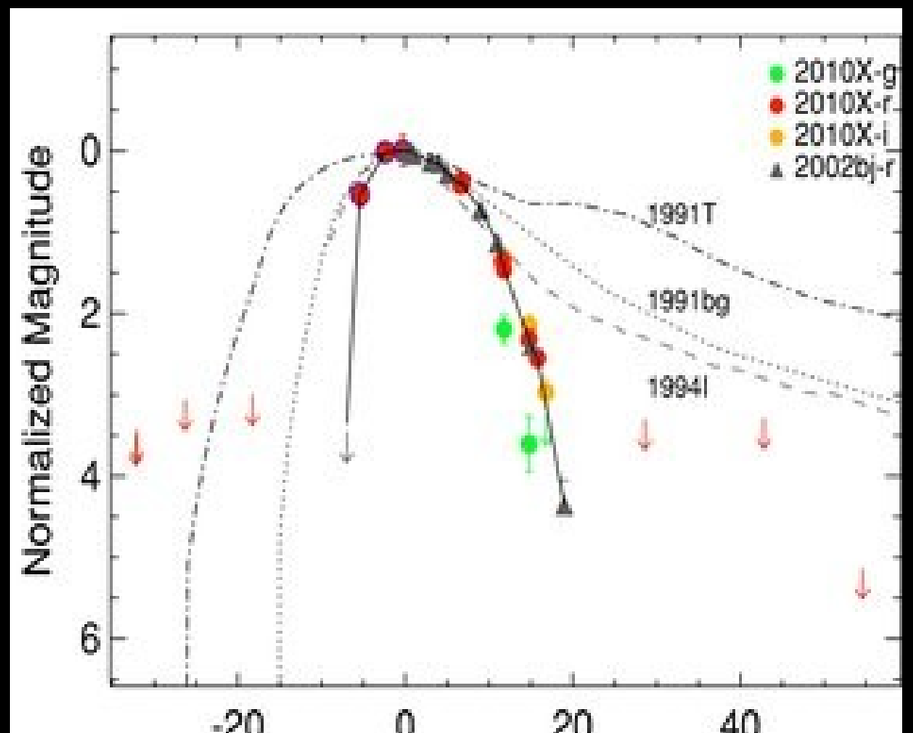
If stable mass transfer: still fireworks

- NS: peculiar X-ray bursts
- WD:
  - Helium novae
  - When mass transfer rate drops: envelope mass increases → explosion
  - Special type of supernovae
  - Weird SN are found (PTF etc)

V445 Pup, Woudt+2010



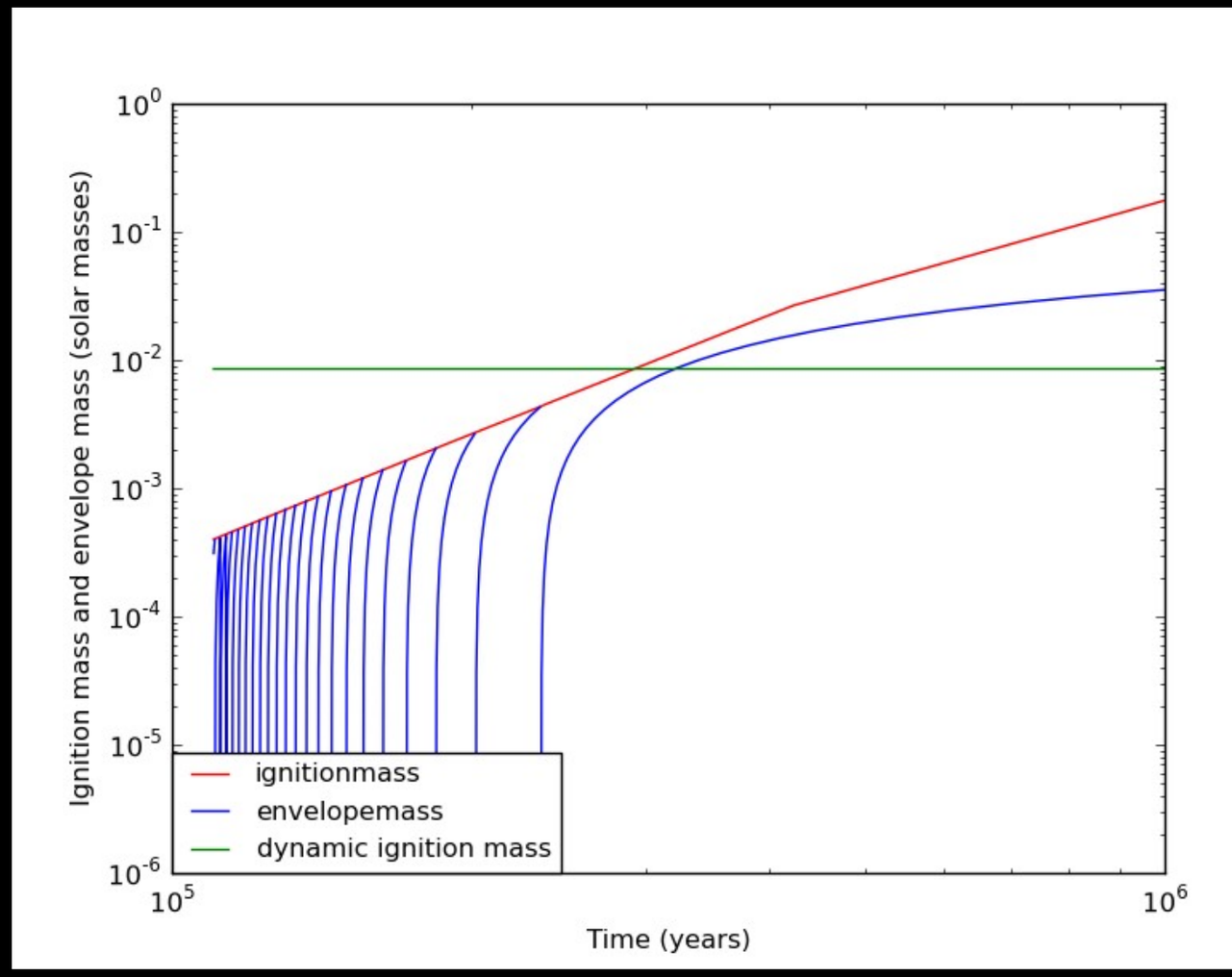
Bildsten et al. 2007



Kasliwal et al 2010

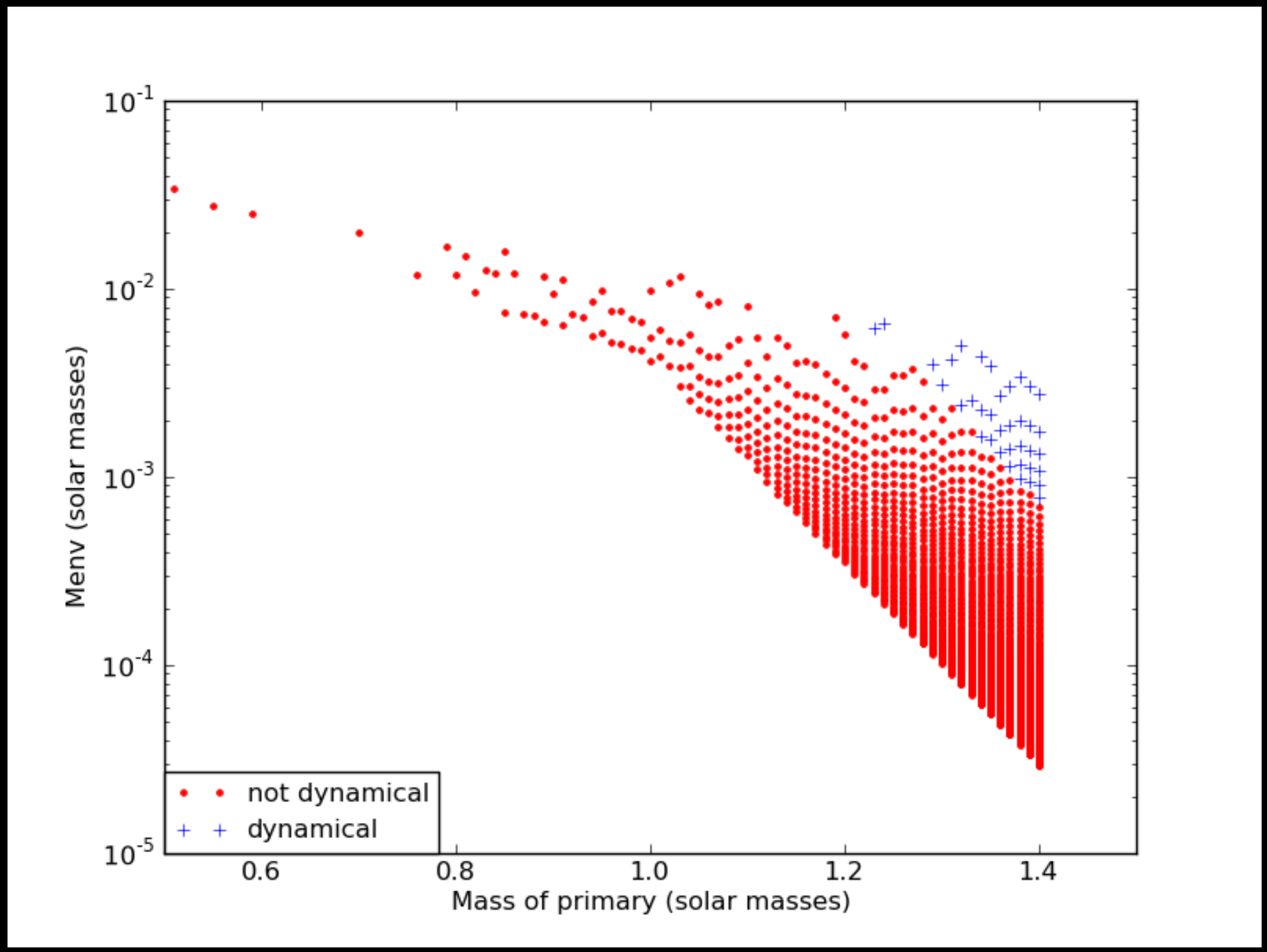
He novae

- Ignition masses very unclear
  - Combination of estimates
    Iben & Tutukov, Shen & Bildsten
- Start of MT: stable He burning!
- Afterwards several novae
- Final one (or more) possibly .Ia
- Work in progress (master student Sjoerd Arnts)

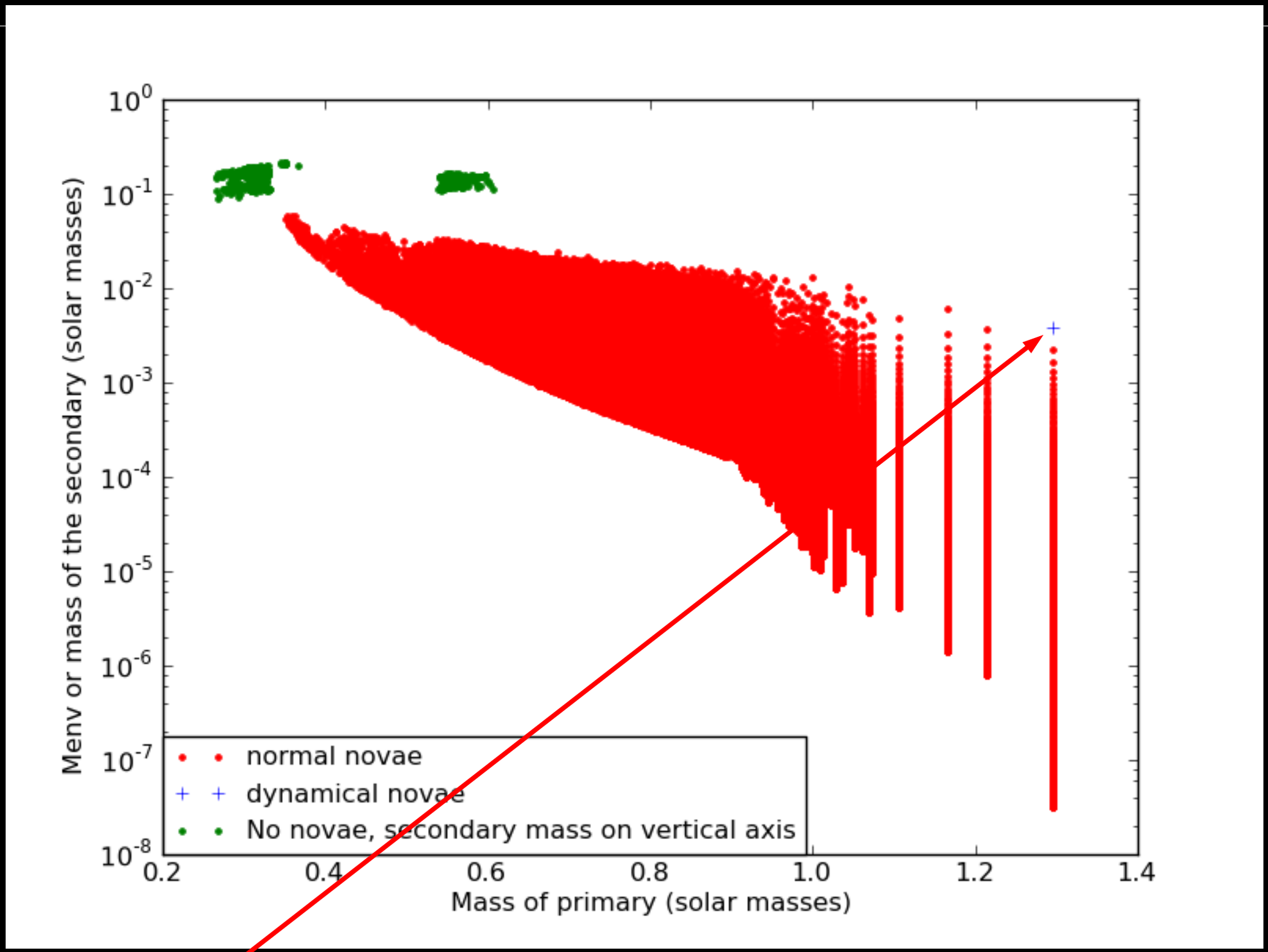


Results for grid of accretion masses

Ignitionmass suggested by Lars Bildsten



Results for population from SeBa (prelim!)



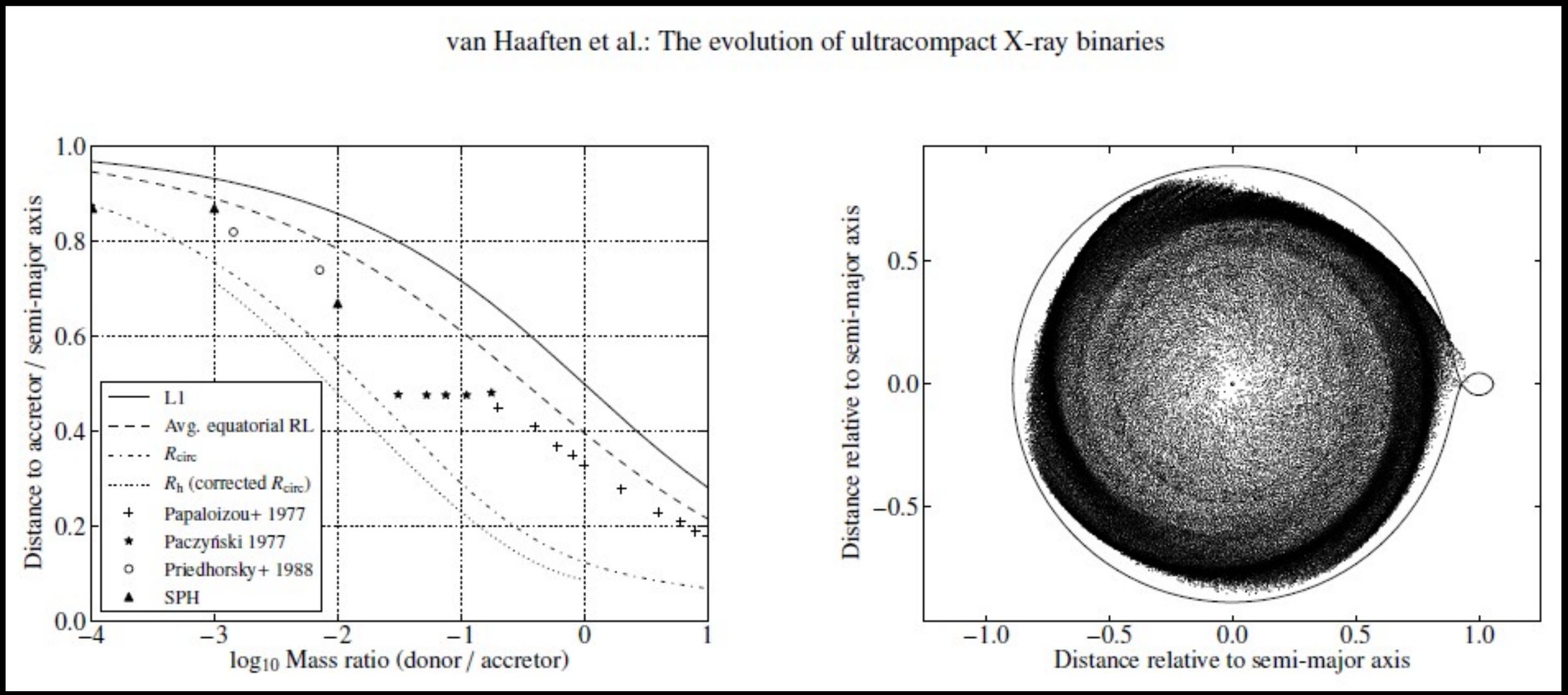
Hardly any .Ia

Late time evolution

- At late times (small mass ratio) coupling disk – orbit lost because disk cannot grow → system unstable → single WD/NS?

Ruderman & Shaham

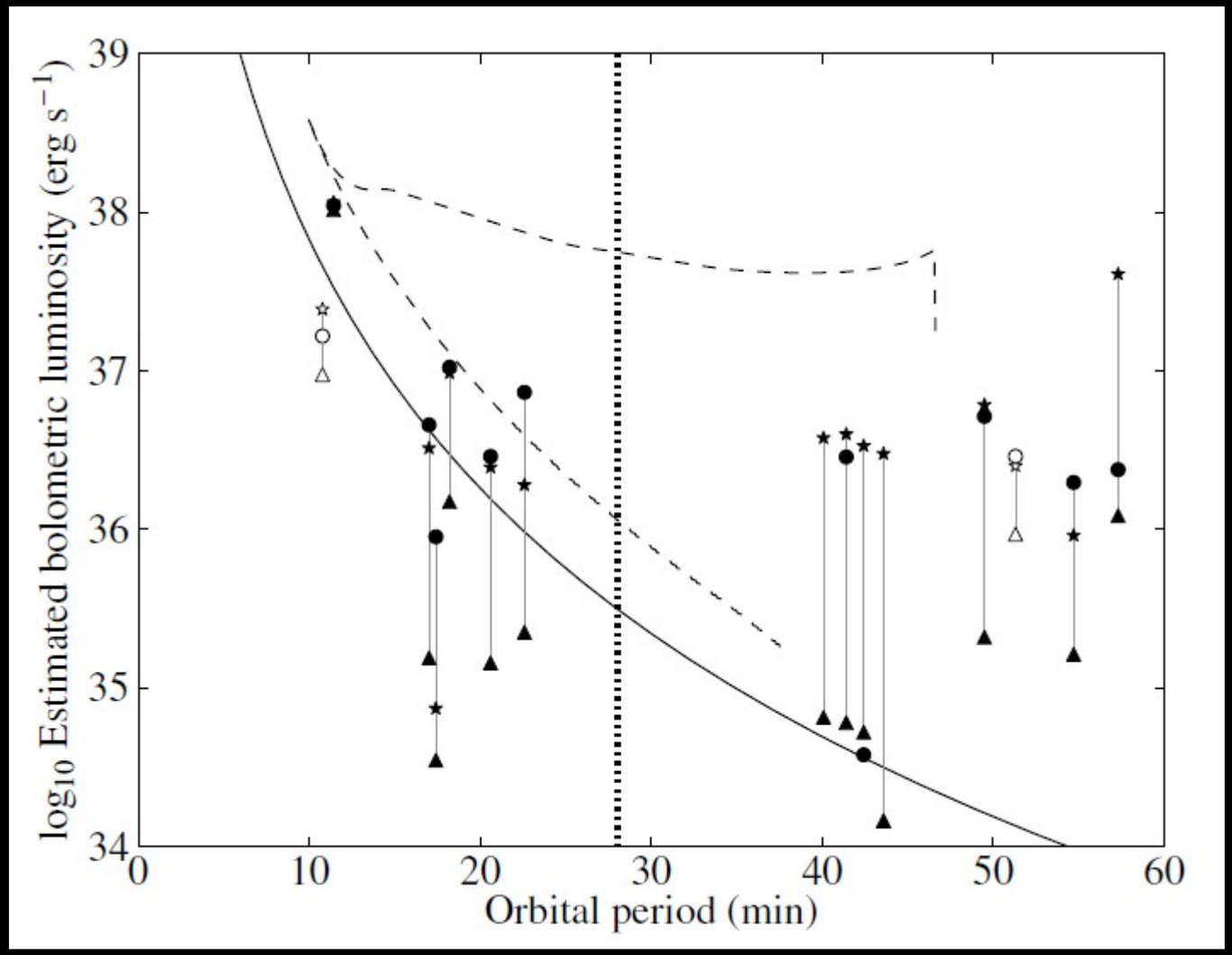
- Answer: No



Late time evolution UCXBs: but...?

- No disruption: mass transfer keeps going down
- Observationally seems not to happen

  Van Haaften et al., in prep
- Additional angular momentum loss? Wind from donor?

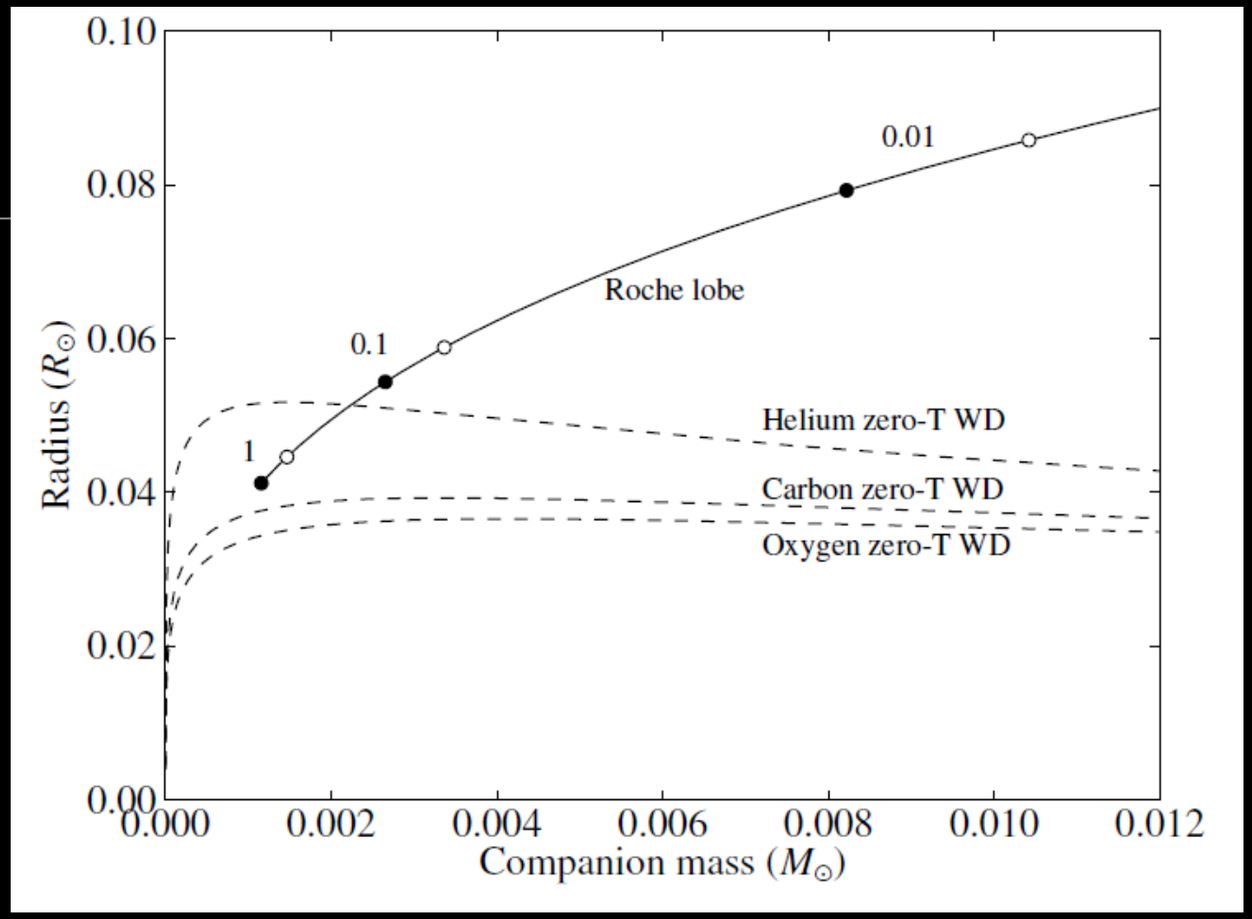


Van Haaften et al., in prep

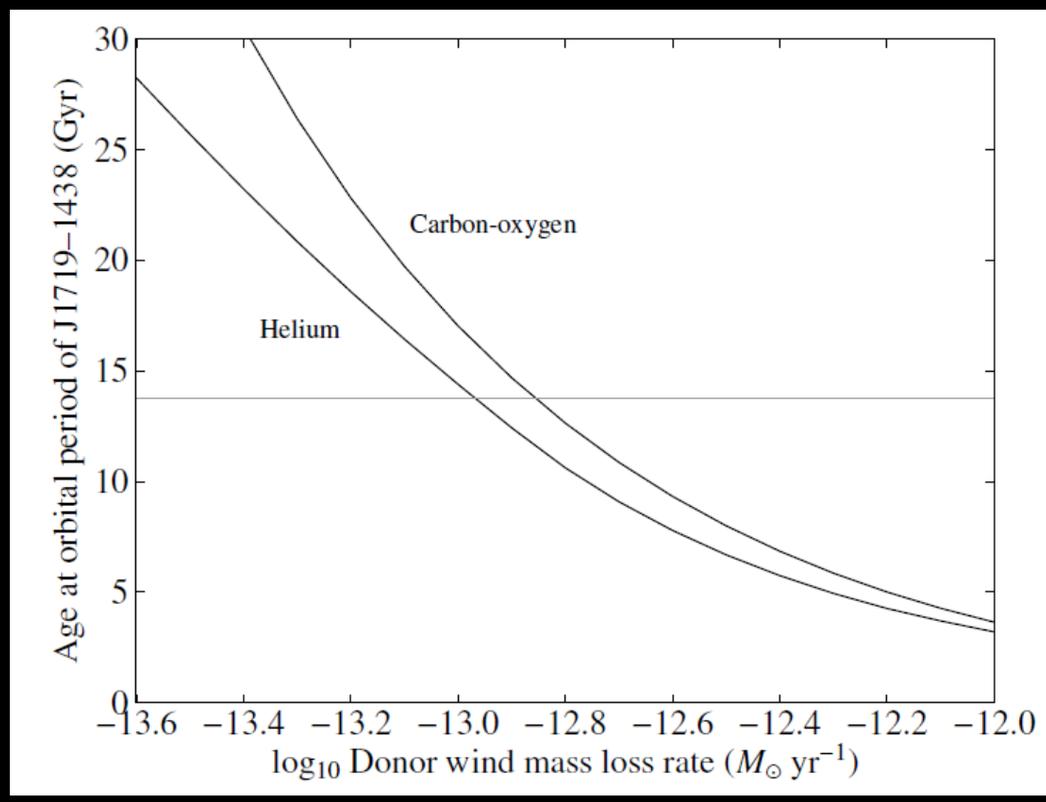
Van Haaften et al., in press

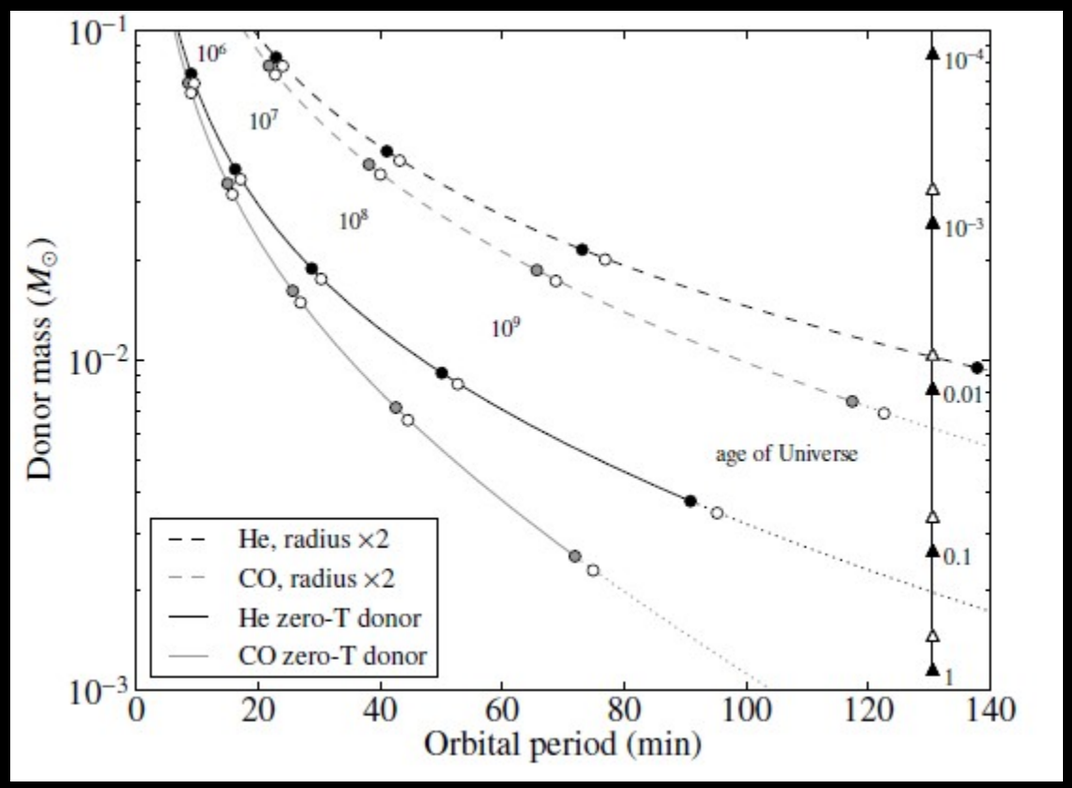
PSR J1719-1438

- Detached MSP plus low-mass, compact companion Bailes et al. 2011
- Evolved from UCXB? Period too long
- Need faster evolution (bigger donor? Wind mass loss?)
- How did it get detached?



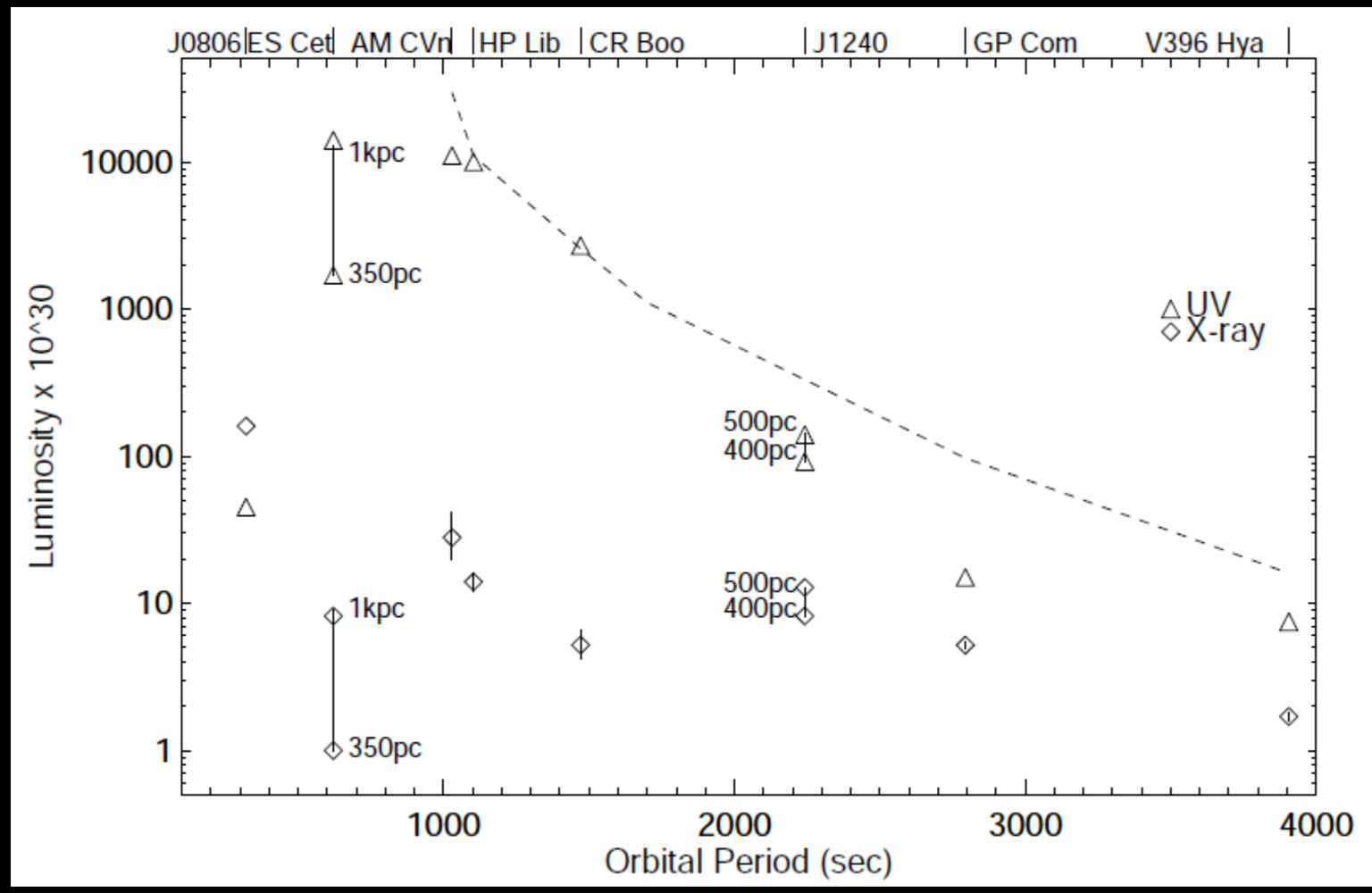
Van Haaften et al., in press





What about AM CVn late time evolution?

- As far as I know no sign of higher than expected Mdot?
- Estimate from XMM X-ray and UV
- Donor wind driven by X-rays?



Ramsay et al.

Conclusions

- Formation and population still very unclear (theoretically): observations are now ahead!
- Stability of mass transfer: important!
  - Much work done on hydro
  - Outcomes difficult to interpret (for me)
- In early times, He novae and possibly .Ia supernovae expected (but not many)
- Great prospects with synoptic surveys
- Late time evolution
  - Disks continue to feed back AM
  - Interesting connection with UCXBs
- Where are the long period systems?