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Hot White Dwarf Donors

Bildsten '02 (Ap J 577, L27)
Deloye & Bildsten '03, in preparation

- R(M) measured in 2 ultracompacts
  - ↳ Cold, pure He or C/O WD's cannot fill RL ⇒ T≠0!!
- Basic Physics of Finite T WD's
  - ↳ Min mass as fn of T_c!
- What Determines T_c is
  WD cooling prior to contact + Tidal heating
- What's future of Ultracompacts?
  - A) Mass Transfer Instab
    - ↳ Isolated MSP
  - B) Cold WD → 5-10 M_{Jup} in 60-90 min orbit
- Impact for $\dot{M}(P_{orb})$ in AM CVn's.

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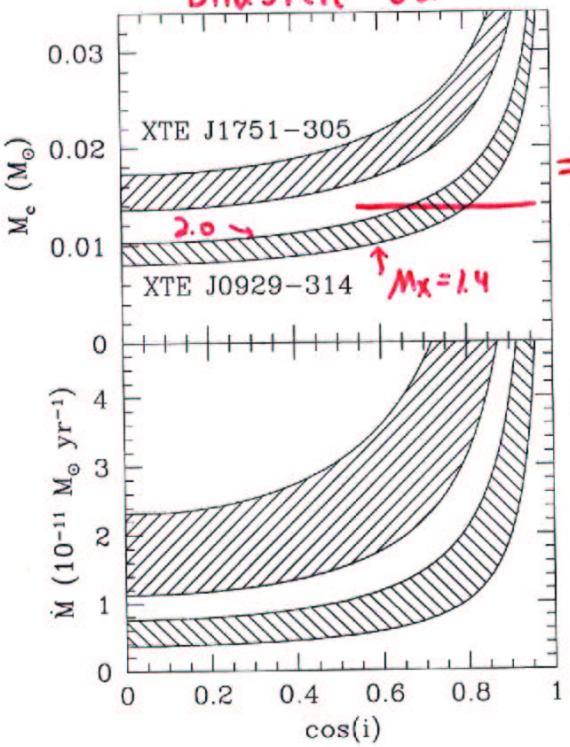
Ultracompact Binaries

Both have ms pulsars and $P_{orb} \simeq 43$m
(Markwardt et al '02; Galloway et al '02)
and measured $a_x \sin i$!!

Bildsten '02



⇒ $M_c \gtrsim 0.013 M_\odot$
If same Companions

$\dot{M}_{GR} \simeq \frac{3}{2} M_c \frac{\dot{J}_{GR}}{J}$

$\dot{M} \sim 10^{-11}\ M_\odot/yr$

So

$T_{evol} \sim \frac{M}{\dot{M}} \sim$ Gyr

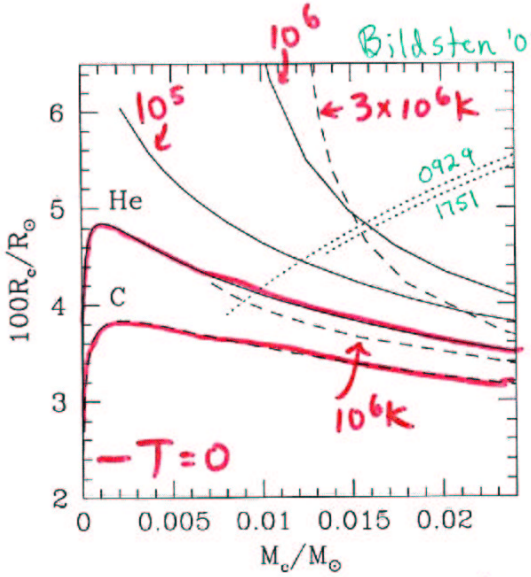
⇓

Time to evolve forward.

- Low $\dot{M}$ is likely cause for outbursts.

Roche Lobe Filling — 3

- 0929 can have cold He, but NO Cold C/O
- 1751 Must have hot WD.
- Alternative is slight H content (Podsiadlowski Rappaport & Pfahl '02)



$\frac{H}{He} = ?$

- Cold solns are Zapolsky & Salpeter
- Finite T are Bildsten '02

Very low mass, cold objects 4

have

$$P_{Hyd} \sim \frac{GM^2}{R^4} \sim P_{Deg} + P_c$$

Hydro Balance — Deg e^- — Coulomb.

$$P_c \sim -n_i \frac{e^2 z^2}{a} \qquad a = \text{ion spacing}$$

$$\sim -K_c \rho^{4/3} \qquad P_{deg} \sim K_d \rho^{5/3}$$

and $\rho \approx M/R^3$

$$\Rightarrow \frac{GM^2}{R^4} \sim K_d \frac{M^{5/3}}{R^5} - K_c \frac{M^{4/3}}{R^4}$$

or $$R \sim \frac{K_d M^{1/3}}{K_c + GM^{2/3}} \rightarrow \begin{cases} M^{1/3} & M \to 0 \\ M^{-1/3} & M \to \infty \end{cases}$$

and transition mass

$$M_{crit} \sim \text{few } M_{Jup}$$

Hot Low Mass WD's

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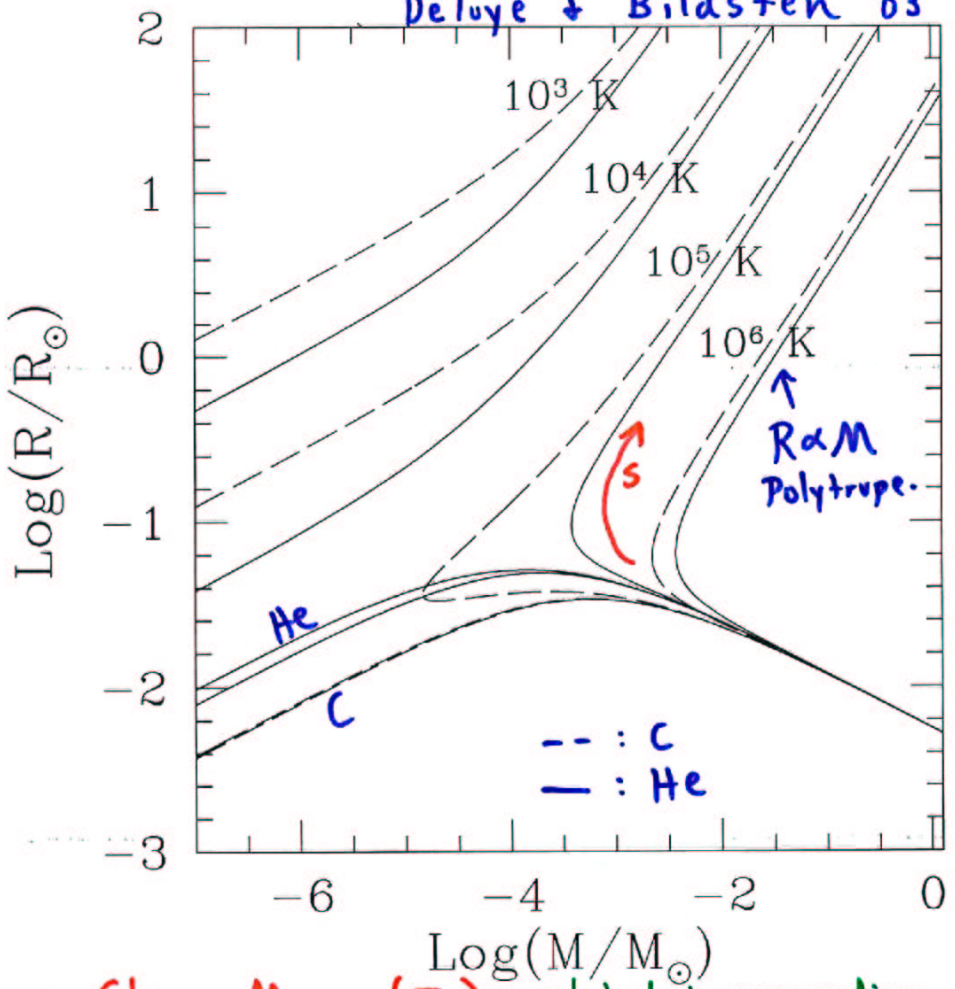
Deluye & Bildsten '03



- Clear $M_{min}(T_c)$; related to evaporation
- No way to reach R∝M polytropes as mass is lost!

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What T_c to Expect?

Scenario I consider is CE at WD formation → GW's drive into contact. During this time, the WD cools:

① He & C/O Cool Differently (Althaus & Benvenuto '97, Hansen & Phinney '98)

Larger specific heat of He WD slows its cooling

$M = 0.2 M_\odot$ $T_c = 10^7$ K @ 1 Gyr, $\approx 3\times10^6$ @ 4 Gyr

whereas C/O cools to 2.5×10^6 in 4 Gyr and since ρ is higher, entropy lower.

② After contact ρ drops

All entropy in liquid ions

adiabat ⇒ $T_c \propto \rho_c^{0.5\to0.6} \propto M_c$

⇒ A $0.013 M_\odot$ He WD made from $0.2 M_\odot$ has $T_c = (3\to6)\times10^5$ K (NO TIDAL!)

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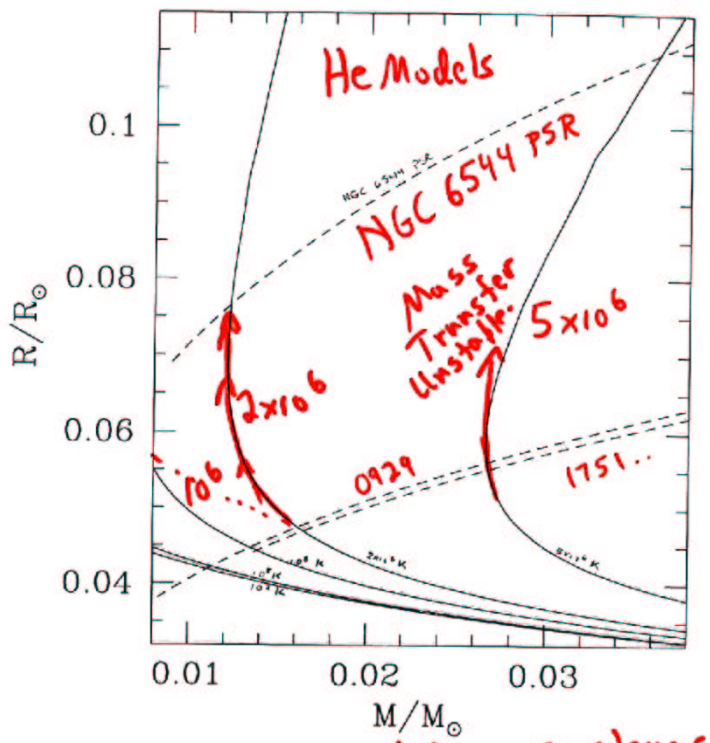

- Connecting the accreting systems to Radio MSP's requires knowledge of tidal heating
- Plotted isotherms would require lots of tidal heating.

↳ Conservative is No Heating

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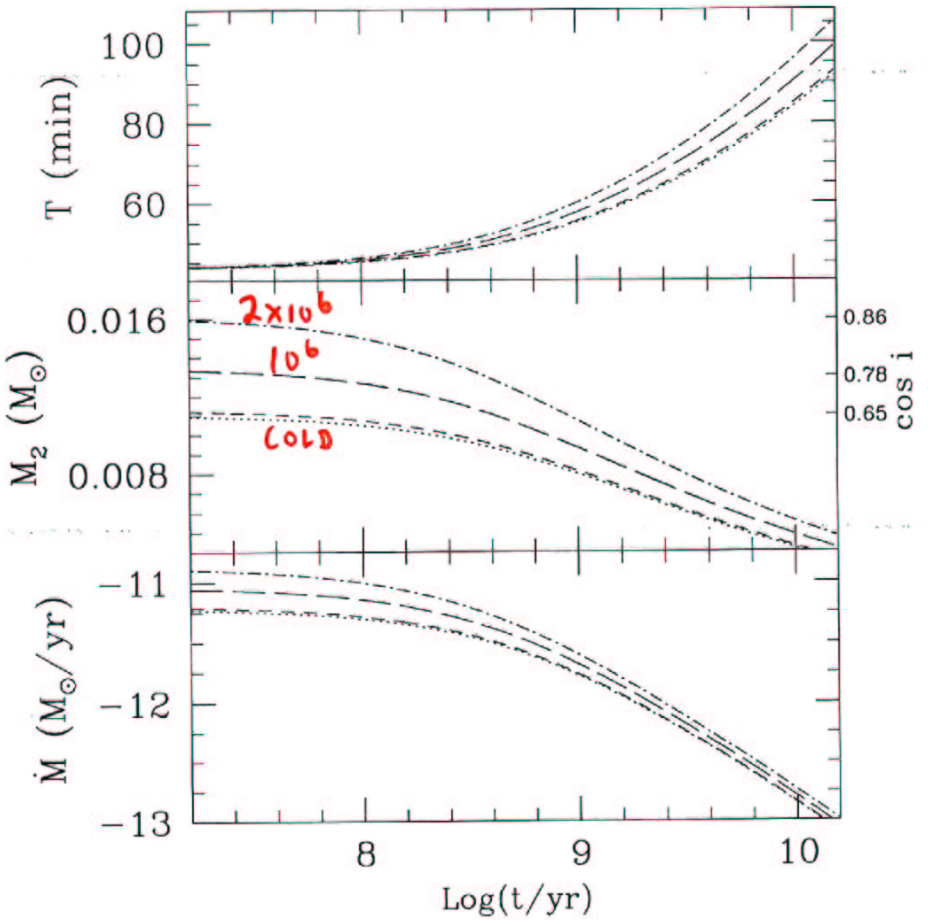
XTE J0929-314's Future!



Just adiabatic evolution, so minimal model.

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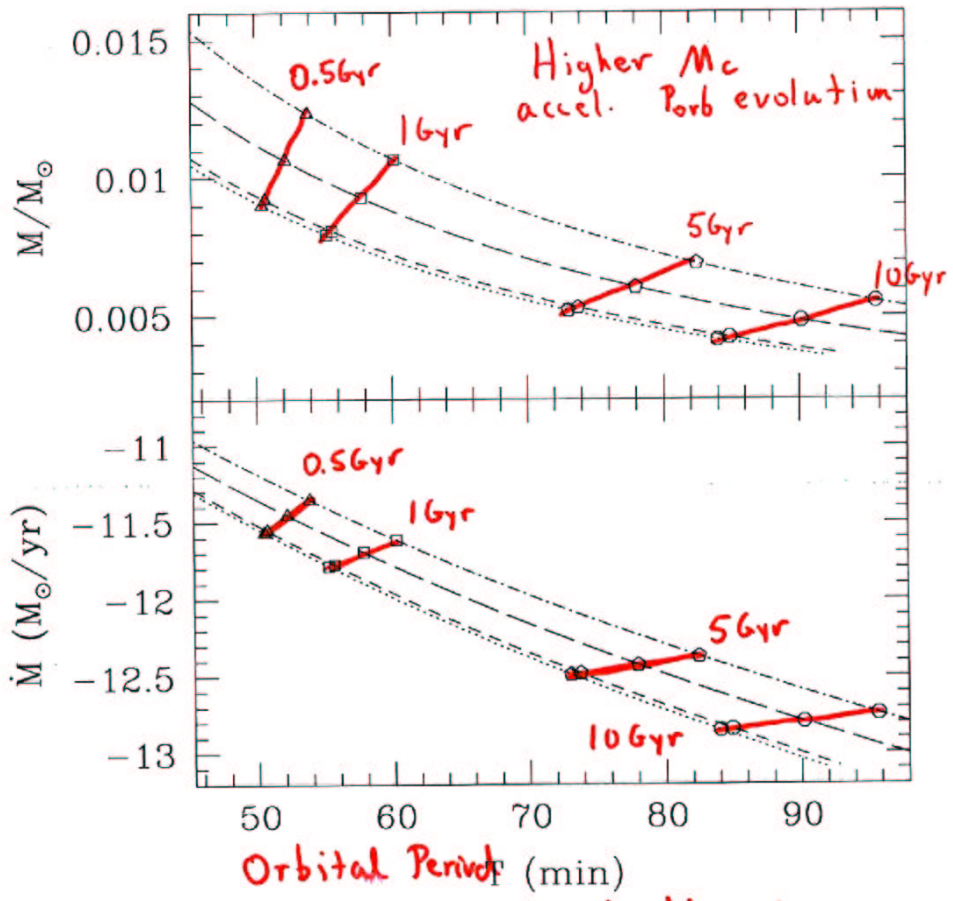
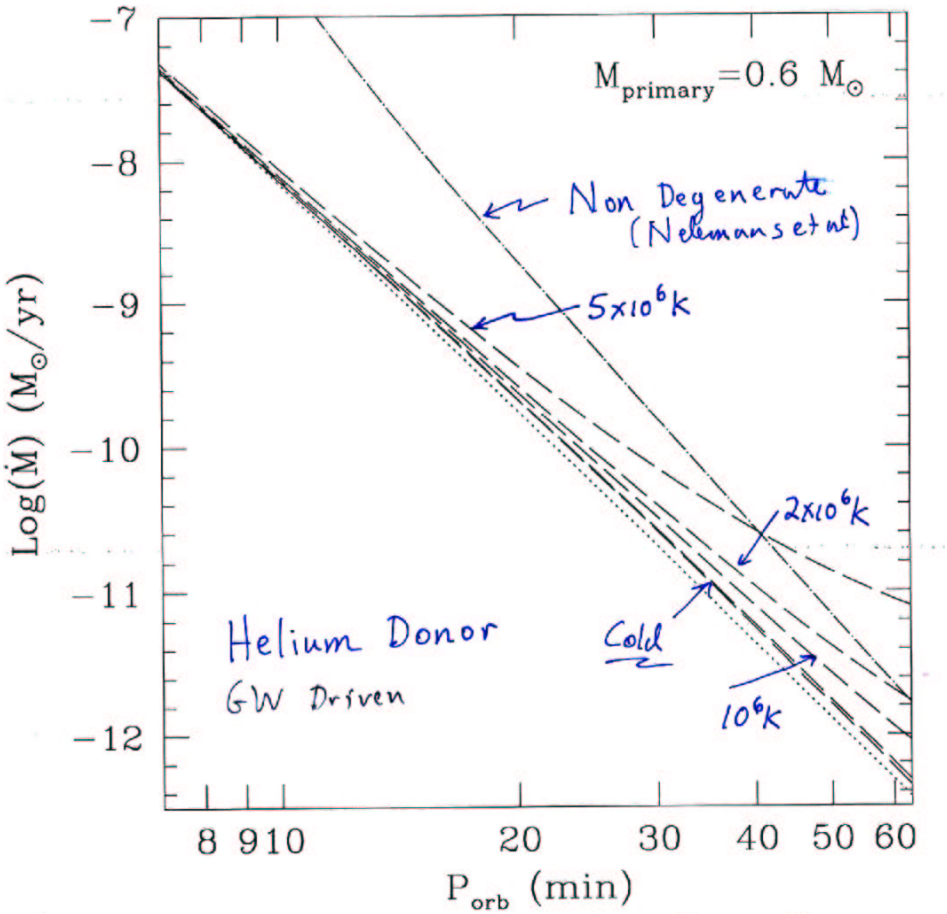


⇒ If mass accretion halts & MSP turns on ⇒ $M_c \simeq 5\text{-}10\ M_{Jup}$ with $P_{orb} \simeq 60 \to 90$ minutes (Tough to detect!). Tidal heating only speeds this up!

Impact on AM CVn Systems



⇒ Largest impact at low M_c and long P_{orb} ⇒ Directly impacts total #'s as systems "pile up" at low P_{orb}.

Future

- Find how much tidal heating is needed to get mass transfer instability for ultracompacts.
- Convince MSP observers to search for remnants at 60 → 90 min
- Include WD cooling in binary evolution codes to set initial WD entropy (AMCVN)

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