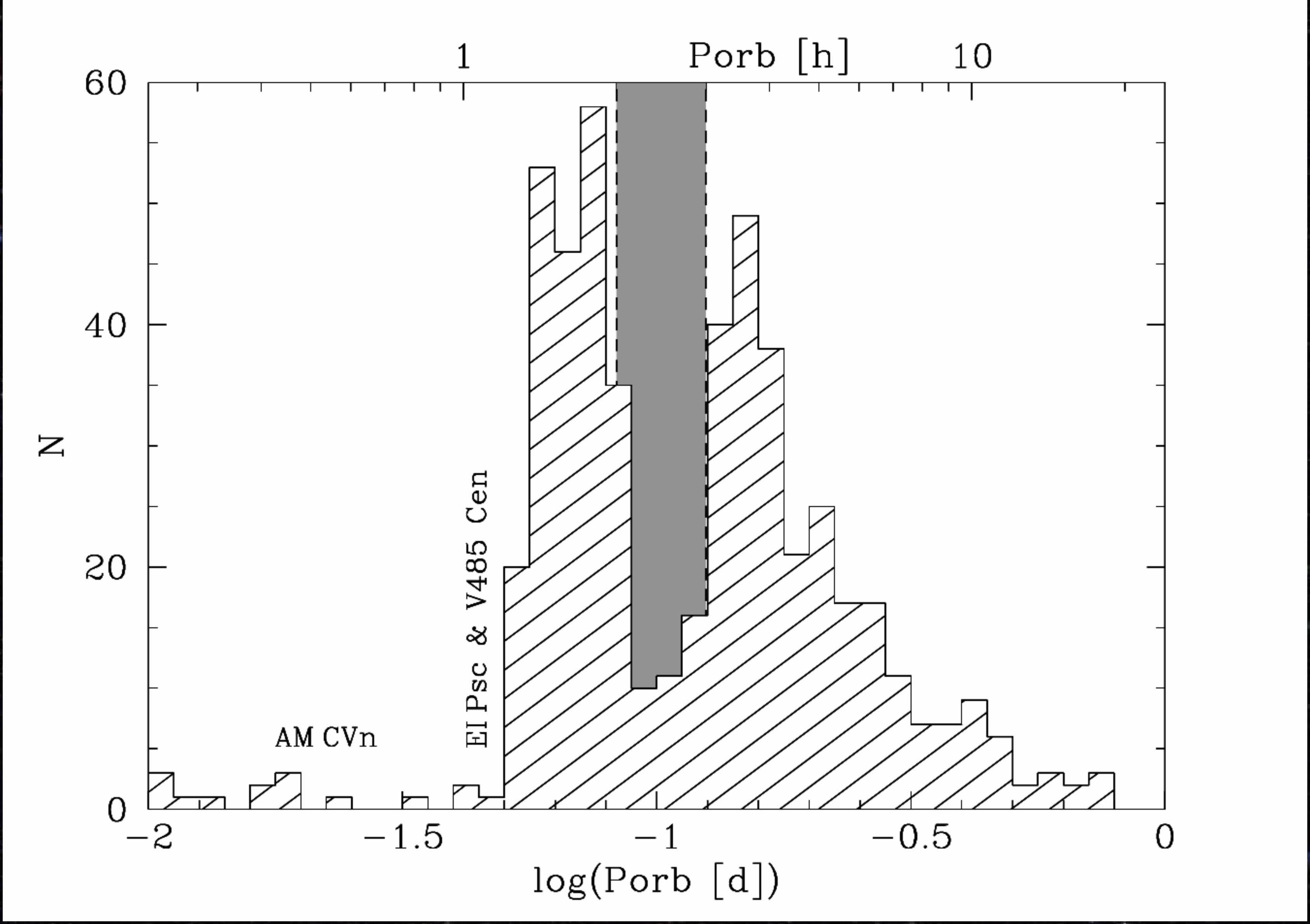
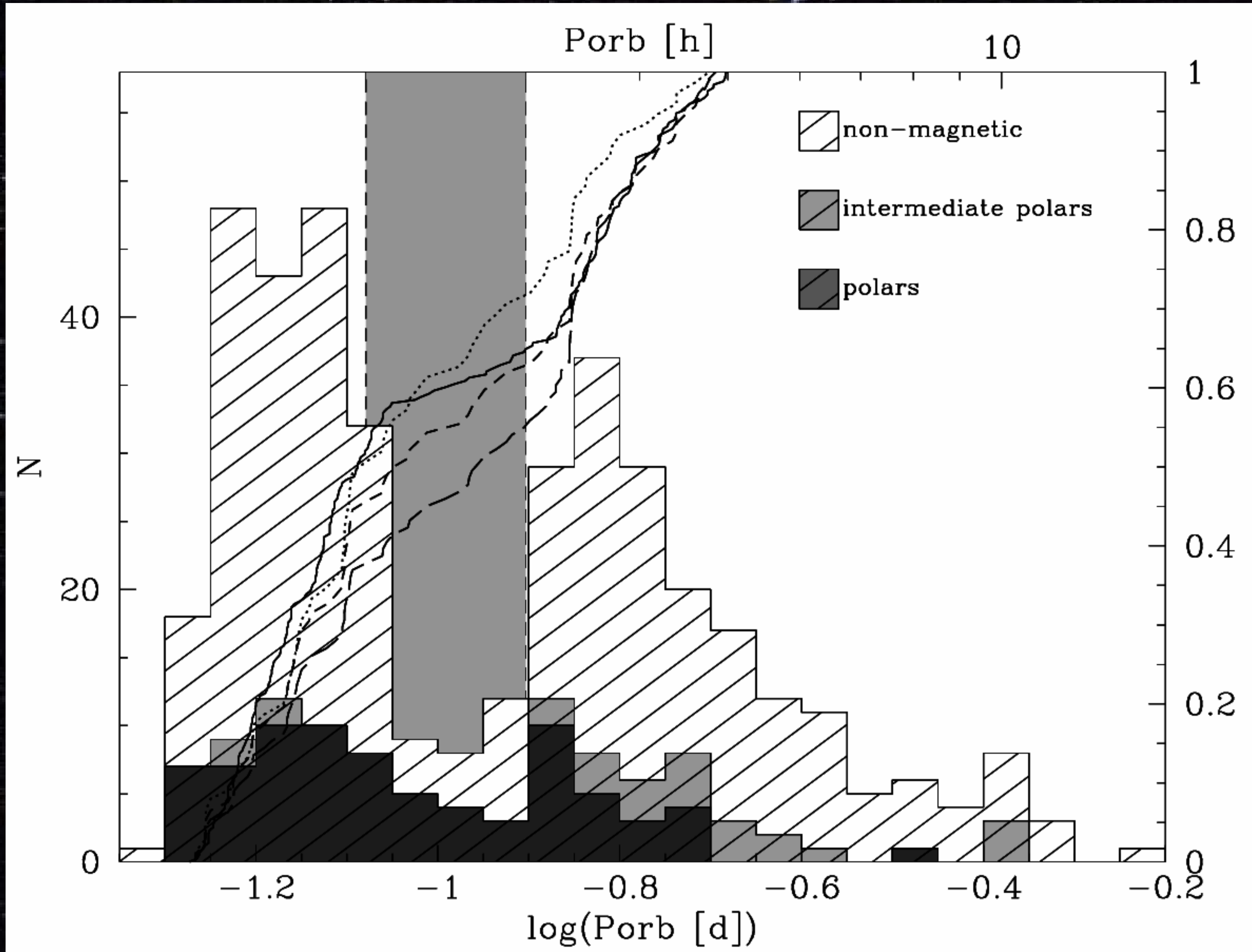
The Uncertain Fate of Cataclysmic Variable Stars and Related Systems

Jean-Pierre Lasota

Institut d'Astrophysique de Paris &
Astronomical Observatory Jagellonian University
& KITP

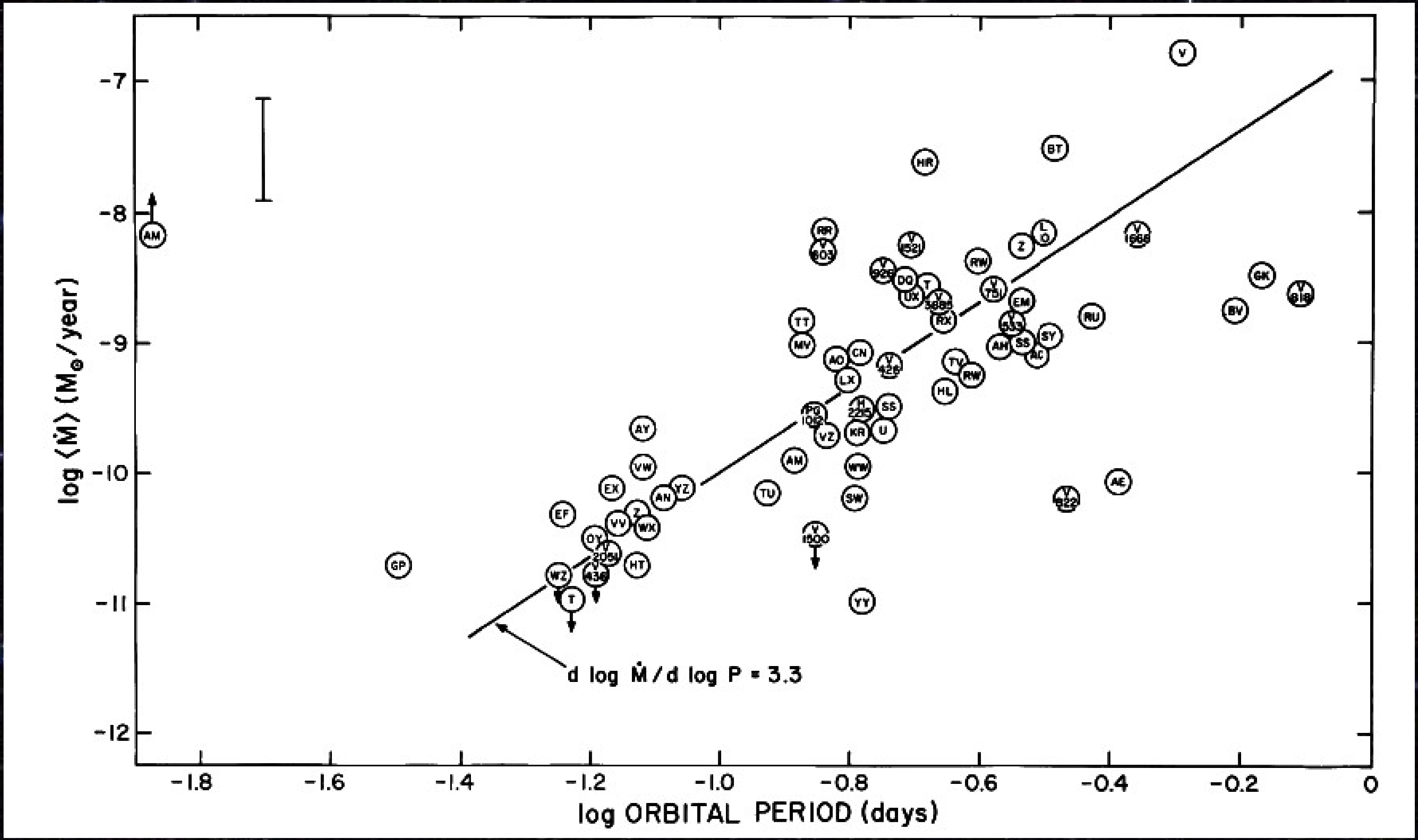


(Gaensicke 2005)

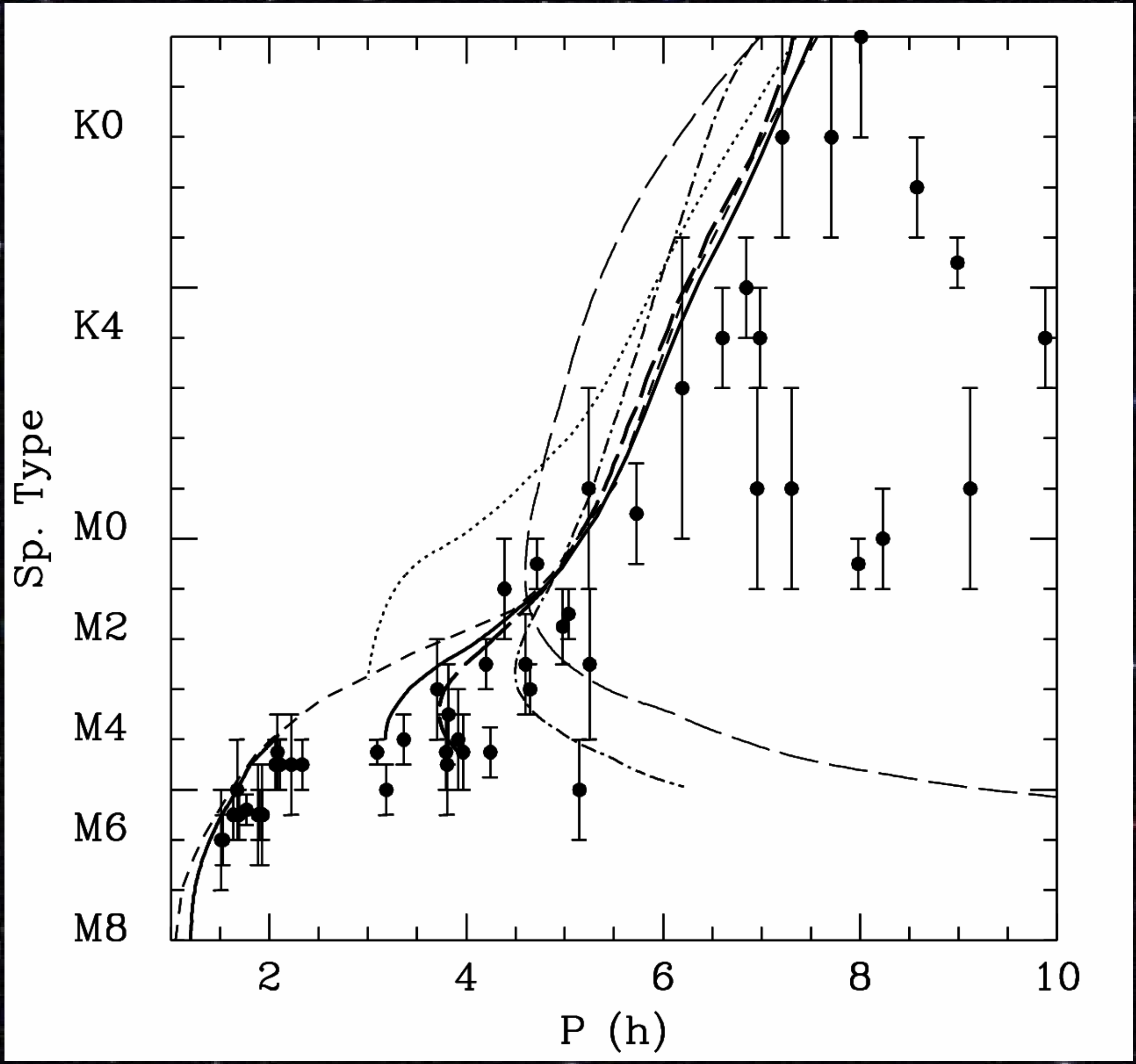


Dotted: polars, short-dashed: polars and intermediate polars (IPs), longdashed: polars, IPs and SWSex stars, solid: dwarf novae and novalike variables excluding SWSex stars

(Gaensicke 2005)



Patterson 1984



Baraffe & Kolb 2000

$$\frac{\dot{a}}{a} = \frac{2\dot{J}}{J} + \frac{2(-\dot{M}_2)}{M_2}\left(1 - \frac{M_2}{M_1}\right).$$

$$\frac{\dot{R}_L}{R_L} = \frac{2\dot{J}}{J} + \frac{2(-\dot{M}_2)}{M_2}\left(\frac{5}{6} - \frac{M_2}{M_1}\right)$$

Roche-lobe filling MS secondary $R_2 \propto M_2$; with $R_2 = R_L$

$$\frac{(-\dot{M}_2)}{M_2} = \frac{-\dot{J}/J}{4/3 - M_2/M_1}.$$

$$t_{\dot{M}} = \frac{M_2}{-\dot{M}_2}$$

According to the Virial theorem, Eth = - 0.5 Epot,grav ~ GM^2/R, so $\tau \sim GM^2/RL$

$$\tau_t \simeq 3.1 \times 10^7 \left(\frac{M}{M_\odot}\right)^2 \frac{R_\odot}{R} \frac{L_\odot}{L} \text{yr} \qquad = 3.1 \times 10^7 M^{-2} \text{ yr} \qquad (3)$$

$$L_2/L_\odot \simeq m_2^{3.5}$$

$$t_{KH} \simeq 1.5 \times 10^9 (P_h/2)^{-2.5} \text{ yr}$$

$$-\dot{M}_2 = \dot{M}_{GR} \simeq 10^{-10} \left(\frac{P_h}{2}\right)^{-\frac{2}{3}} M_\odot \text{yr}^{-1}$$

$$t_{\dot{M}} \simeq 2 \times 10^9 (P_h/2)^{\frac{5}{3}} \text{ yr}$$

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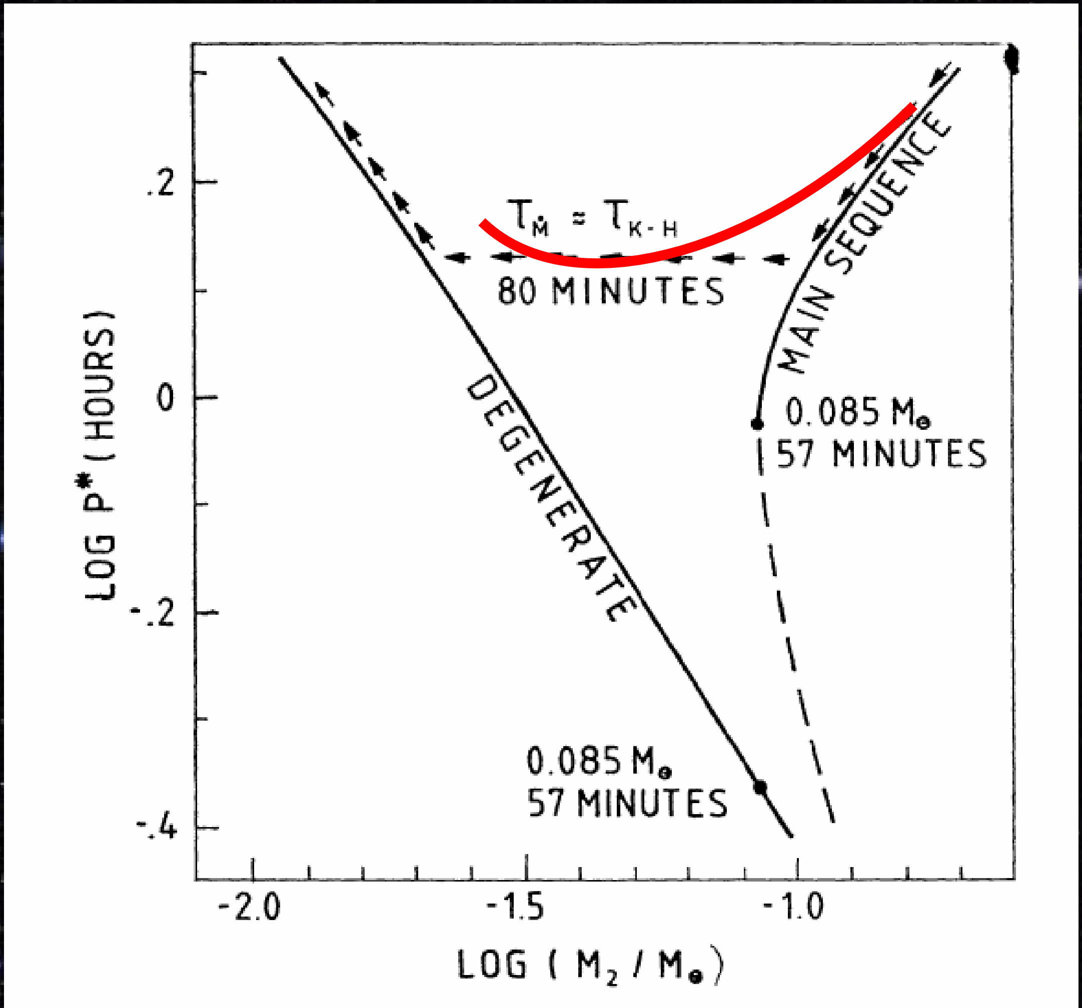
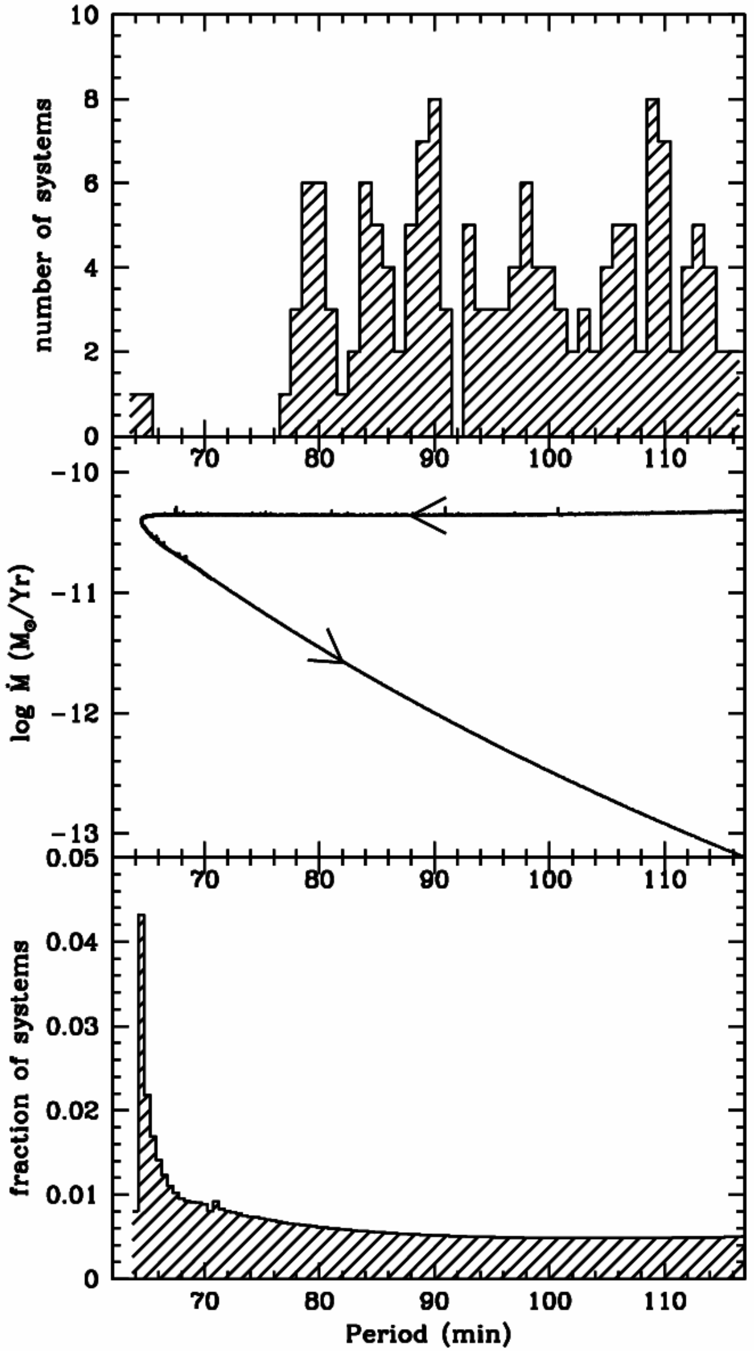
$t_{KH} \sim t_{\dot{M}}$ for $P_{orb} \sim 1.5h$

Minimum period



Paczyński 1981



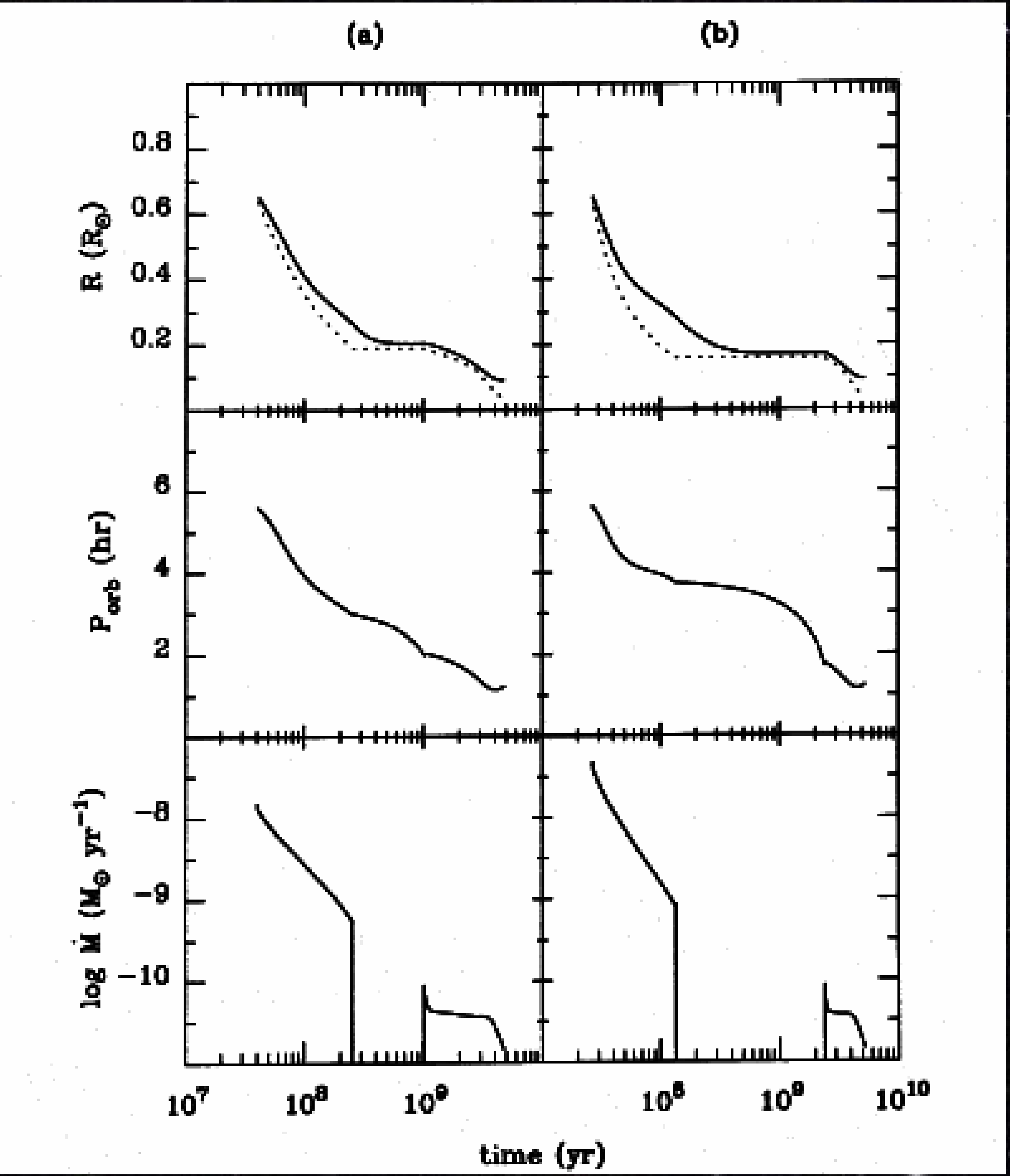
Barker & Kolb 2003

The standard model of CV evolution

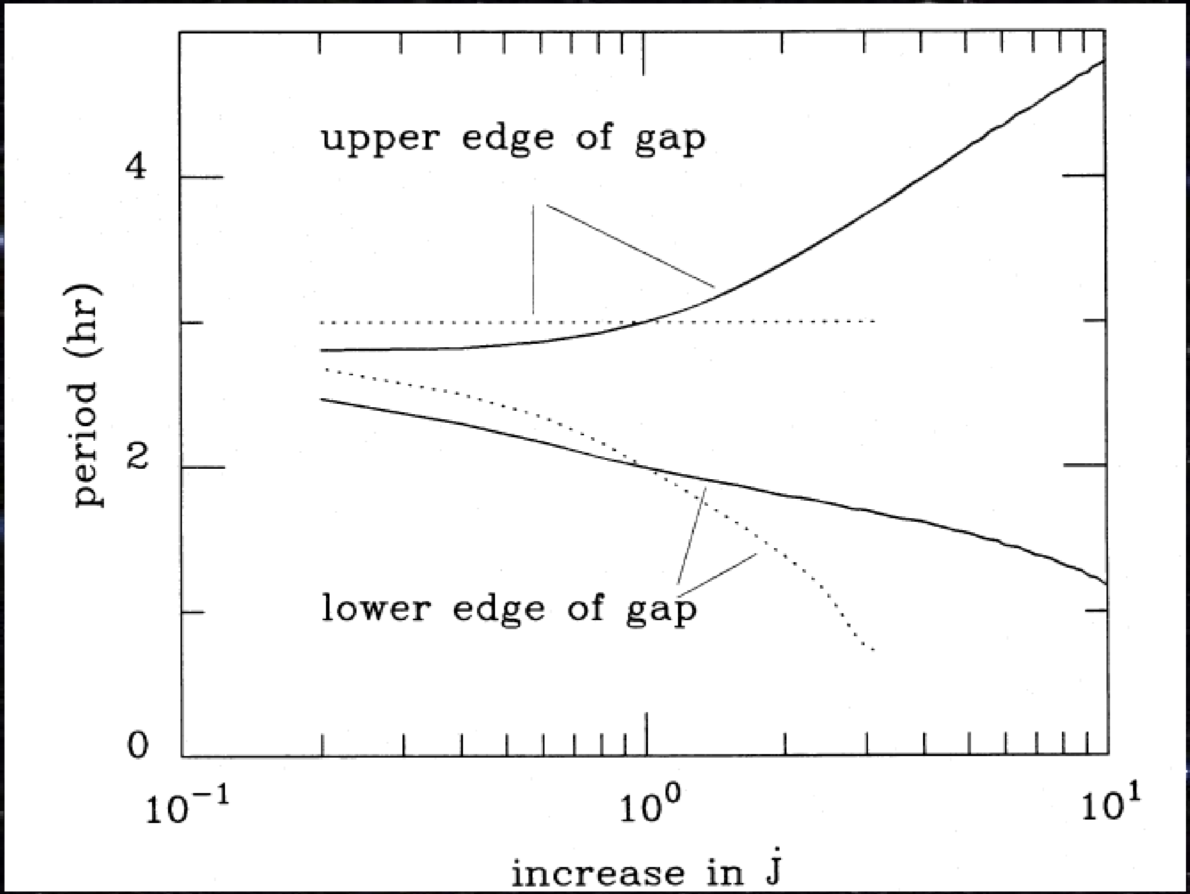
Interrupted Magnetic Braking:

MB switched off when secondary fully convective

Skumanich law: $\dot{J} \sim \Omega^3$

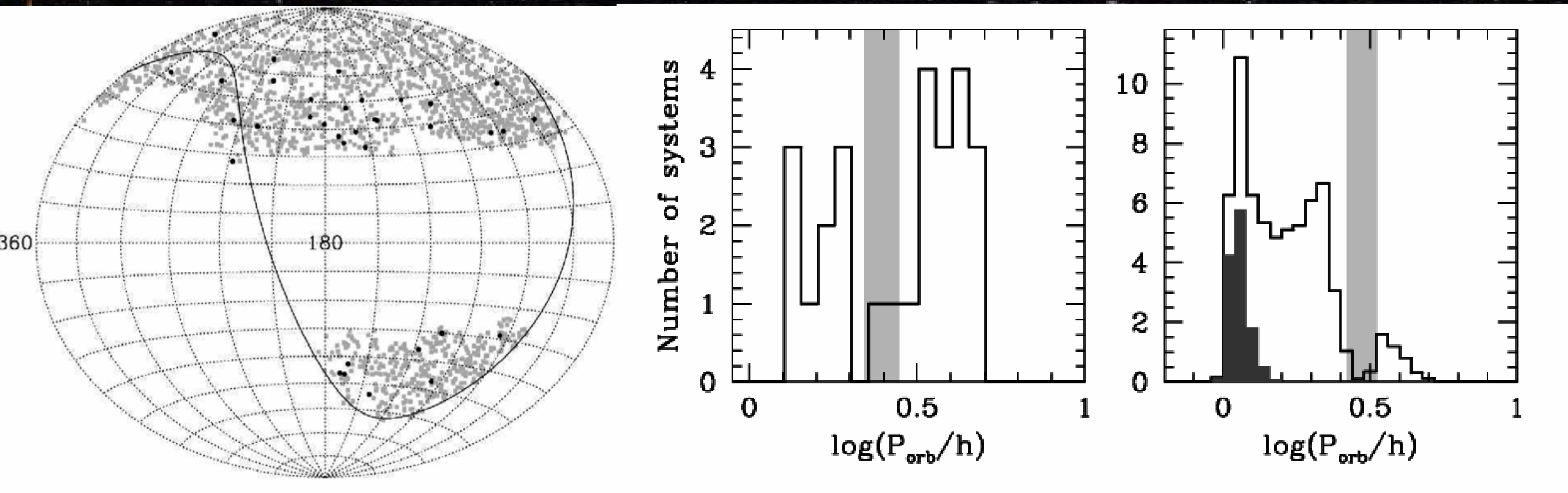


Hameury et al. 1987



Hameury et al. 1987

The PG CV test

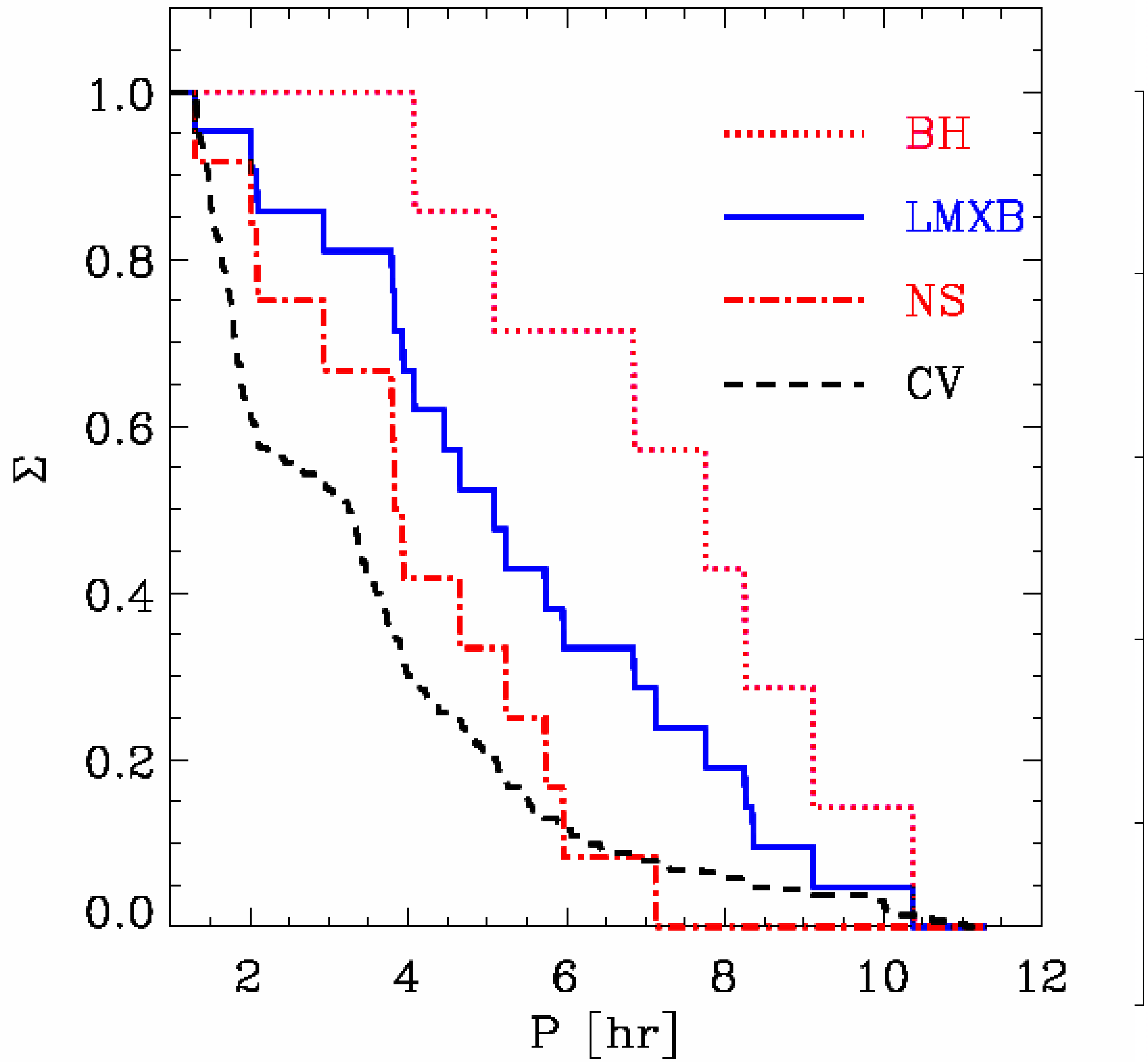


(vii) A simulation of the selection effects present in the PG CV sample shows that observational biases are not sufficient to reconcile the intrinsic population predicted by standard CV evolution theory (with strong magnetic braking above the period gap) with the observed PG sample. The real intrinsic CV population cannot contain as large a fraction of short-period systems (and, specifically, period bouncers) as is predicted by theory.

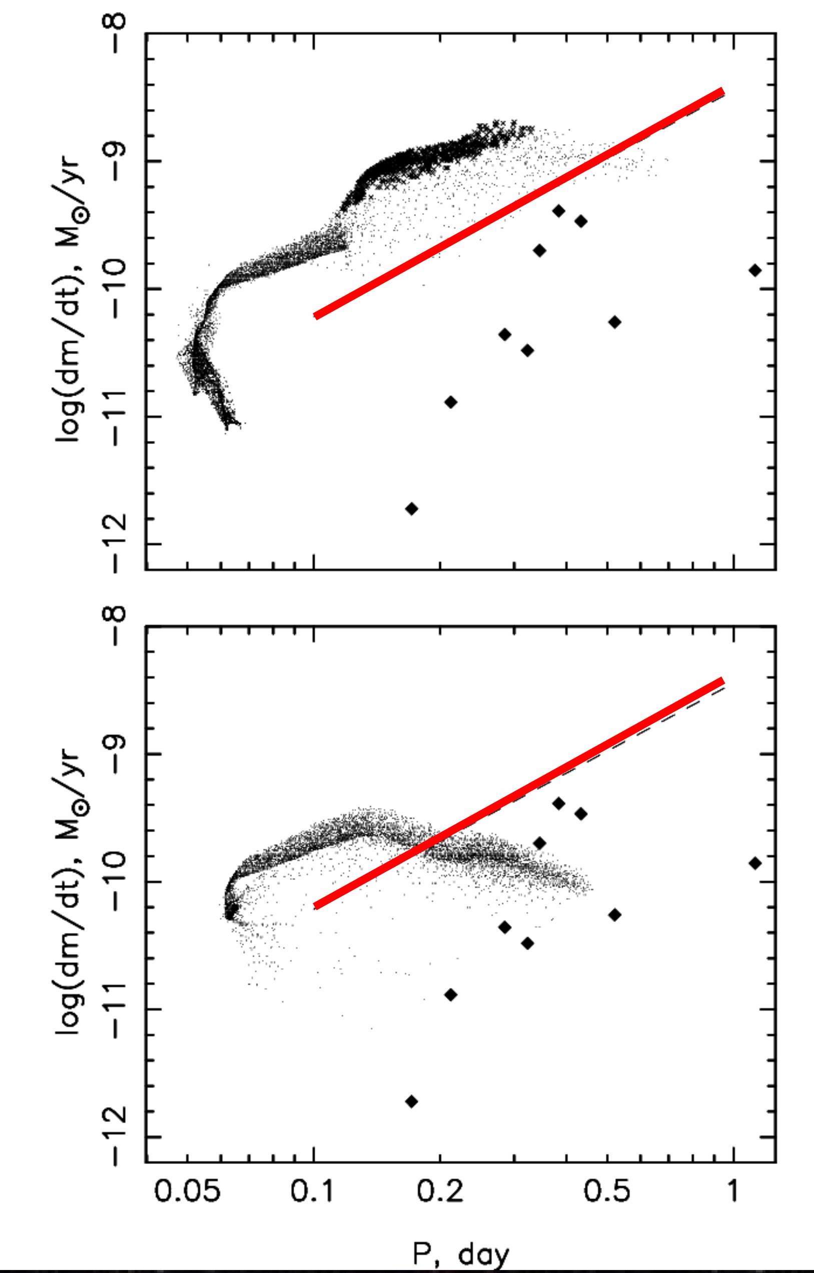
Pretorius et al. 2007

Black Holes
Neutron Stars

N



Orbital Period (day)

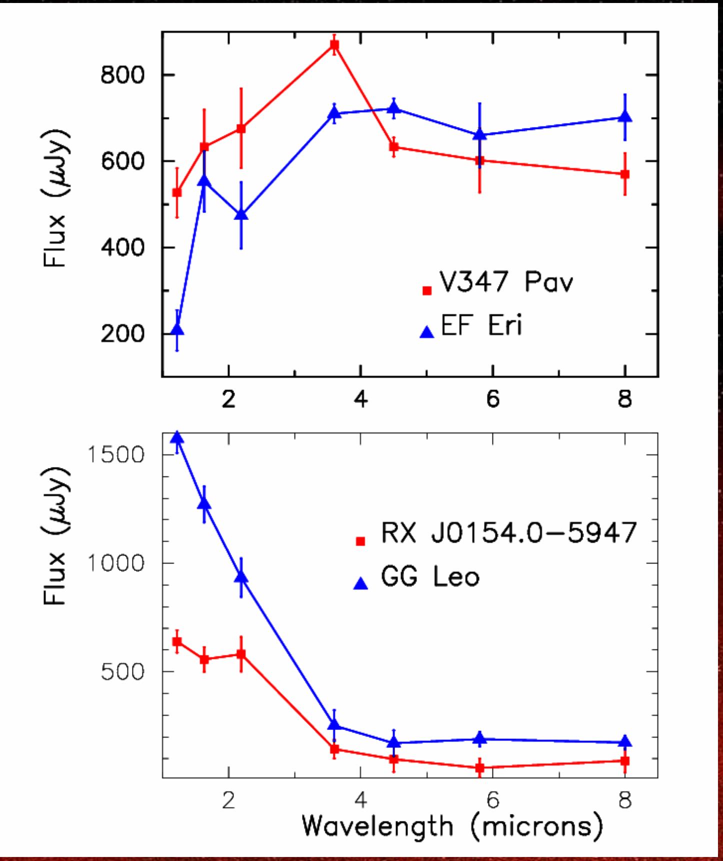


With MB

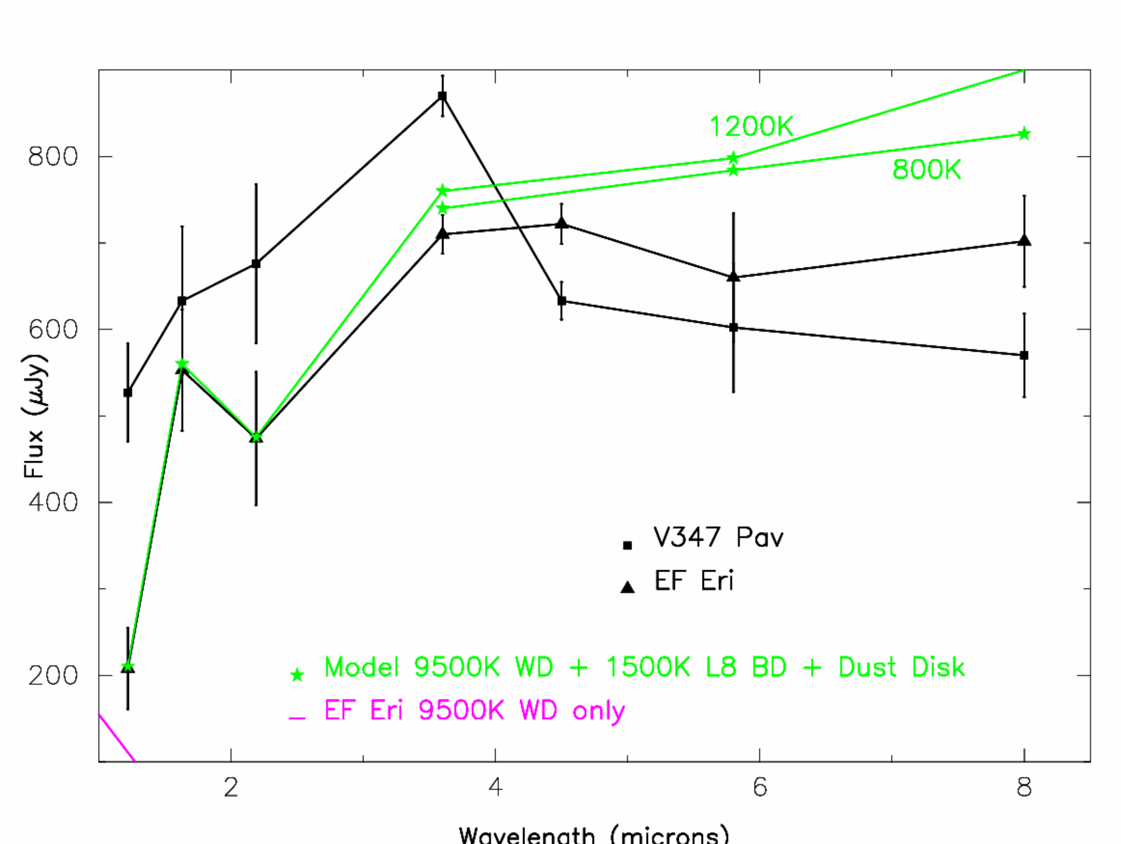
Without MB

Yungelson et al. 2006

Circumbinary discs



Howell et al. 2006



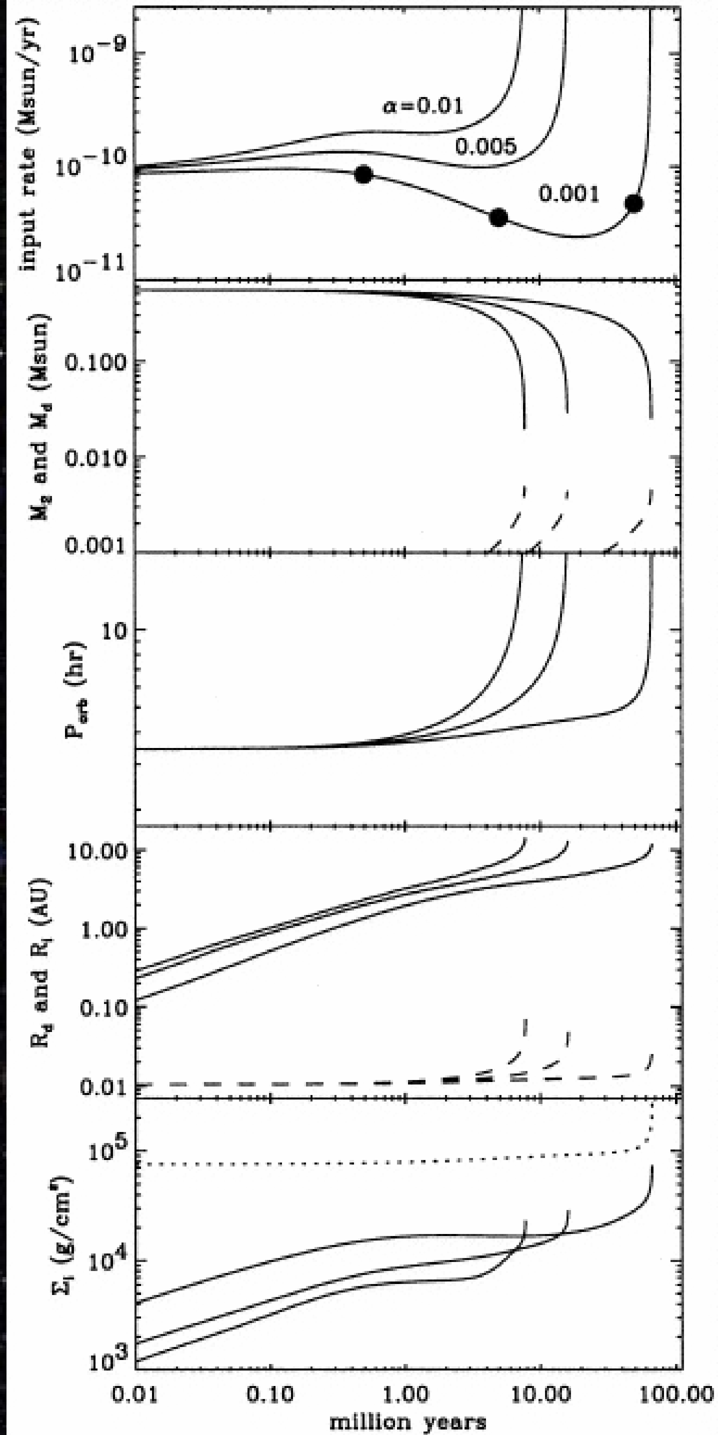
The CB disc provides an additional ("consequential") sink of orbital angular momentum

$$\dot{J}_d = 3\pi (R_i/a)^{1/2} \Omega_0 a^2 \nu_i \Sigma_i$$

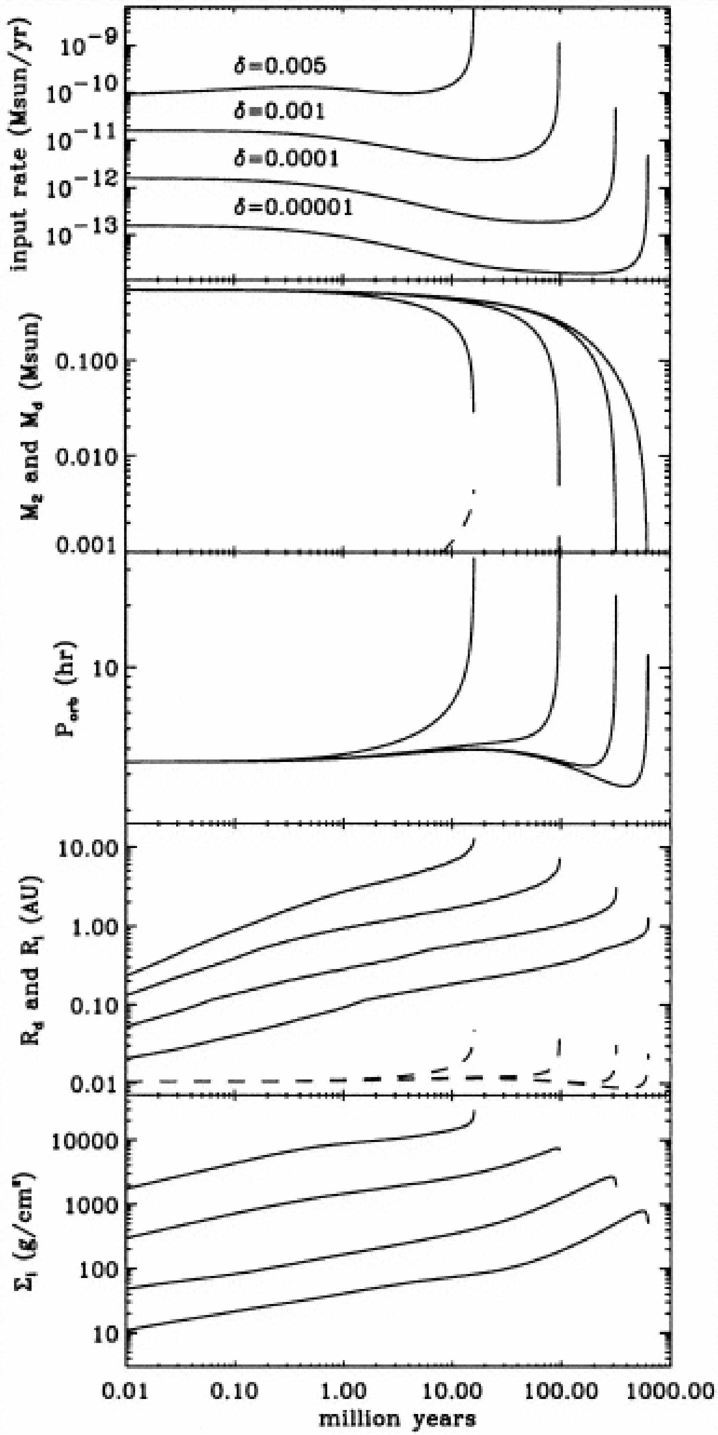
$$-\dot{J}/J = t_w^{-1} + 3\pi (R_i/a)^{1/2} (1+q)/M_2 \nu_i \Sigma_i$$

$\Sigma_i(M_i)$ – column density in the CB disc

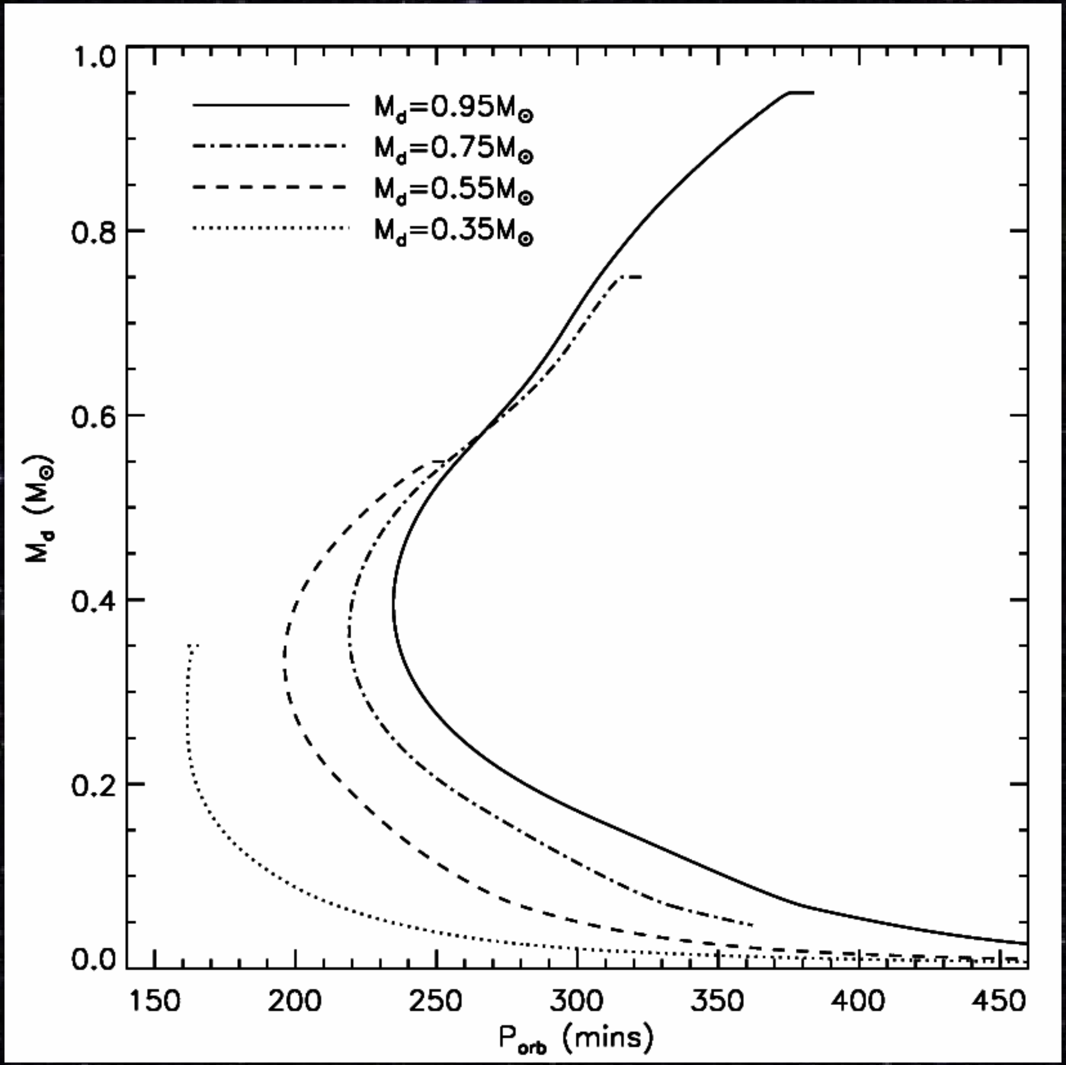
$\dot{M}_i = \delta \dot{M}_2$; $\nu = \alpha c_s^2 H$



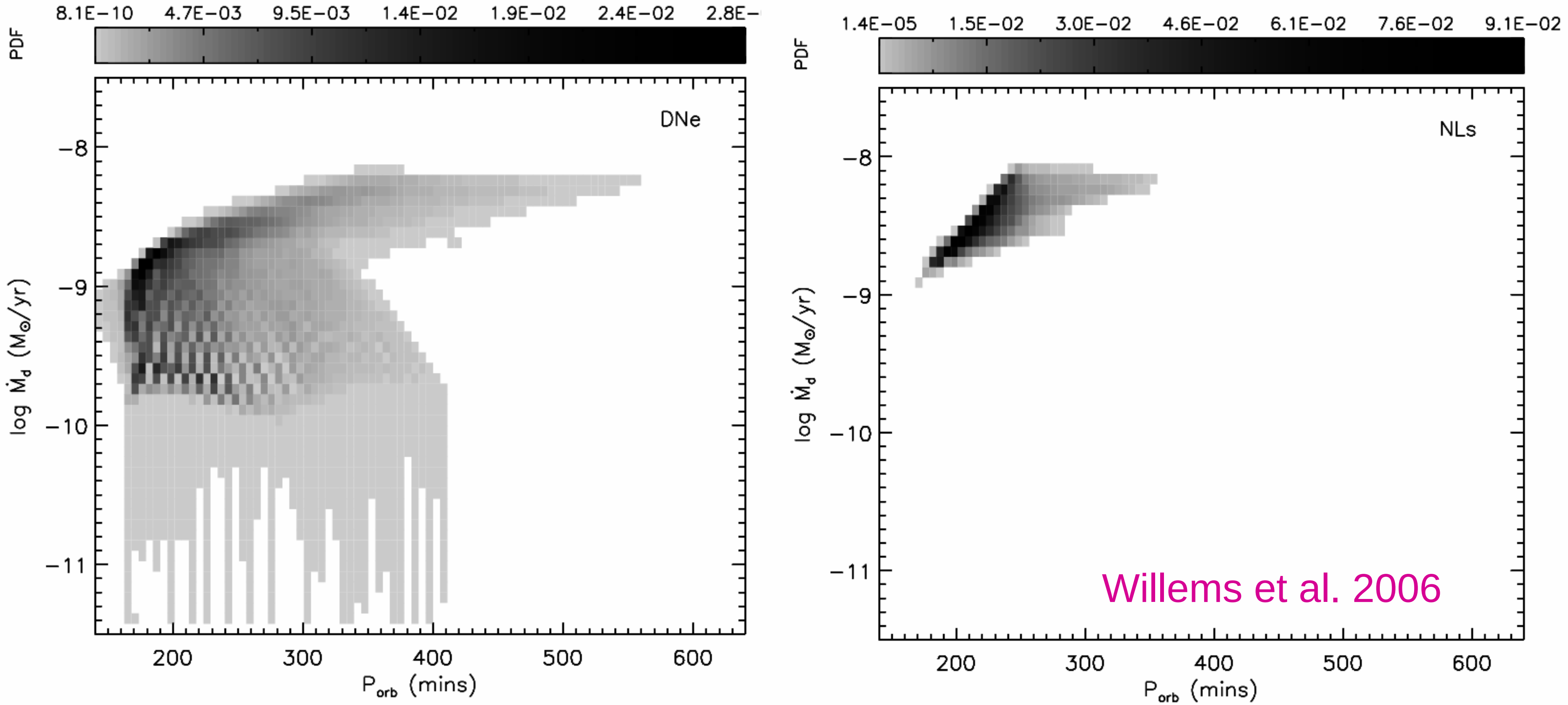
Dubus et al. 2002

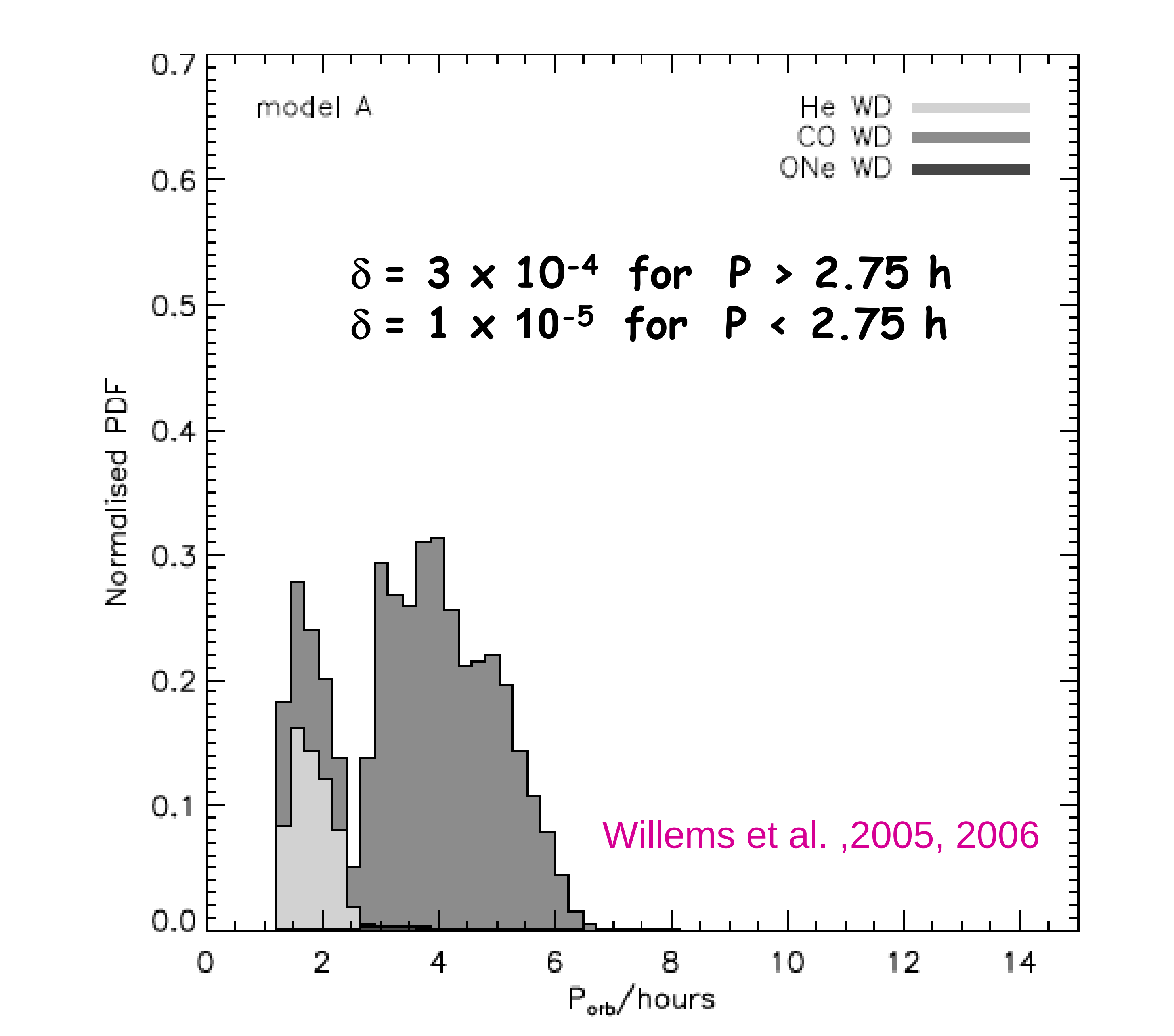


Dubus et al. 2002

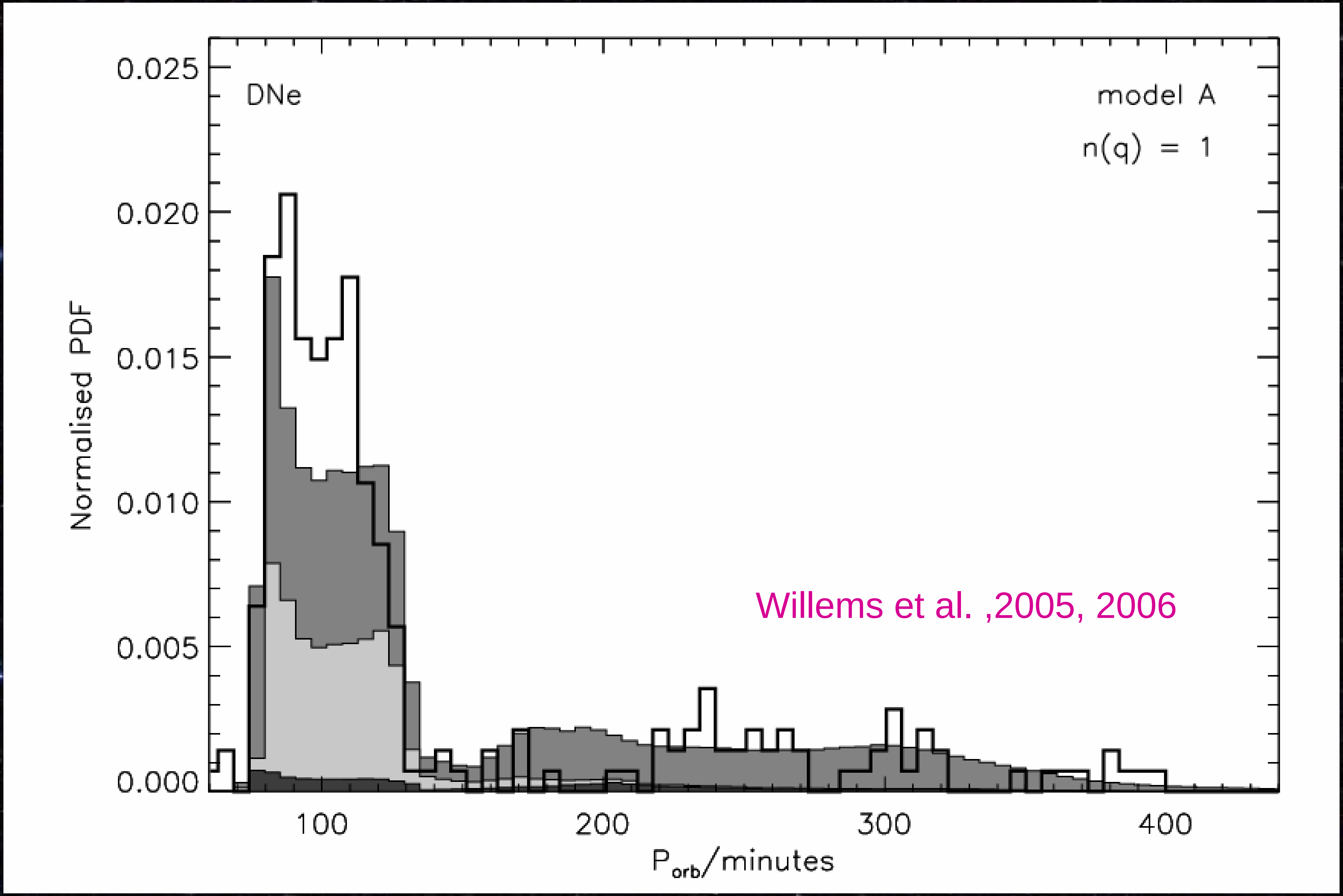


Willems et al. 2005, 2006


PDF
8.1E−10 4.7E−03 9.5E−03 1.4E−02 1.9E−02 2.4E−02 2.8E−
DNe
log $\dot{M}_d$ ($M_\odot$/yr)
−8
−9
−10
−11
200 300 400 500 600
P_{orb} (mins)
PDF
1.4E−05 1.5E−02 3.0E−02 4.6E−02 6.1E−02 7.6E−02 9.1E−02
NLs
log $\dot{M}_d$ ($M_\odot$/yr)
−8
−9
−10
−11
200 300 400 500 600
P_{orb} (mins)
Willems et al. 2006



model A
He WD
CO WD
ONe WD
$\delta = 3 \times 10^{-4}$ for P > 2.75 h
$\delta = 1 \times 10^{-5}$ for P < 2.75 h
Willems et al. ,2005, 2006
Normalised PDF
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
2
4
6
8
10
12
14
P_{orb}/hours


0.025
0.020
0.015
0.010
0.005
0.000
Normalised PDF
DNe
model A
n(q) = 1
Willems et al. ,2005, 2006
100
200
300
400
P_orb/minutes

Conclusions

- The standard model does not work
- "Improving" the MB mechanism is not a solution
- CB disks might be the solution
- ???