# An ultra-massive, fast-spinning white dwarf in a peculiar binary system

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**An Ultramassive, Fast-Spinning White Dwarf in a Peculiar Binary System**
S. Mereghetti, *et al.*
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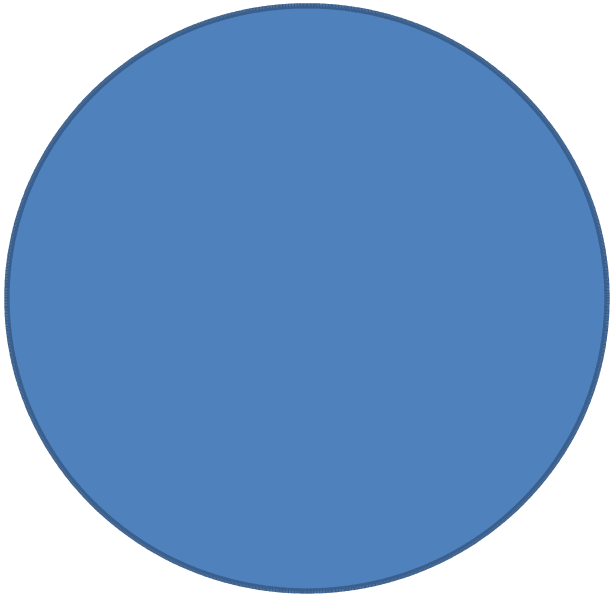
1) INAF – IASF MILANO
2) INAF Oss. Astron. ROMA

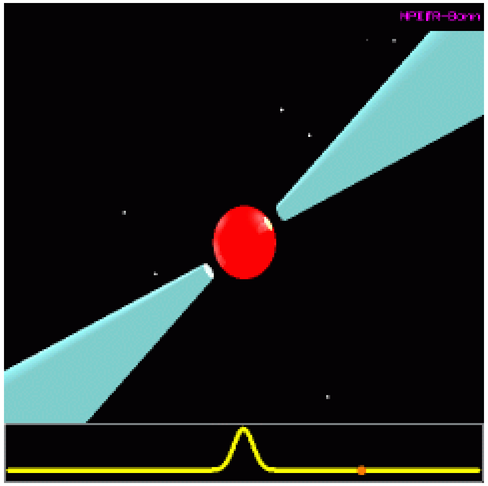
# A peculiar X-ray binary

## HD 49798



Hot subdwarf
(sdO type )
B = 8 mag

## RX J0648-4418



X-ray pulsar
P = 13.2 s

$P_{orb}$ = 1.5 days

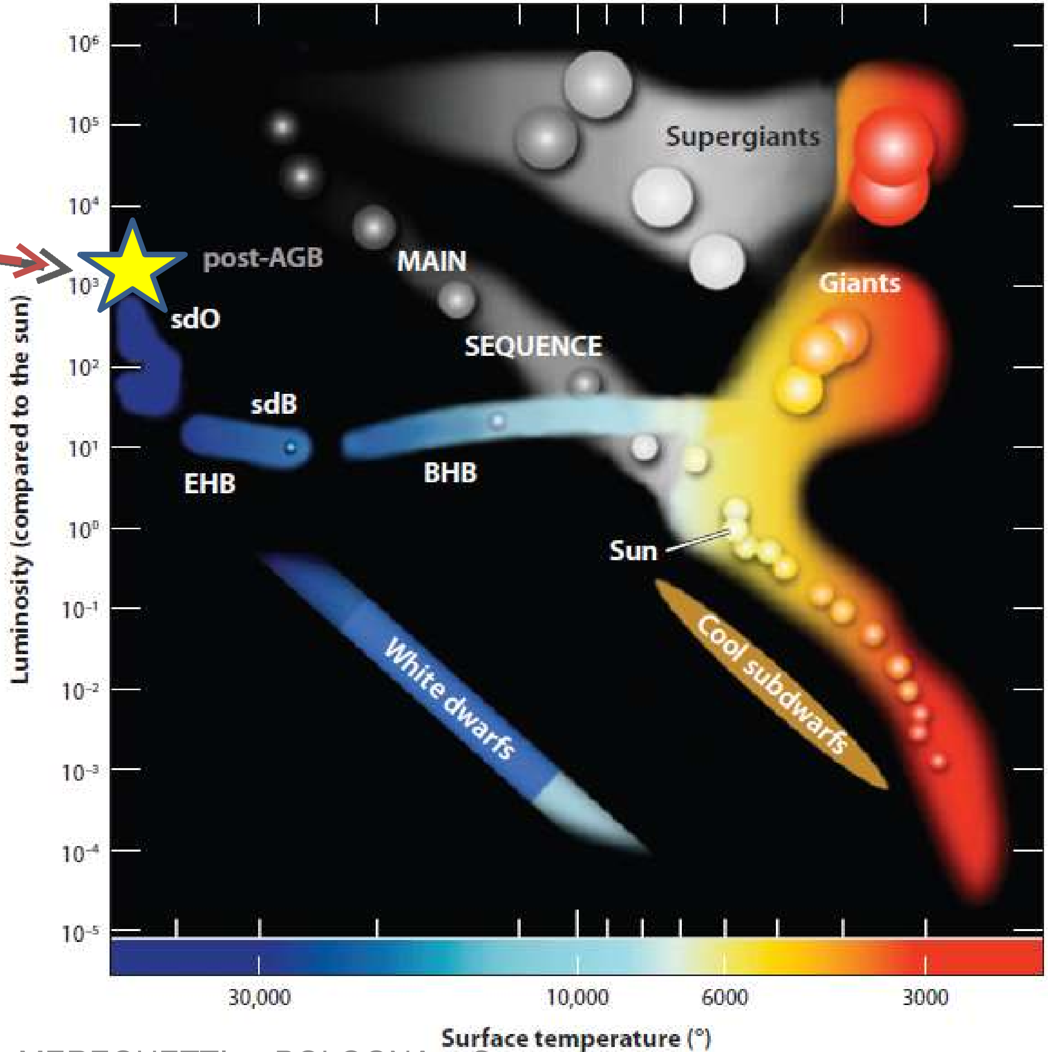
(Israel et al. 1997)

# Hot subdwarf stars

**Heber 2009, ARAA**

HD 49798

T = 47,500 K
L ~ $10^4$ L sun



# HD 49798

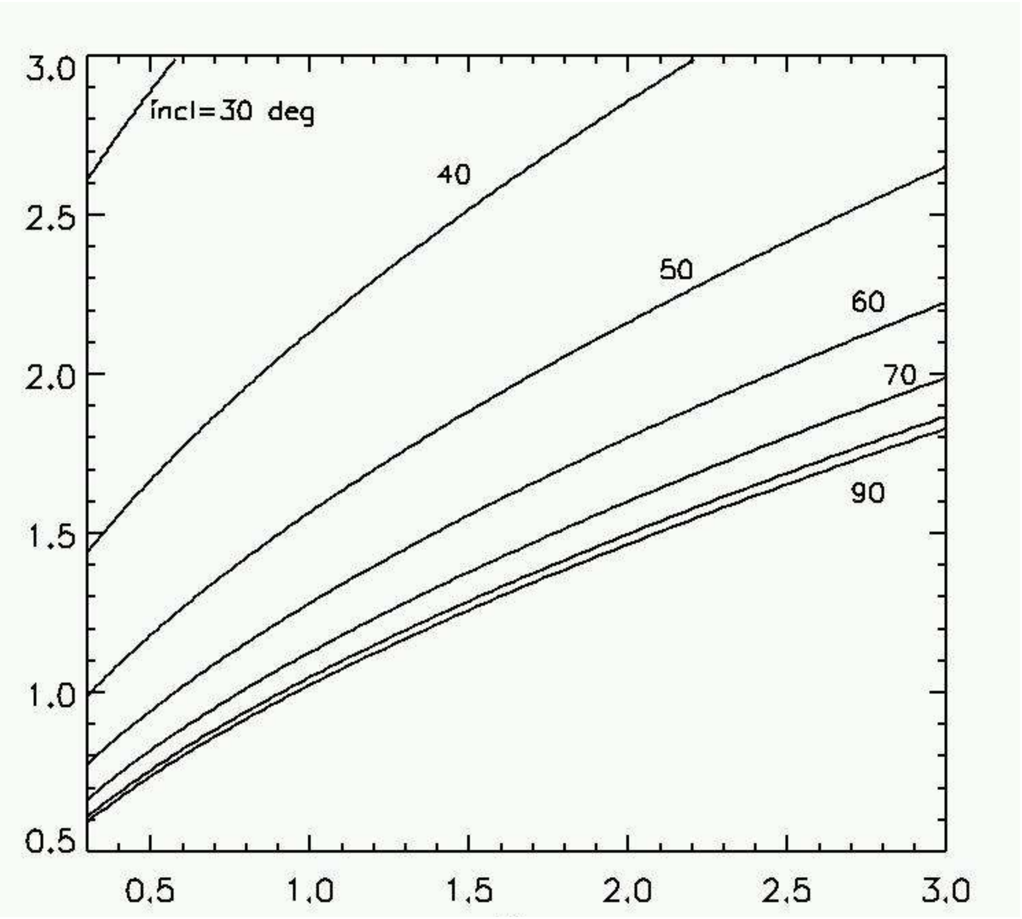
- the brightest sdO → well studied single-lined spectroscopic binary
- Hydrogen poor, Helium rich
- $P_{orb}$ = 1.5476632(32) days
- circular orbit
- Optical mass function 0.263 +/- 0.004 Msun

Thackeray 1970
Hamann et al. 1981
Stickland & Lloyd 1984

Kudritzky et al. 1978
Bruhweiler et al. 1981
Bisscheroux et al. 1997

# Optical mass function

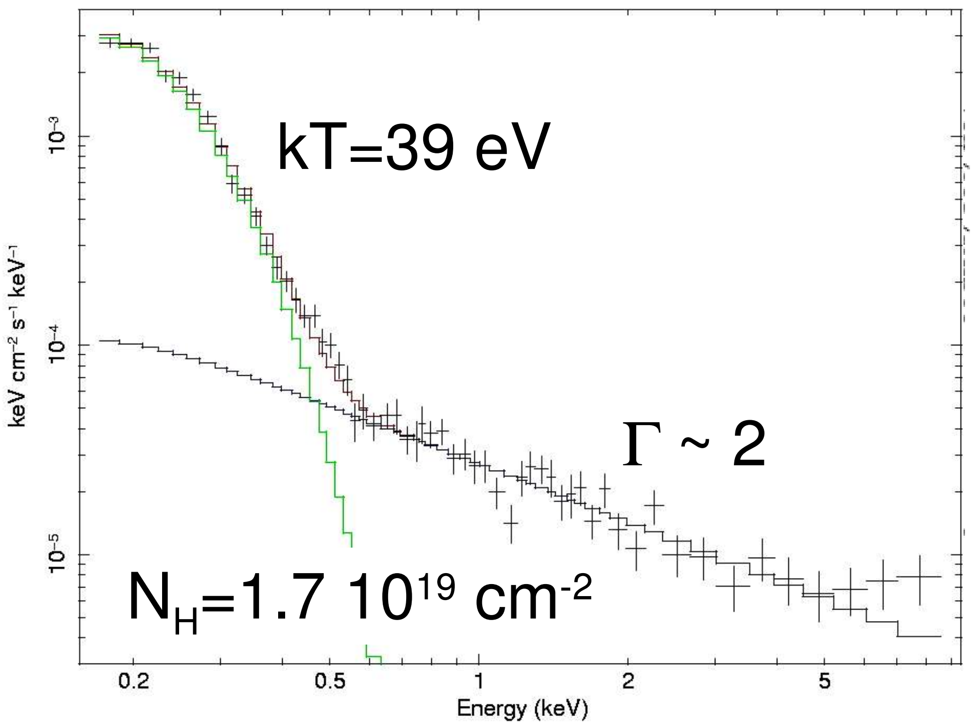
X-ray pulsar mass

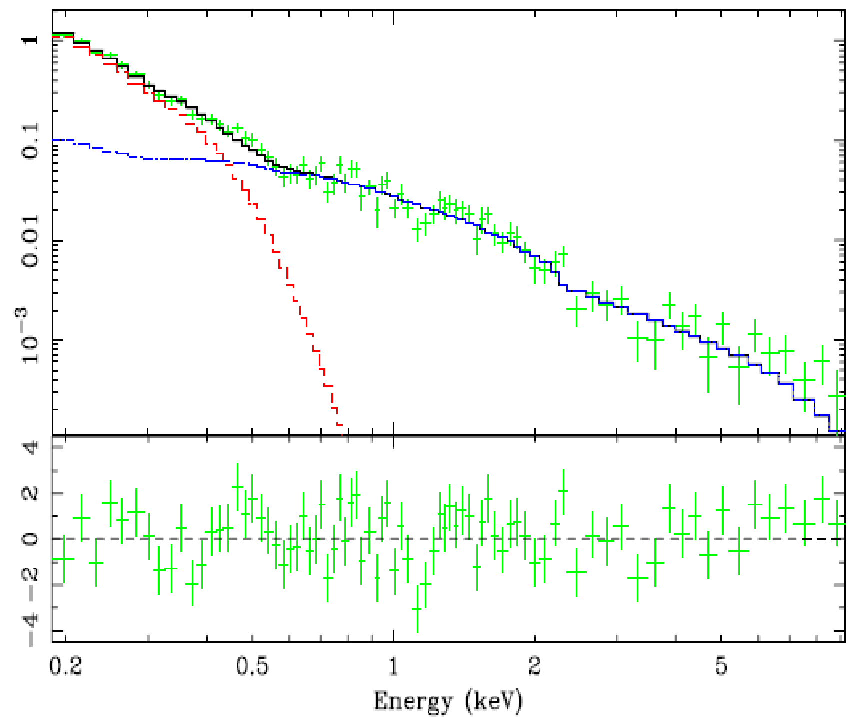



Companion mass

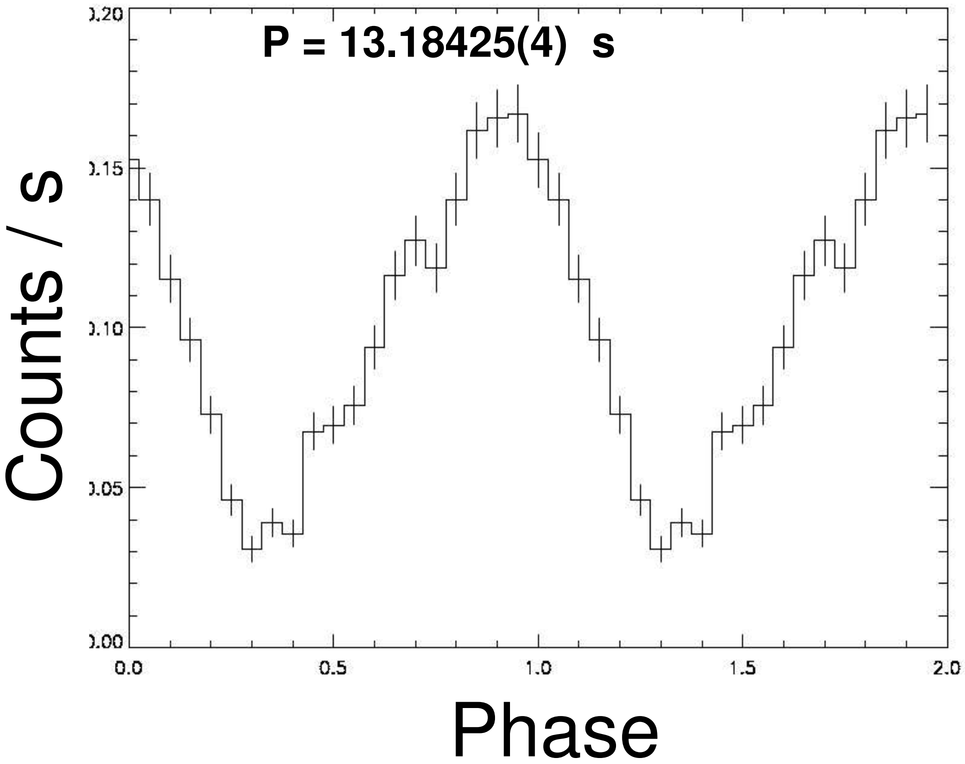
# XMM-Newton results: spectroscopy

- 44 ks observation on May 10, 2008
- BB + PL spectrum
- $L_X = 2\ 10^{31}$ erg/s @ 650 pc (0.2-10 keV) → WD

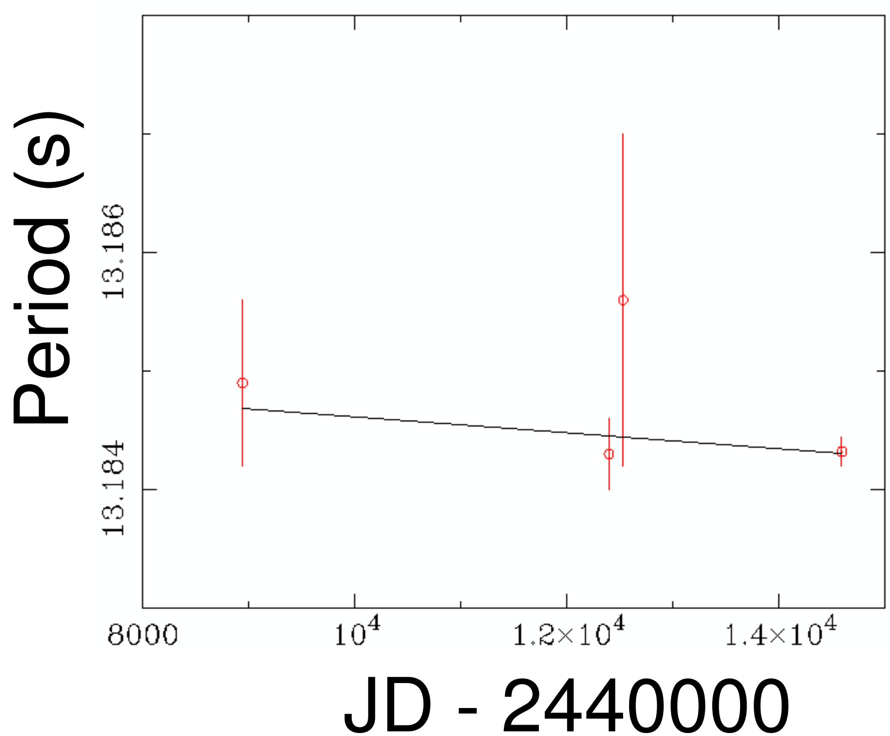


# XMM-Newton results: timing



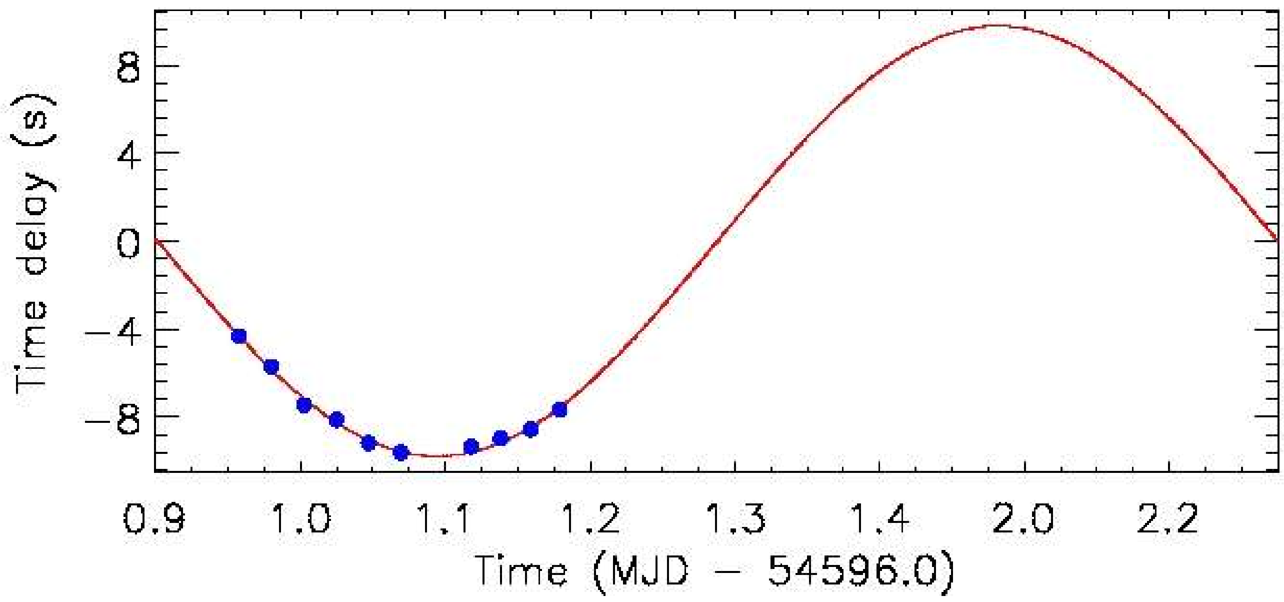

**$dP/dt < 4\ 10^{-13}$ s/s**




**Pulsed fraction 62%**

**(0.14-0.4 keV)**

# Time delays in X-ray pulses



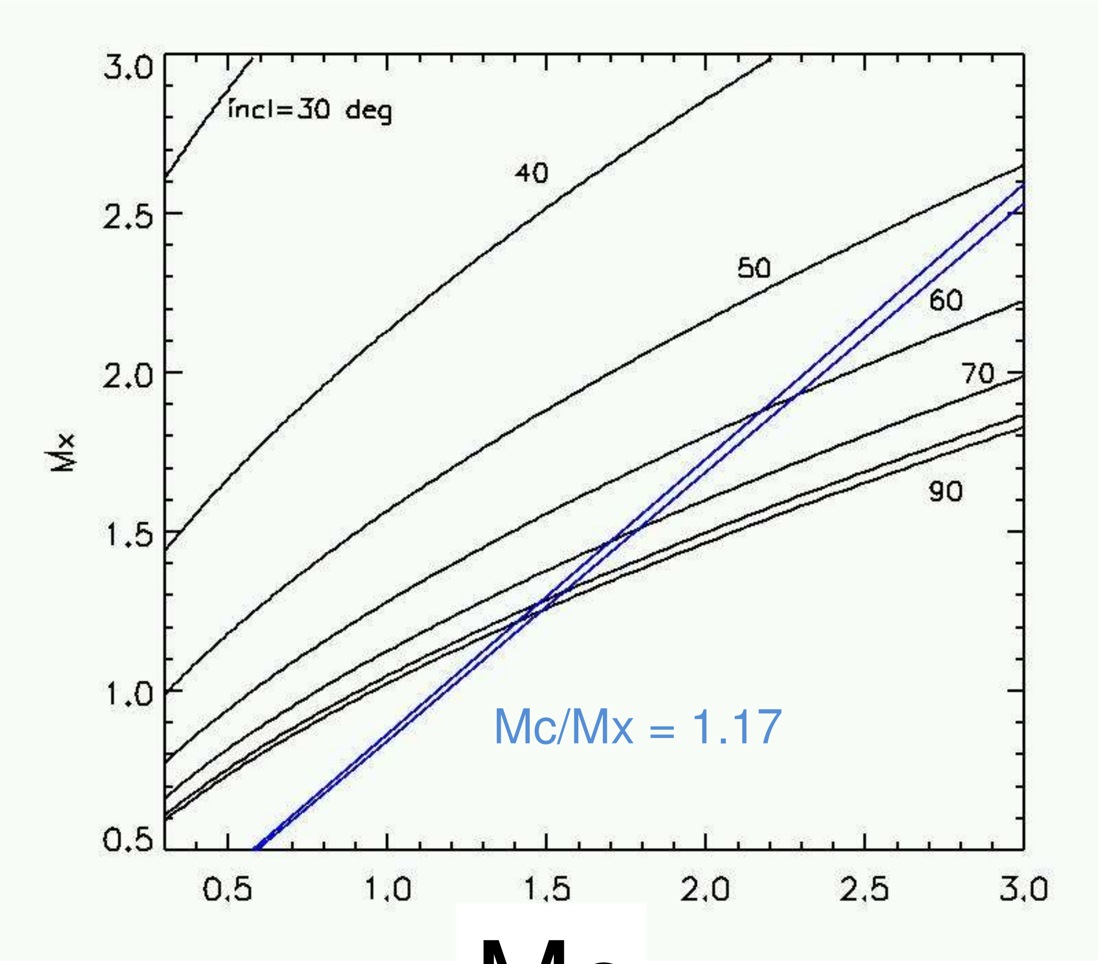

- X-ray projected semi major-axis :

Ax sini = 9.78 +/- 0.06 light-sec

\+ opt. mass funct. → q = Mc/Mx = 1.17 +/- 0.01

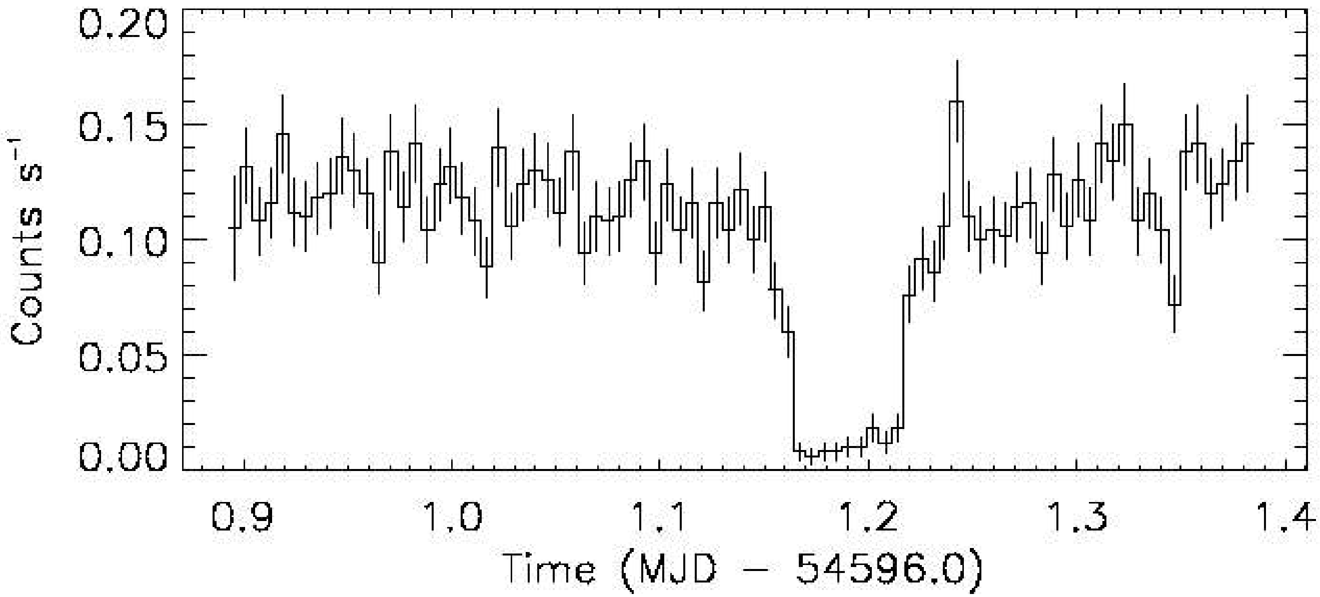
# Optical + X-ray mass functions

Mx




Mc

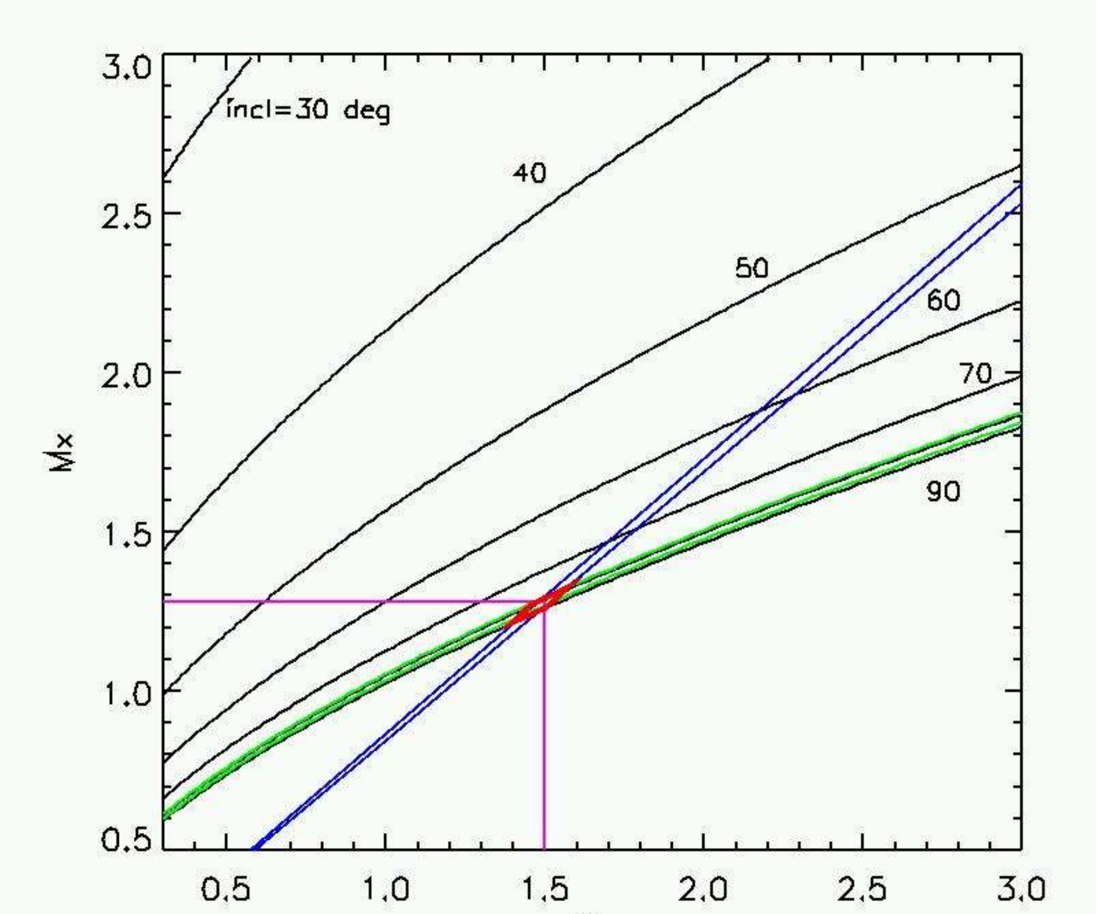
# Discovery of X-ray eclipse




$$(R_C/a)^2 = \cos^2 i + \sin^2 i \sin^2 \Theta$$

- Eclipse duration = 1.3 hours
- Radius of HD 49798 = 1.45+/-0.25 Rsun
- → inclination 79—84 degrees

# Opt. and X-ray m.f. + inclination



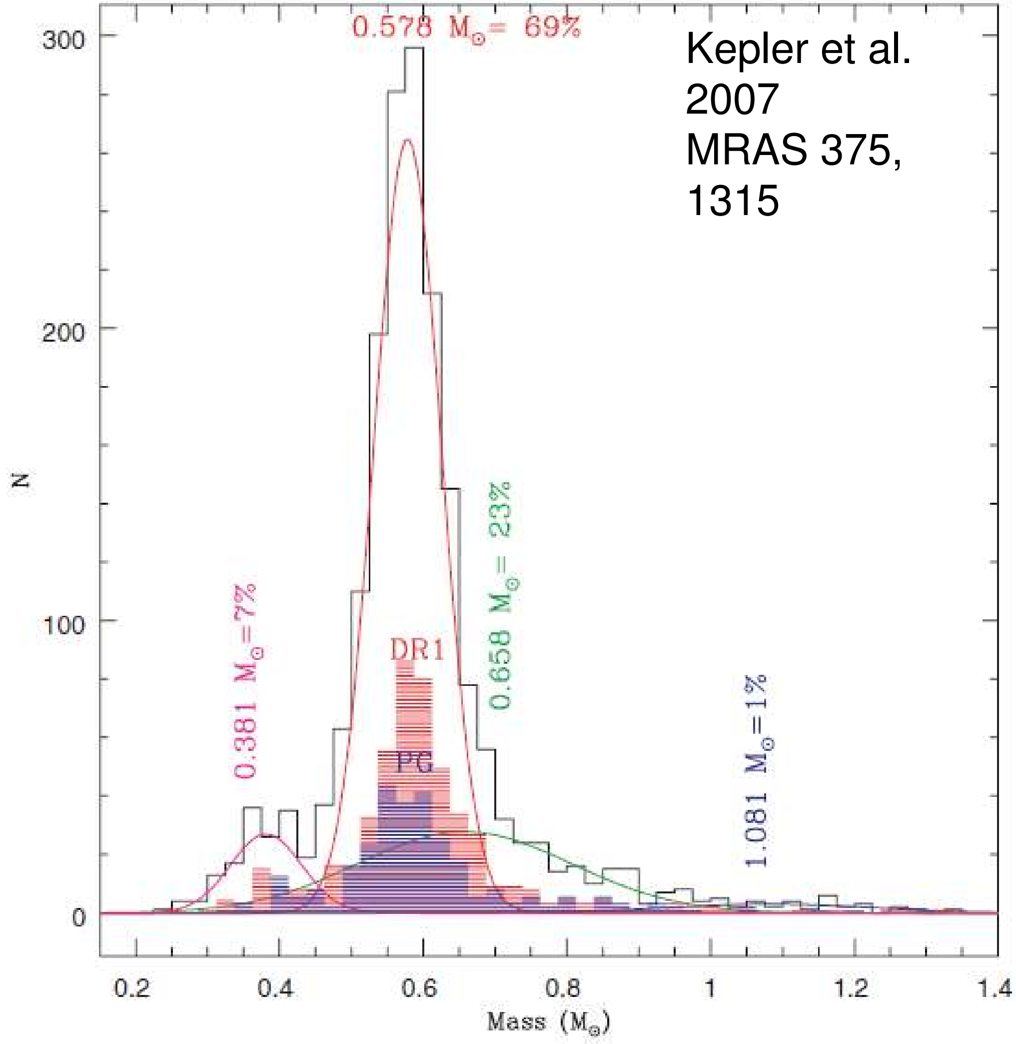

**Mx = 1.28 Msun**

**Mc = 1.5 Msun**

RX J0648-4418 is an ultra-massive white dwarf

$M_{wd}$ = 1.28 +/- 0.05 $M_{sun}$

# White Dwarf masses



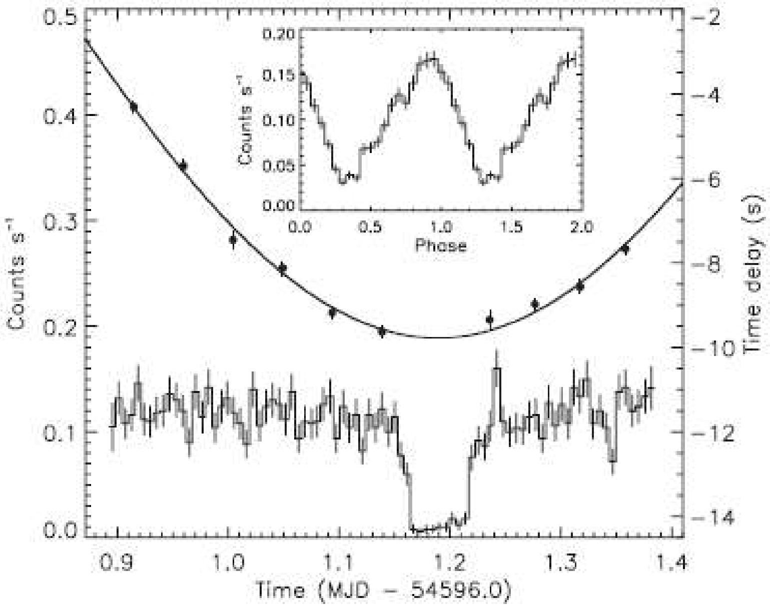

Kepler et al. 2007
MRAS 375, 1315

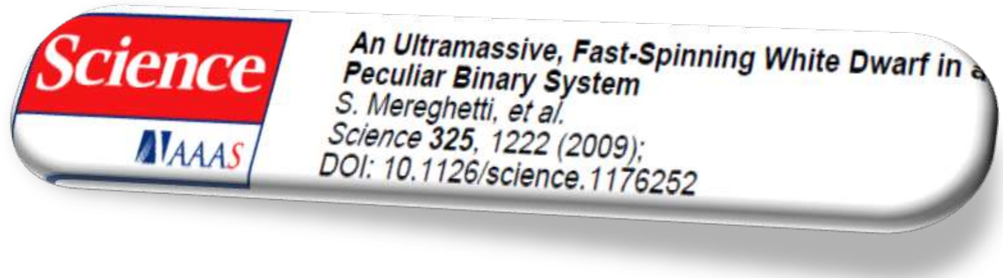
# RX J0648-4418 is an ultra-massive white dwarf

$$M_{wd} = 1.28 +/- 0.05 \ M_{sun}$$

Dynamical measurement → Robust, ''assumptions-free" result
→ not dependent on Mass-Radius relation

Most WD masses are derived indirectly:
spectroscopic and photometric methods → L, T, log g → $M/R^2$
gravitational redshift → M/R
and rely on M-R relation to finally get M


Counts s⁻¹
Time delay (s)
Time (MJD − 54596.0)
Counts s⁻¹
Phase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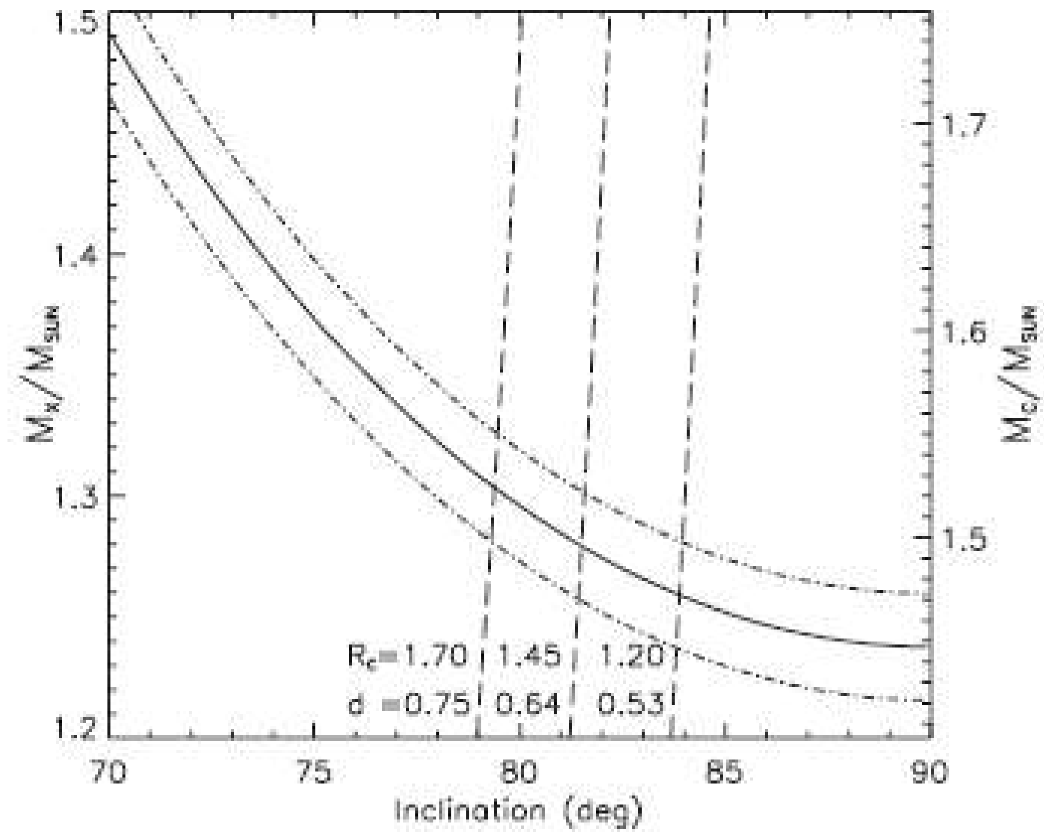
$M_X/M_{SUN}$
$M_C/M_{SUN}$
$R_c$=1.70 1.45 1.20
d =0.75 0.64 0.53
Inclination (deg)

# Ramifications

- Type Ia SN progenitors
- Common Envelope evolution
- Initial / Final mass relation
- Origin of O-type subdwarfs
- White dwarfs equation of state
- Effects of fast rotation
- Magnetic fields of white dwarfs
- Accretion physics
- …???...

# Conclusions

- First robust, model-independent determination of M > 1.2 Msun for an accreting white dwarf
- This is also the fastest spinning WD (P=13.2 s) → low B to avoid propeller
- High M, short P, and low B could be the result of the past accretion history → a WD analogue of recycled pulsars in LMXB?
- Post Common Envelope binary with well determined masses → optimal test-bench for evolutionary models
- especially relevant as possible SN Ia progenitor