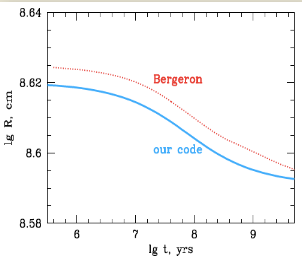
FIRST EVIDENCE FOR A YOUNG, CONTRACTING WHITE DWARF

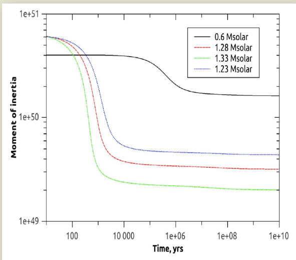
S.Mereghetti[1], S.B.Popov[2], F.Pintore[1], S.I.Blinnikov[2,3], A.G.Kuranov[2], L.R.Yungelson[4], P.Esposito[1], N.La Palombara[1], A.Tiengo[5,1], G.L.Israel[6], L.Stella[6]

(1) INAF-IASF Milano, Italy (2) Sternberg Astron. Institute Moscow, Russia (3) ITEP Moscow, Russia
(4) Russian Academy of Science Moscow, Russia (5) IUSS Pavia, Italy (6) INAF-Osservatorio Astronomico di Roma, Italy

SUMMARY

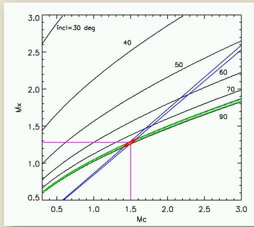
White dwarfs undergo a significant ontraction during the first few million years of their life, but no observational evidence of this has been found up to now.
We discovered a long term spin-up of the white dwarf in the binary system HD 49798/RX J0648.0—4418 (Mereghetti et al. 2016). This is too large to be produced by accretion torques, but it is well explained by the decrease in moment of inertia caused by the contraction of a young white dwarf with age of ~ 2 Myrs (Popov et al. 2017).





A UNIQUE X-RAY BINARY

HD 49798/RX J0648.0—4418 is a single-line spectroscopic binary (P_{ORB}=1.55 days) composed by the brightest known hot subdwarf of O spectral type (V=8, L=10^4 $L_\odot$) and a very soft X-ray source with spin period P=13.2 s (Israel et al. 1997).
The masses of the two components have been accurately determined through the optical and X-ray mass functions, and the system inclination from the eclipse duration:

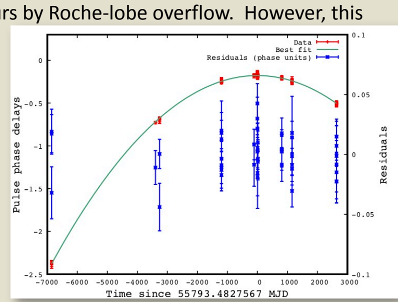


HD 49798 mass = 1.50+/-0.05 $M_\odot$
Companion mass = 1.28+/-0.05 $M_\odot$

Although the mass of the compact companion is compatible with both a neutron star and a WD, the X-ray luminosity of ~10^{32} erg/s is consistent with accretion from the weak wind of HD 49798 onto a WD. An accreting NS should be more luminous.
Thus the companion of HD 49798 is the **fastest rotating** and one of the **most massive** known white dwarfs, making this system a good candidate Type Ia SN progenitor (Mereghetti et al. 2009).

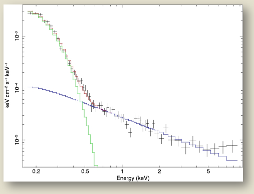
DISCOVERY OF SPIN-UP AND ITS IMPLICATIONS

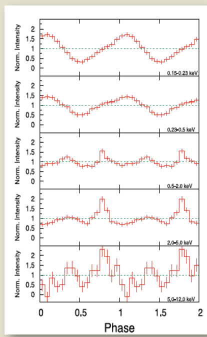
A phase-connected timing solution using all the XMM-Newton, Swift/ XRT and ROSAT data, spanning almost 25 years (from 1992 to 2018), shows a remarkably stable spin-up of the white dwarf at a rate of (-2.180+/-0.015) x 10^{-15} s s^{-1}. The specific angular momentum carried by the accreted matter is insufficient to give such a high spin-up for a WD, unless accretion occurs by Roche-lobe overflow. However, this would require d>4 kpc to Reconcile the observed and predicted X-ray luminosity, while the GAIA DR2 parallax gives d = 0.51 +/- 0.02 kpc.
We propose that the spin-up is caused by the contraction of the WD (Popov et al. 2017).



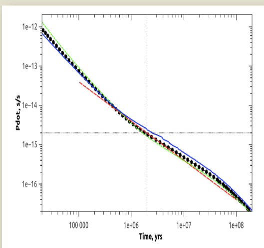
SPECTRAL AND TIMING PROPERTIES

The spectrum is a strongly pulsed, soft blackbody (kT~30 eV) plus a hard power-law tail (phot.index ~1.9) with a double peaked modulation (Mereghetti et al. 2011, 2013).
The bolometric X-ray luminosity is (1.2+/-0.5)x10^{32} erg/s (for d=500 pc).





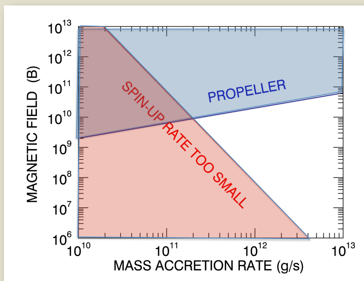
THE MODEL



We found that the observed spin-up rate requires, for such a massive WD, an age of ~2 Myr. With evolutionary calculations, we demonstrate that the current properties of HD 49798 are consistent with such an age (Popov et al. 2017).
Note that the spin-up caused by radial contraction cannot be detected in isolated white dwarfs (which rotate much more slowly and are very old) and in cataclysmic variables, where the star rotation rate is strongly affected by accretion torques. Only the combination of a young WD and a companion providing a very low and stable accretion through a faint wind has allowed us to detect this effect.
We estimated that our Galaxy should contain ~500 systems similar to this one, consistent with the presence of HD 49798 at only 0.5 kpc. Therefore, Athena should be able to discover more systems of this kind.

WHY A NEUTRON STAR COMPANION IS VERY UNLIKELY

Thanks to its ~10^5 smaller momentum of inertia, it is easier to spin-up a NS than a WD. However, a fine tuning between accretion rate and magnetic field strength is required in this case to have a sufficiently large torque without entering the propeller state. The minimum accretion rate (>2x10^{11} g/s) gives L_X consistent with the observations, but a rather small magnetic field would be required for a NS.



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