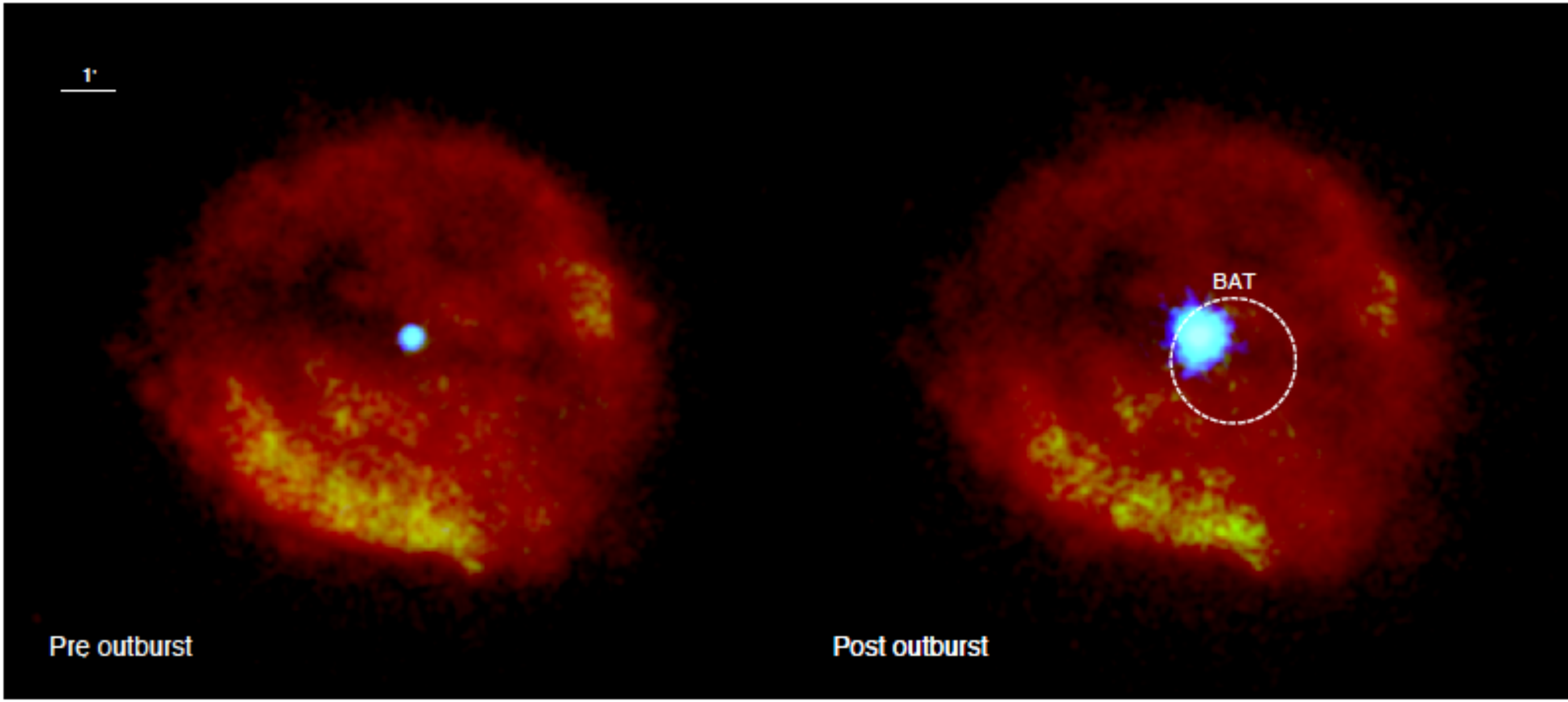
For FPS7 in Guangzhou, 2018

# Rotational evolution of magnetars in the presence of a fallback disk

全号 (广州大学)

2018.7

Outburst from the CCO in RCW 103, D'Ai et al. 2016



# Nature of CCO in RCW 103

1. a young magnetar!
2. a very special magnetar compared with magnetars, CCOs, normal neutron stars and accreting neutron stars: the longest spin period (6.6 hours)!
(at that time; the 2nd longest up to 2018)
3. a magnetar braked down by a fallback disk in the past?

$$\dot{M}_{\rm acc} = \dot{M}_{\rm Edd}, \qquad 0 < t < t_{\rm eq},$$
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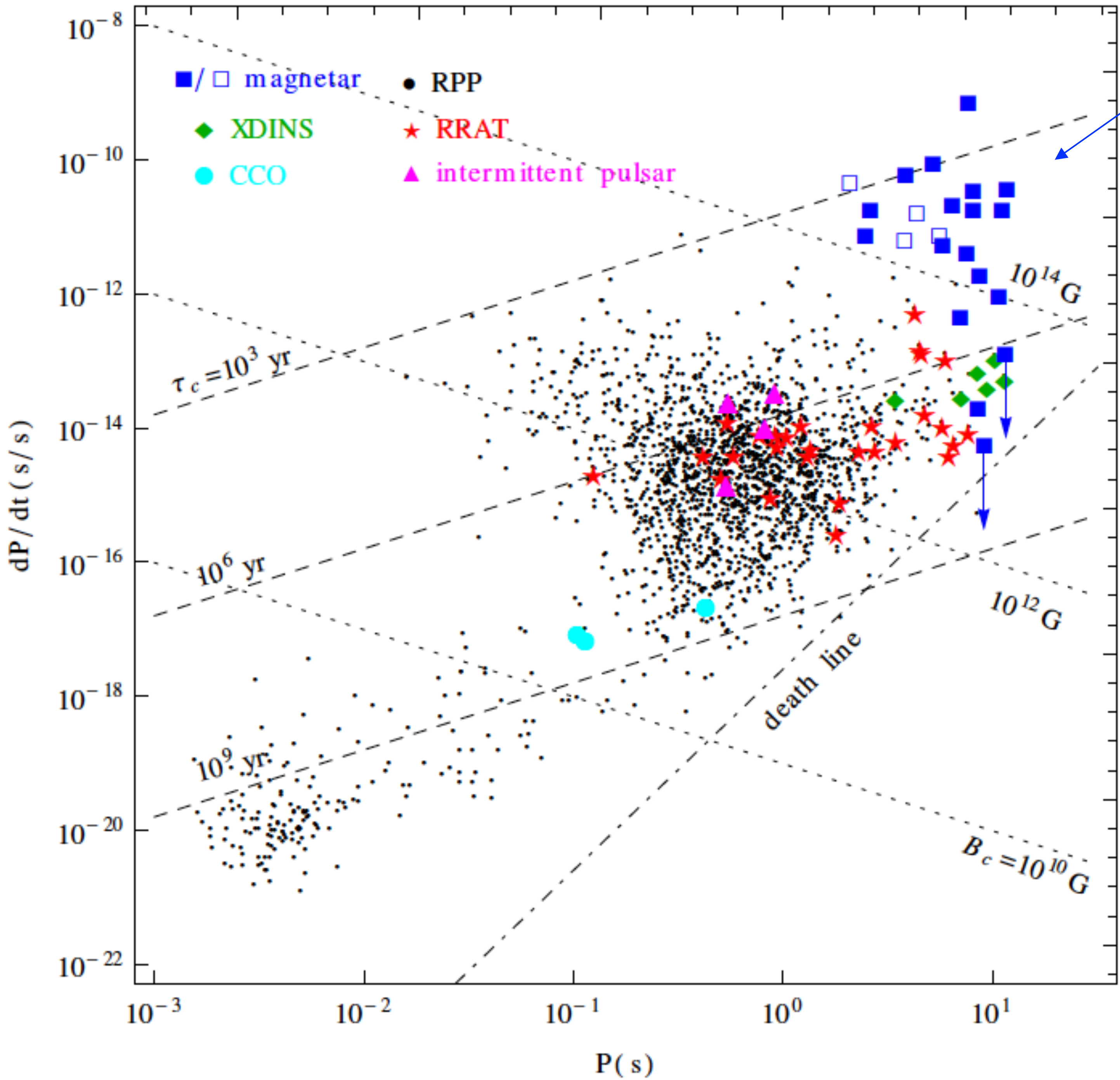


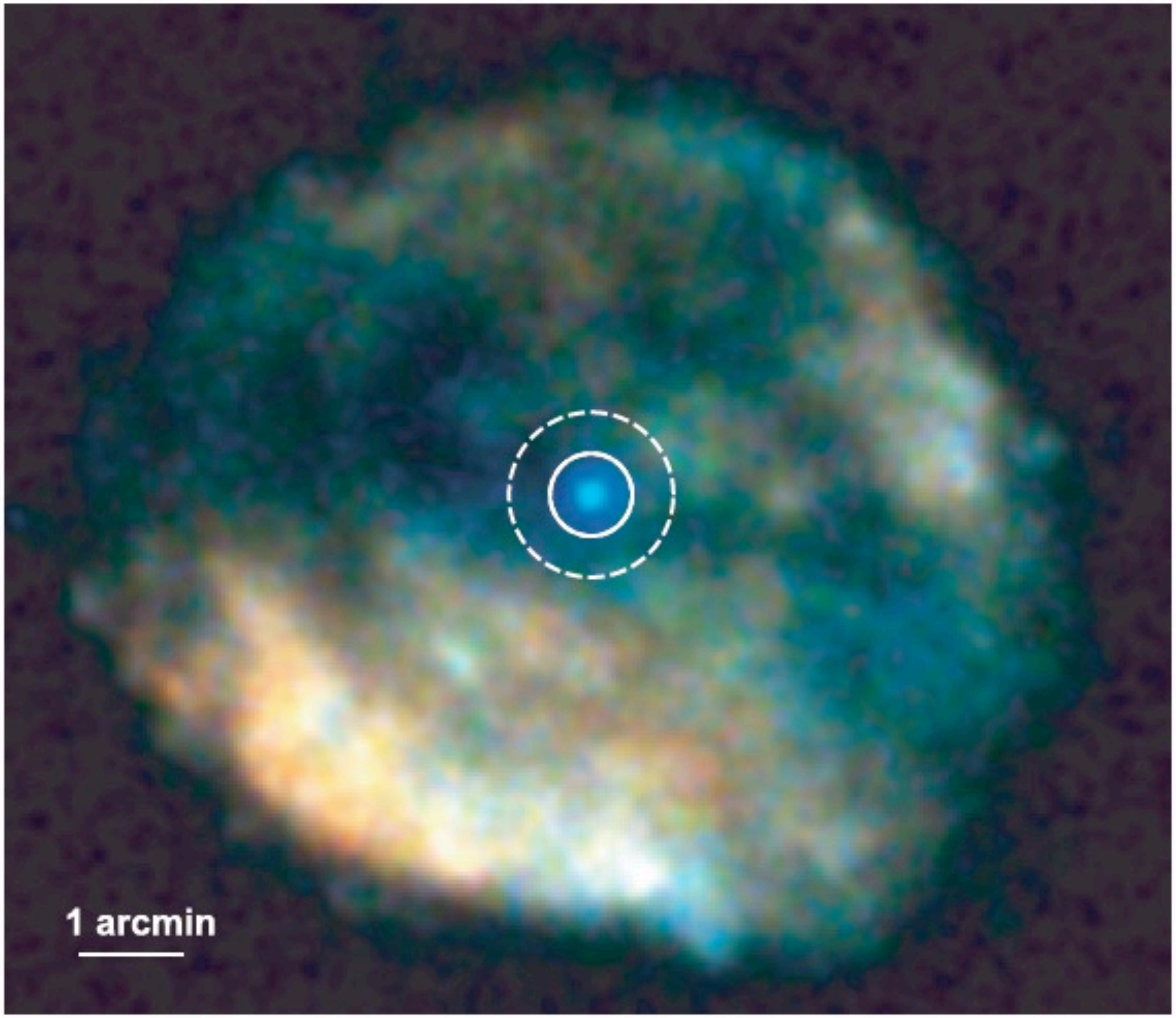

Magnetars my favorite!

Tong & Wang 2014

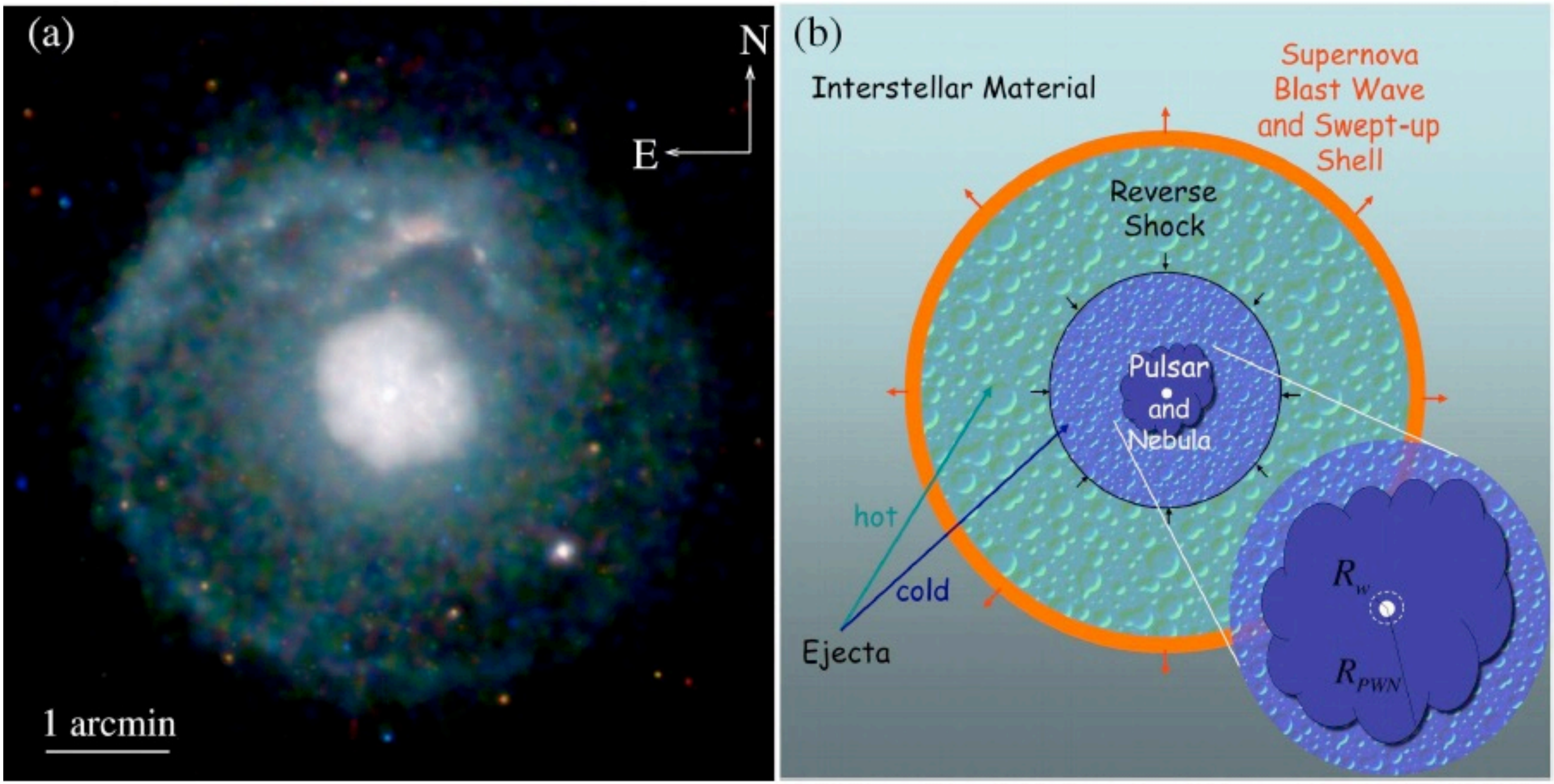
# Pulsars (up to 2018)

1. Rotation-powered pulsars
2. Accretion-powered pulsars
3. Magnetars (?)
    - Anomalous X-ray pulsars
    - Soft gamma-ray repeaters
4. Thermal-powered
    - X-ray dim isolated neutrons (XDINSs)
5. ??
    - Rotating radio transients (RRATs)
    - Central Compact Objects (CCOs)
    - ???, e.g. 1987A pulsars

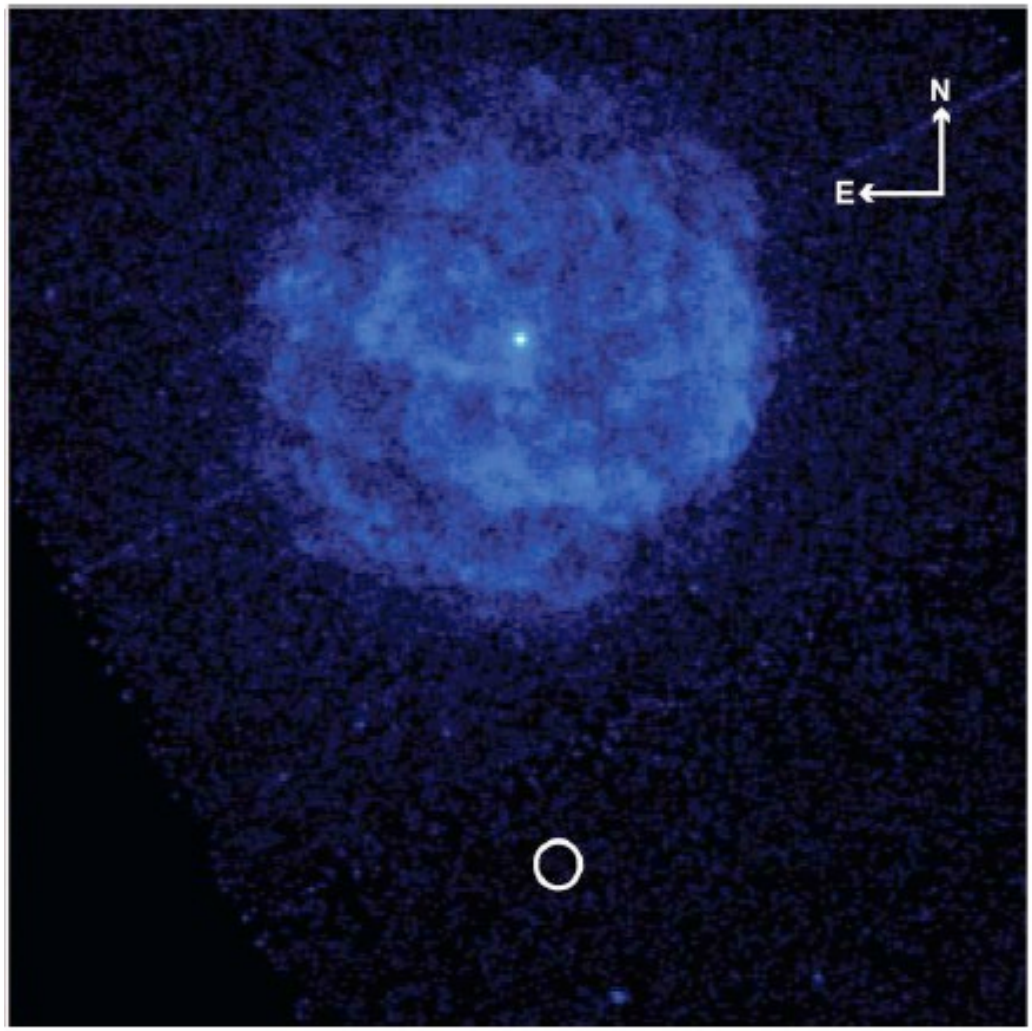
# What's CCO?
(RCW 103, Esposito+ 2011)



# Typical pulsar-SNR system
(Gaensler & Slane 2006)



# Magnetar-SNR system (Camilo+ 2011)



# Observation summary of CCOs

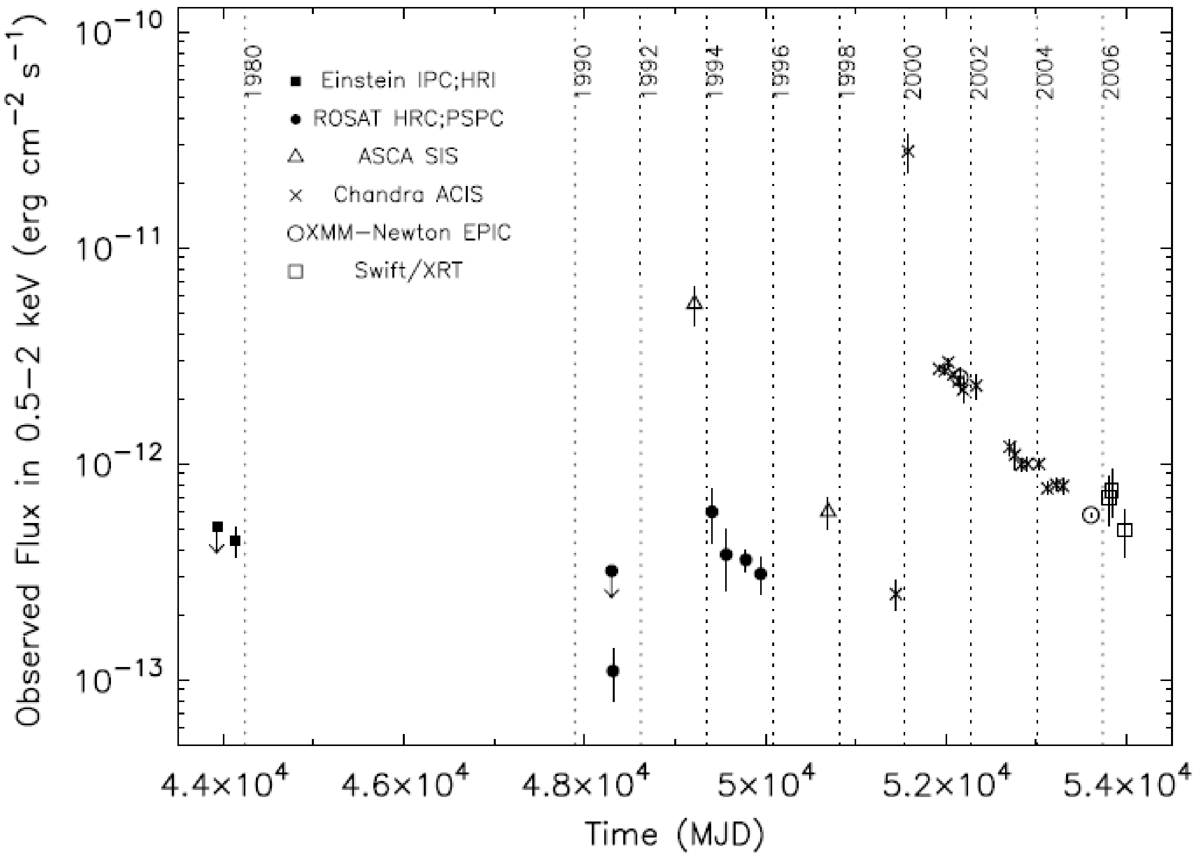
1. Young objects (cf. Crab, magnetars;XDINSs)
2. Steady flux, thermal spectra
3. No radio (no PWNe):
   a new species of young NSs

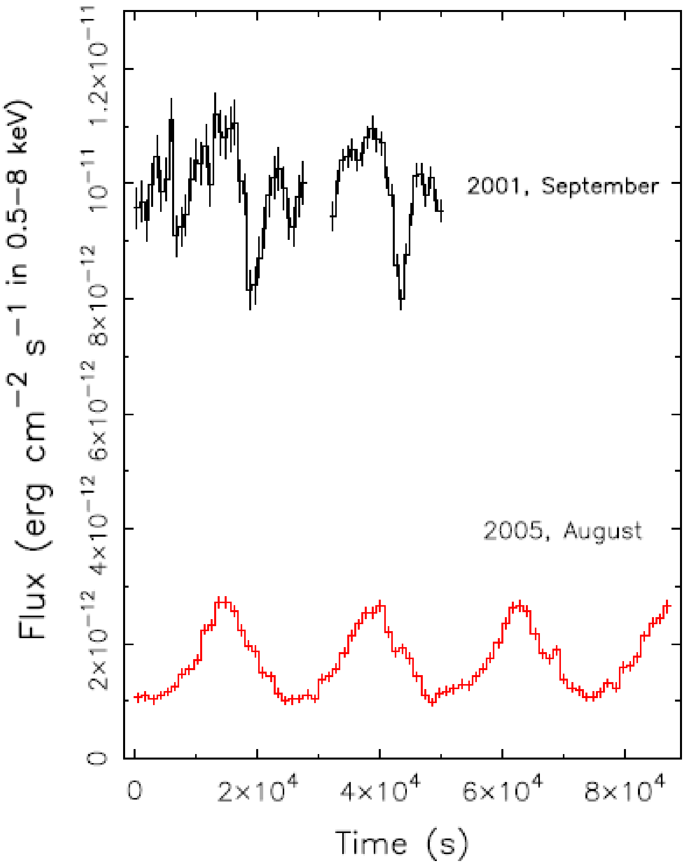
Problems:

- Timing
- Energy budget

Possible solutions: anti-magnetars? (Gotthelf et al. 2013)

# CCO (1E 1613) in RCW 103
## (De Luca+ 2006)



# Peculiarities

1. Variability
2. Periodicity (6.6 hour)

Nature: magnetar!

Problem: P=6.6 hr?

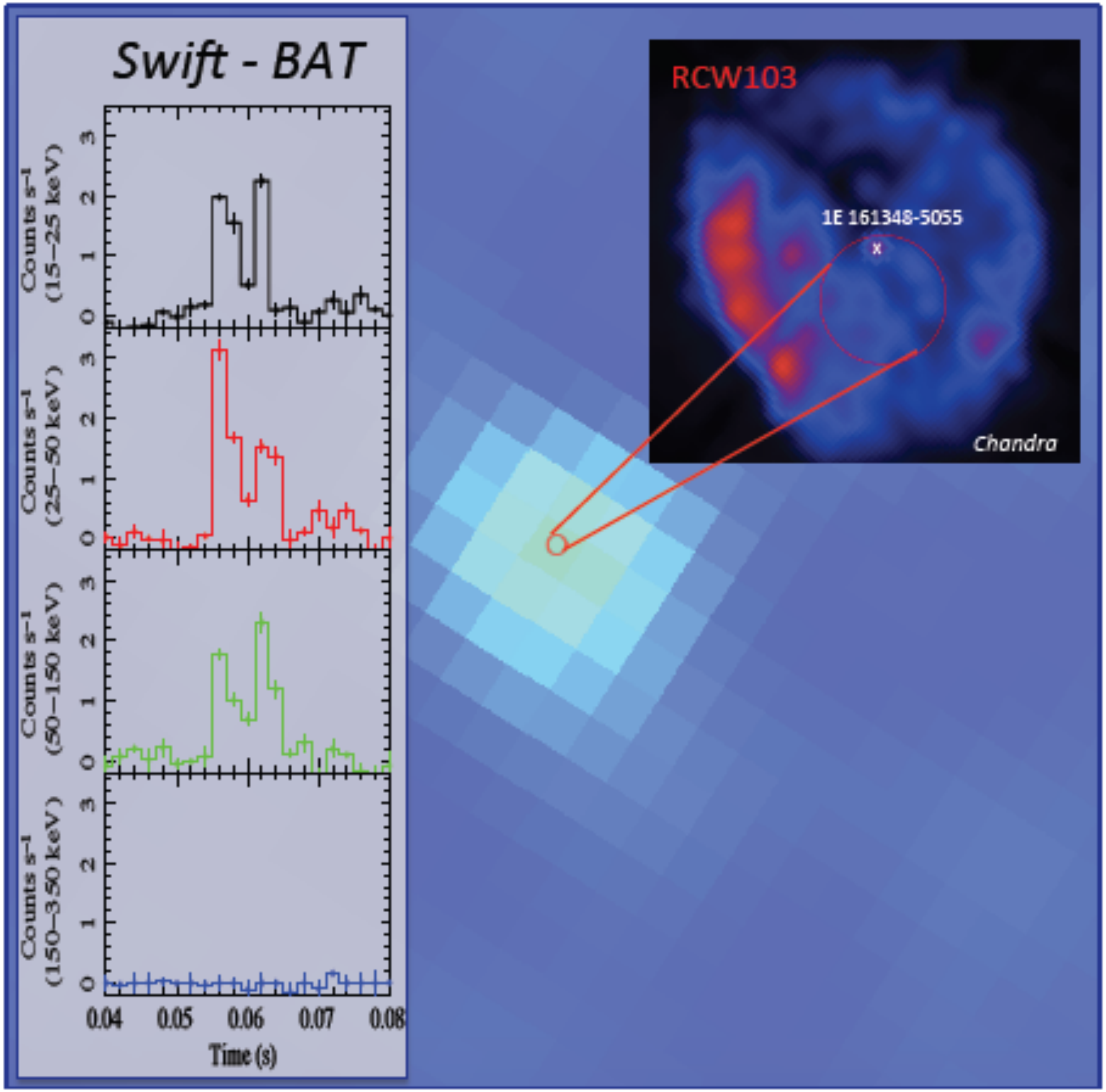
Sol: fallback disk braking

New Problems: Accretion powered? Pdot?

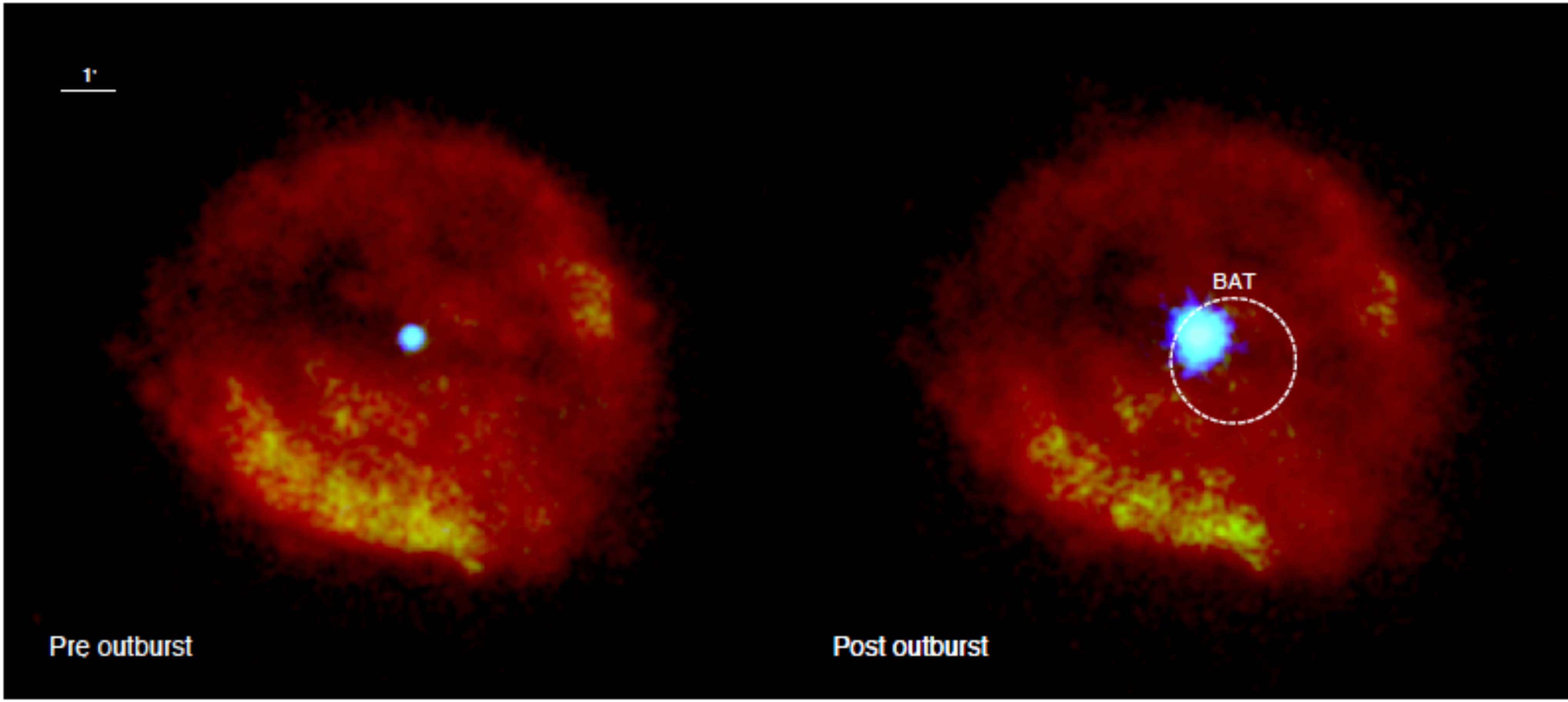
# Magnetar activities from the CCO in RCW 103

- Rea et al. arXiv:1607.04107; D'Ai et al. arXiv: 1607.04264 (appear the same day on the arXiv)
- burst: duration~10 ms, spectra: BB, T~10keV
- Timing: the 6.6hr period is still there
- spectra: 2BB (Chandra)+ PL (NuSTAR), PL index~ 1.2 (transient hard X-ray component, similar to magnetar outburst)
- outburst: three outburst period, energy release can be as high as 10^43 erg

Burst from the RCW 103 direction, Rea et al. 2016



Outburst from the CCO in RCW 103, D'Ai et al. 2016



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3 weeks later (Aug 6th):



Astrophysics > High Energy Astrophysical Phenomena

# Rotational evolution of magnetars in the presence of a fallback disk

H. Tong, W. Wang, X. W. Liu, R. X. Xu

*(Submitted on 6 Aug 2016)*

Magnetars may have strong surface dipole field. Observationally, two magnetars may have passive fallback disks. In the presence of a fallback disk, the rotational evolution of magnetars may be changed. In the self-similar fallback disk model, it is found that: (1) When the disk mass is significantly smaller than $10^{-6}\ \mathrm{M}_{\odot}$, the magnetar is unaffected by the fallback disk and it will be a normal magnetar. (2) When the disk mass is large, but the magnetar's surface dipole field is $10^{14}$ G, the magnetar will also be a normal magnetar. A magnetar plus a passive fallback disk system is expected. This may correspond to the observations of magnetars 4U 0142+61, and 1E 2259 +586. (3) When the disk mass is large, and the magnetar's surface dipole field is as high as $4 \times 10^{15}$ G, the magnetar will evolve from the ejector phase to the propeller phase, and then enter into rotational equilibrium. The magnetar will be slowed down quickly in the propeller phase. The final rotational period can be as high $2 \times 10^{4}$ s. This may correspond to the super-slow magnetar in the supernova remnant RCW 103. Therefore, the three kinds of magnetars can be understood uniformly.

Comments: 12 pages, 4 figures, submitted several days later after our paper: Aug 10th

arXiv.org > astro-ph > arXiv:1608.03149v1

Search or

Astrophysics > Solar and Stellar Astrophysics

# Ejector and propeller spin-down: How might a superluminous supernova millisecond magnetar become the 6.67 hr pulsar in RCW103

Wynn C. G. Ho, Nils Andersson (Univ of Southampton)

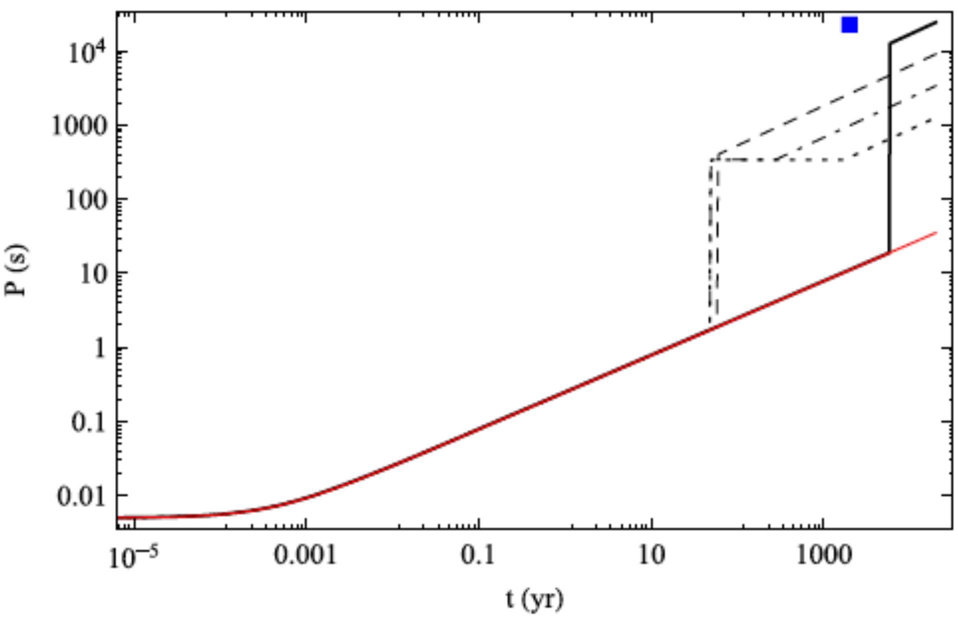
*(Submitted on 10 Aug 2016)*

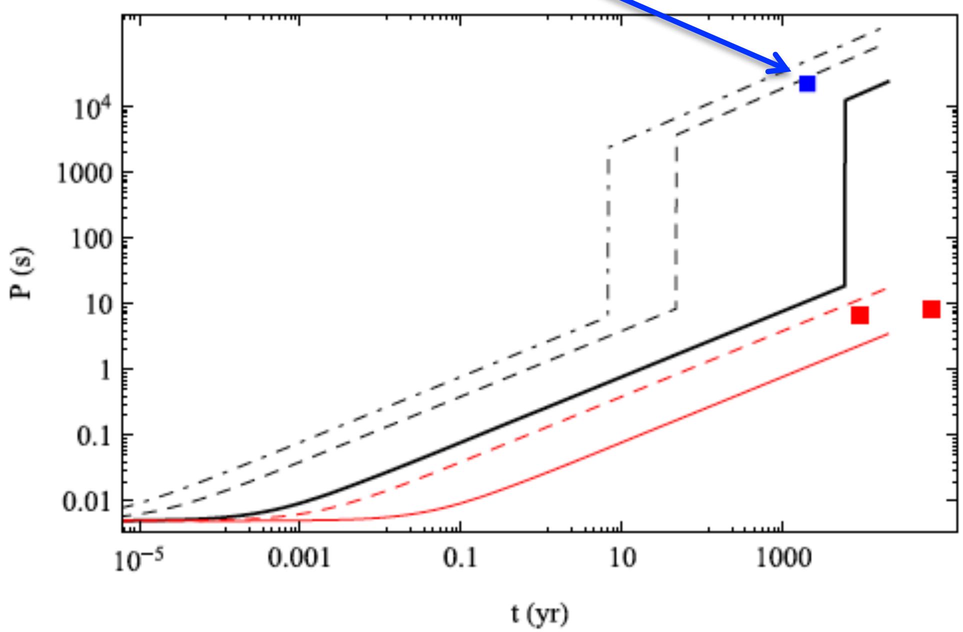
The X-ray source 1E 161348-5055 in the supernova remnant RCW 103 recently exhibited X-ray activity typical of magnetars, i.e., neutron stars with magnetic fields > 10^14-10^15 G. However, 1E 161348-5055 has an observed period of 6.67 hr, in contrast to magnetars which have a spin period of seconds. Here we describe a simple model which can explain the spin evolution of 1E 161348-5055, as well as other magnetars, from an initial period of milliseconds that would be required for dynamo generation of magnetar-strength magnetic fields. We propose that the key difference between 1E 161348-5055 and other magnetars is the persistence of a remnant disk of small total mass. This disk caused 1E 161348-5055 to undergo ejector and propeller phases in its life, during which strong torques caused a rapid increase of its spin period. By matching its observed spin period and ~1-3 kyr age, we find that 1E 161348-5055 has the (slightly) highest magnetic field of all known magnetars, with B~5x10^15 G, and that its disk had a mass of ~10^24 g, comparable to that of the asteroid Ceres.

Rotational evolution of magnetars in the presence of a fallback disk:
for different masses of the disk (left) and different magnetic field of the magnetar (right)

Only for **a high disk mass** (10^-5 Msun) and **high dipole field** (5*10^15 G), the magnetar will be spun down significantly by the fallback disk

Tong et al. 2016



# Summary (1): magnetars in astrophysics

1. AXP/SGR
2. XDINSs: dead magnetar
3. CCO: magnetar-in-waiting /disk braked down magnetar
4. HBPSR: magnetar activities also seen (PSR J1846-0258; and J1119-6127)
5. Low B SGR: magnetar activities in normal pulsars in the future!
6. Magnetars in binary system? (LS I+61, superslow X-ray pulsars, ULX pulsars etc)

# Summary (2): fallback disk modeling

1. Planetary system in normal pulsars
2. Age discrepancies between pulsar and SNR
3. Braking index of radio pulsars: n!=3
4. Debris around AXP 4U 0142+61, Vela etc
5. Fallback disk model for AXPs/SGRs, RRATs/ intermittent pulsars, XDINSs, CCOs etc

the fallback disk model is original proposed to beat the magnetar model

# Summary (3)
## parameter space for pulsar-like objects

1. B/magnetosphere
2. Fallback disk (4U 0142+61;RCW 103)
3. EOS: quark star
4. ?

more observations and theoretical works are need!
e.g. FAST