28 Sept. 2019

Transient phenomena powered by a newborn neutron star

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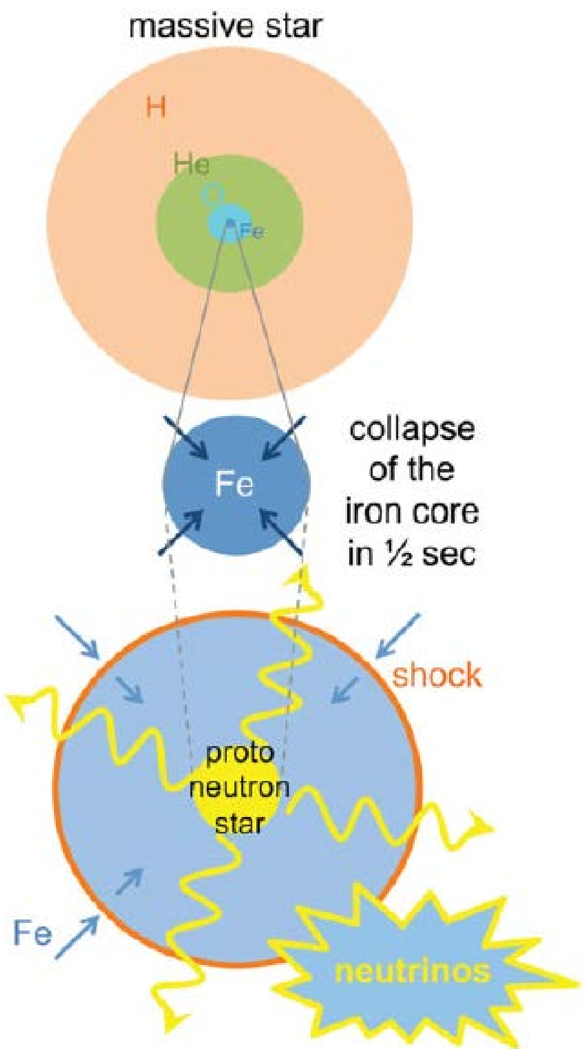
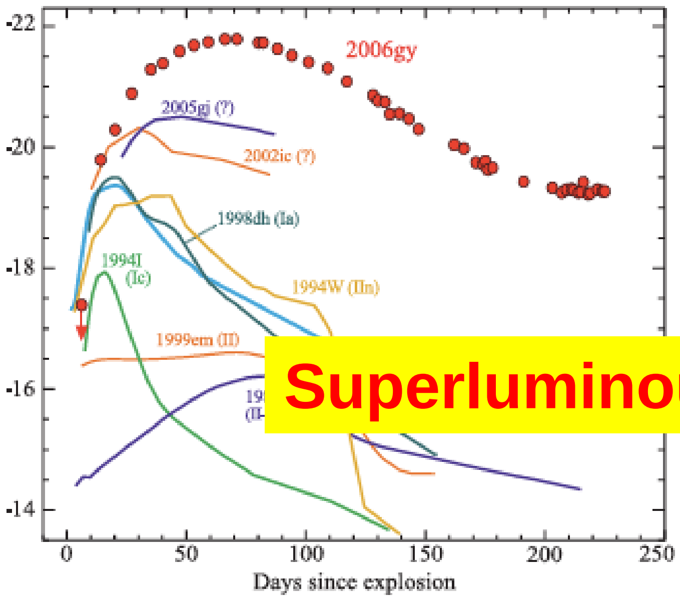
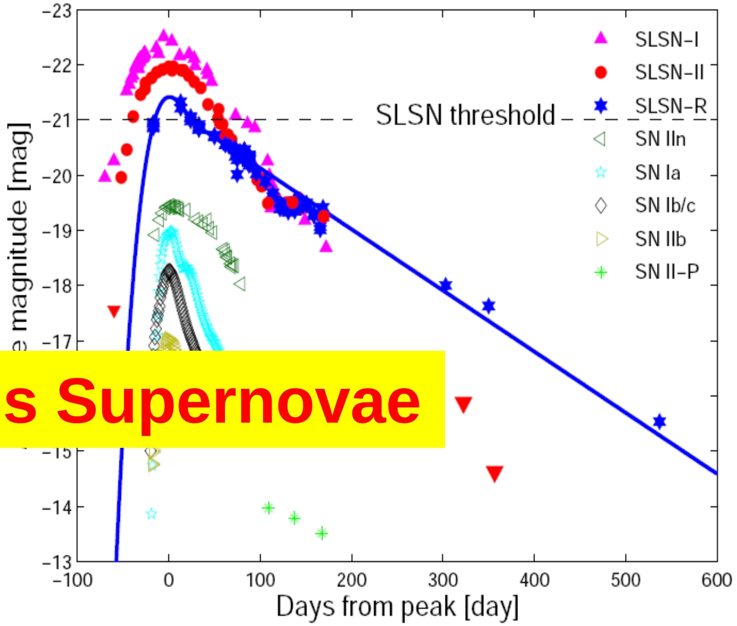
HUAZHONG NORMAL UNIVERSITY

Neutron stars and supernovae





Smith et al. 2007



Gal-Yam 2012

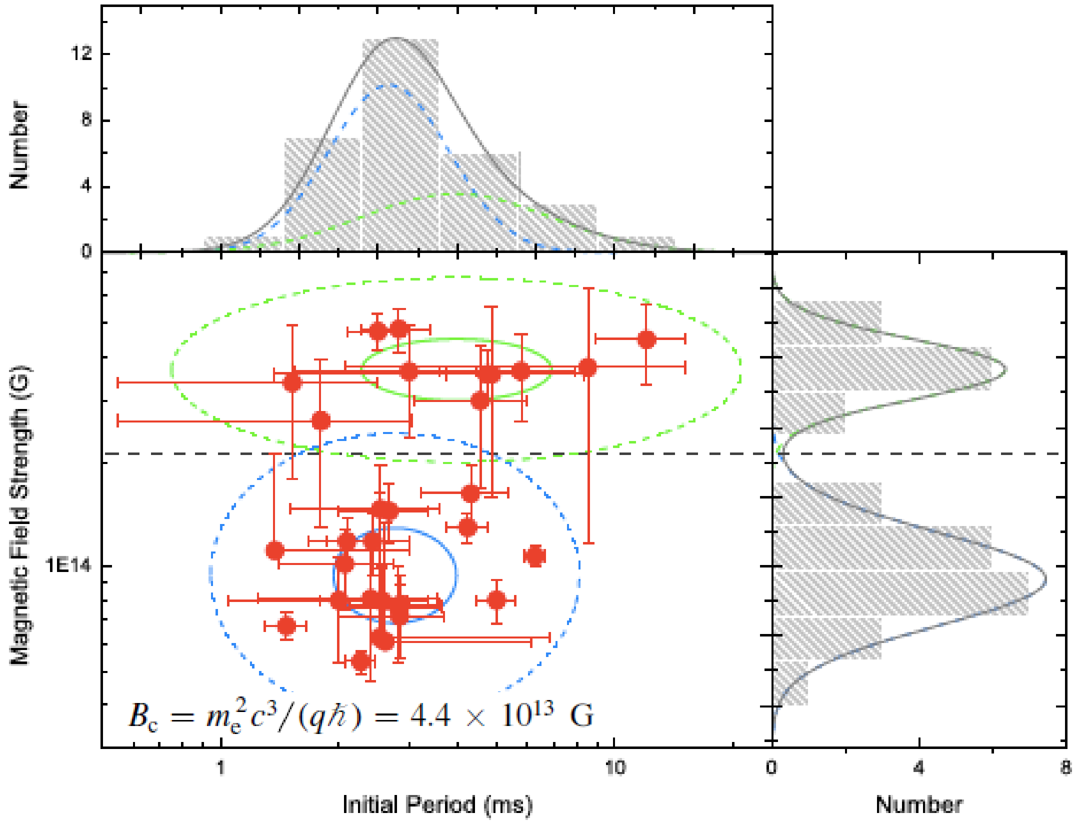
Superluminous Supernovae

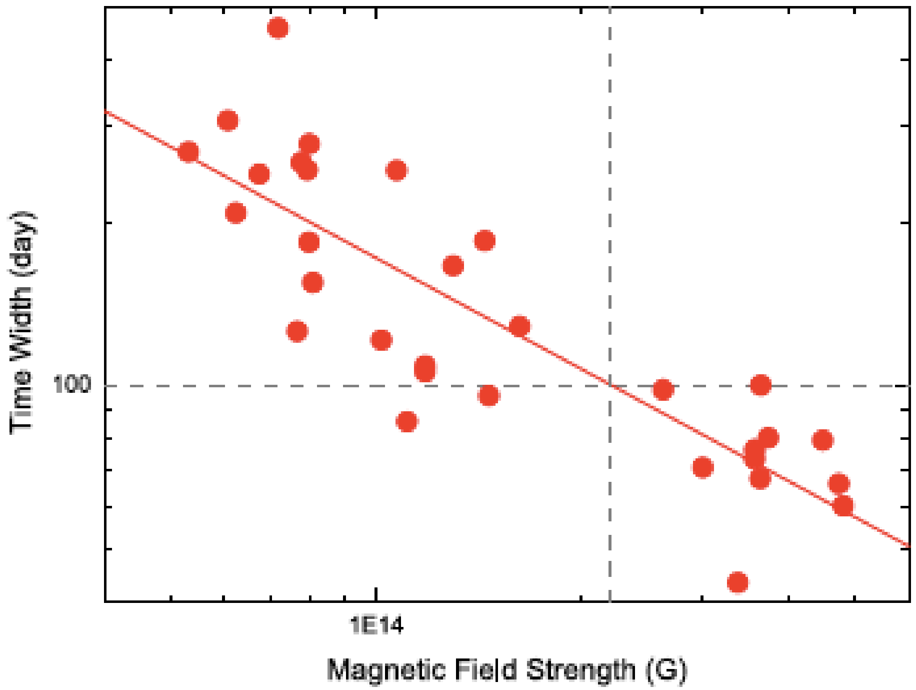
$$E_{rad} \sim 10^{51} \mathrm{erg}$$

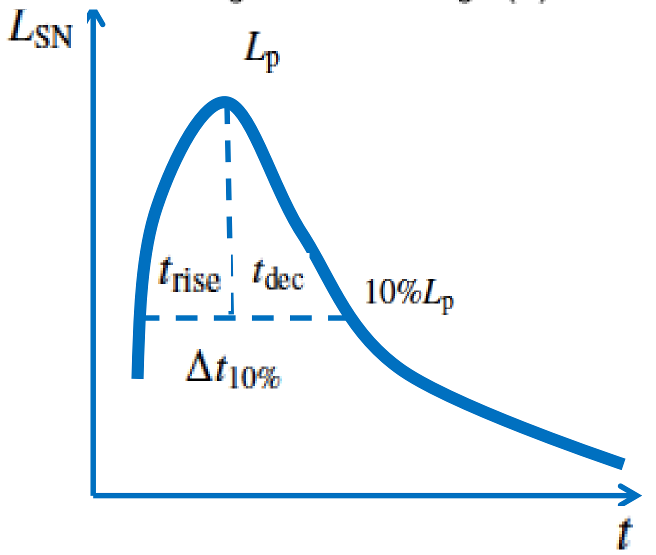
$$E_{Ni56} \sim 10^{49} \left(\frac{M_{56Ni}}{0.1 M_\odot} \right) \mathrm{erg}$$

$$M_{Ni56} \sim 10 M_\odot$$

SLSN magnetars







The magnetic fields of SLSN magnetars are just higher than the Landau critical field strength of electrons.

Does this mean something?

YWY, Zhu, Li et al. 2017, ApJ, 840, 12

Spinning-down magnetars and GRB afterglows

VOLUME 81, NUMBER 20 PHYSICAL REVIEW LETTERS 16 NOVEMBER 1998

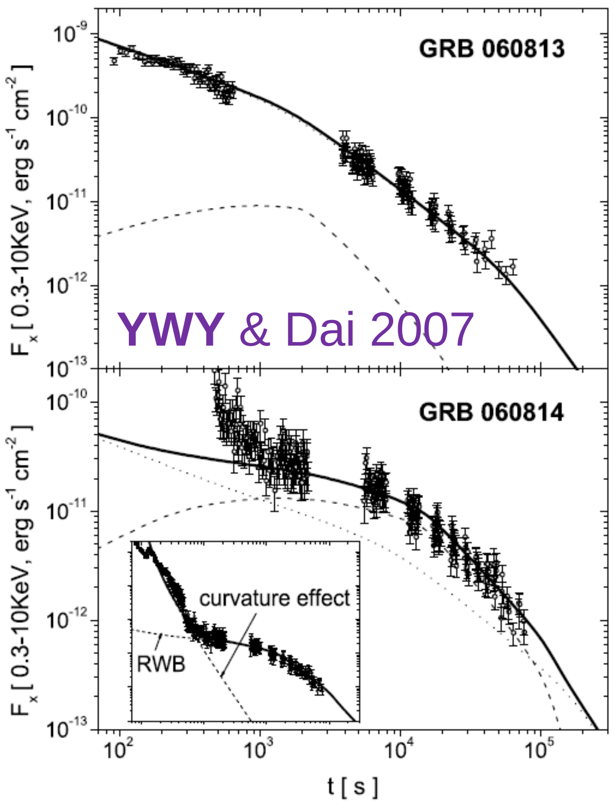
γ-Ray Bursts and Afterglows from Rotating Strange Stars and Neutron Stars

Z. G. Dai and T. Lu
Department of Astronomy, Nanjing University, Nanjing 210093, China
(Received 8 May 1998)

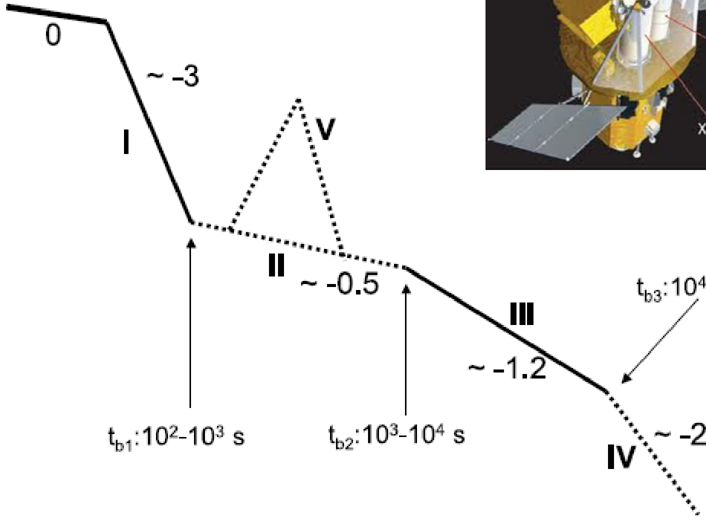
THE ASTROPHYSICAL JOURNAL, 552:L35–L38, 2001 May 1

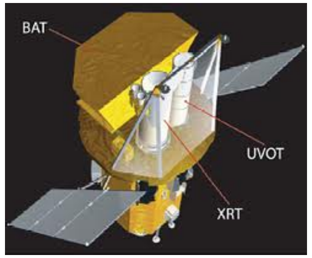
GAMMA-RAY BURST AFTERGLOW WITH CONTINUOUS ENERGY INJECTION: SIGNATURE OF A HIGHLY MAGNETIZED MILLISECOND PULSAR

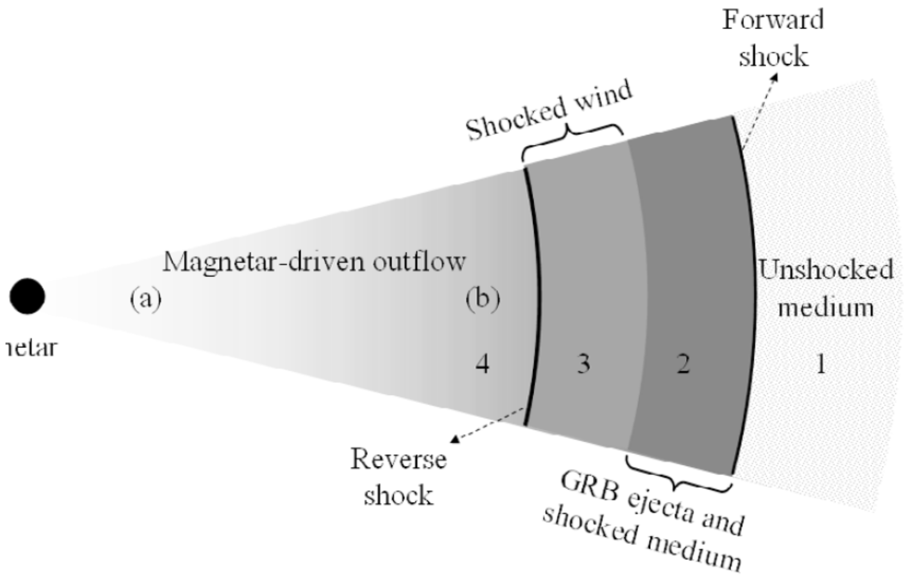
BING ZHANG AND PETER MÉSZÁROS
Department of Astronomy and Astrophysics, Pennsylvania State University, 525 Davey Laboratory, University Park, PA 16802
Received 2000 November 3; accepted 2001 March 20; published 2001 April 16



Zhang et al. 2006







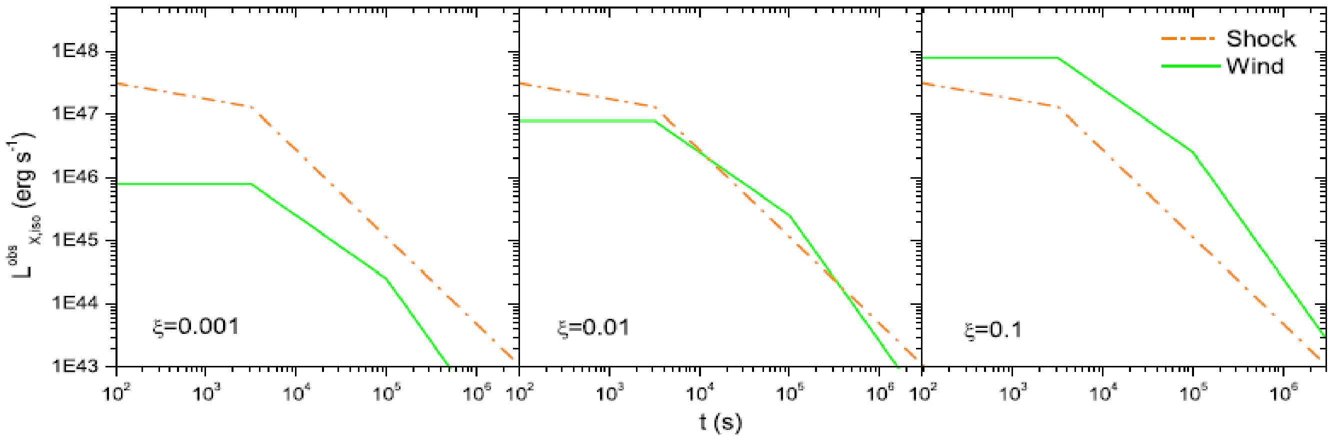
GRB afterglow emission should be substantially affected by post-GRB engine activity.

Spinning-down magnetars and GRB afterglows

THE ASTROPHYSICAL JOURNAL, 715:477–484, 2010 May 20 doi:10.1088/0004-637X/715/1/477

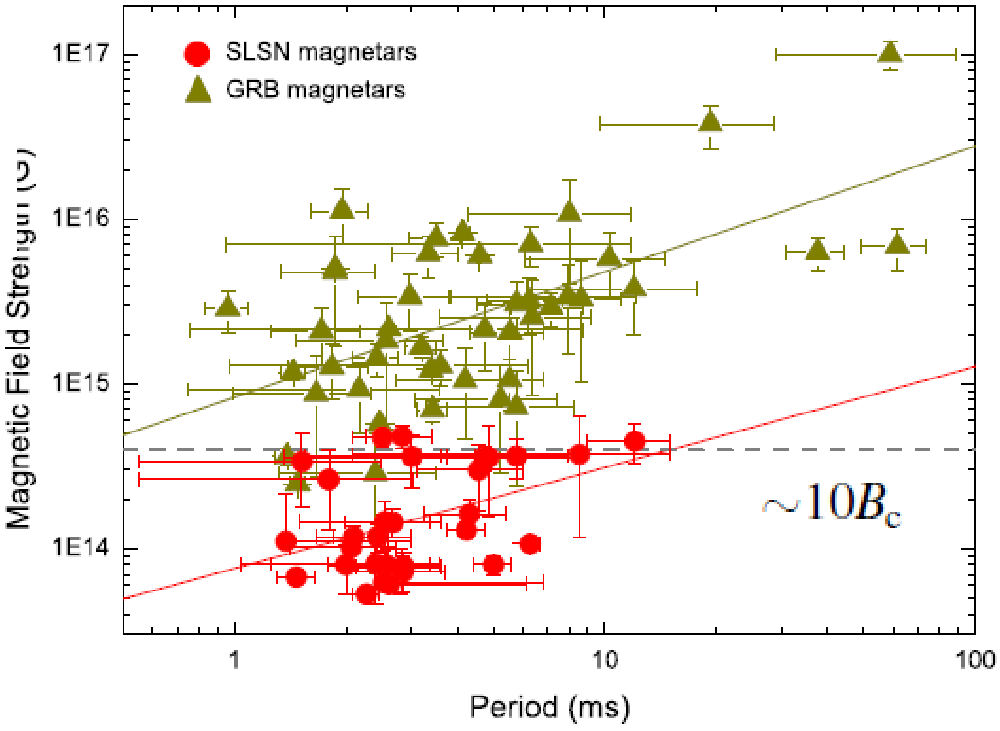
THE ROLE OF NEWLY BORN MAGNETARS IN GAMMA-RAY BURST X-RAY AFTERGLOW EMISSION: ENERGY INJECTION AND INTERNAL EMISSION

YUN-WEI YU[1,2], K. S. CHENG[1], AND XIAO-FENG CAO[2]



Gravitational wave radiation could sometimes play an important role in spinning down GRB magnetars.

YWY, Cheng, Cao 2010

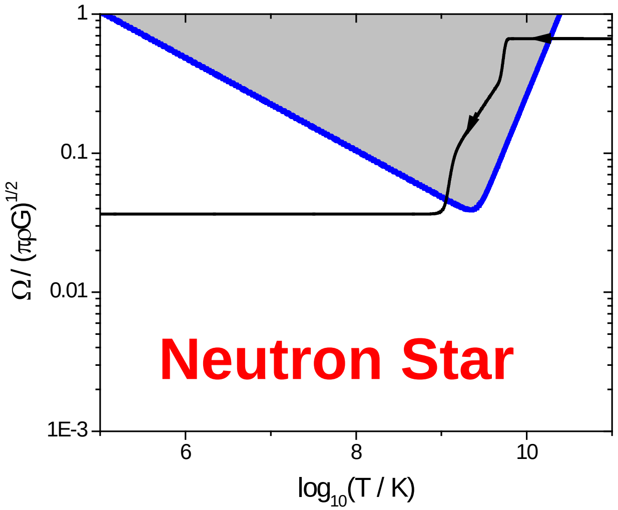


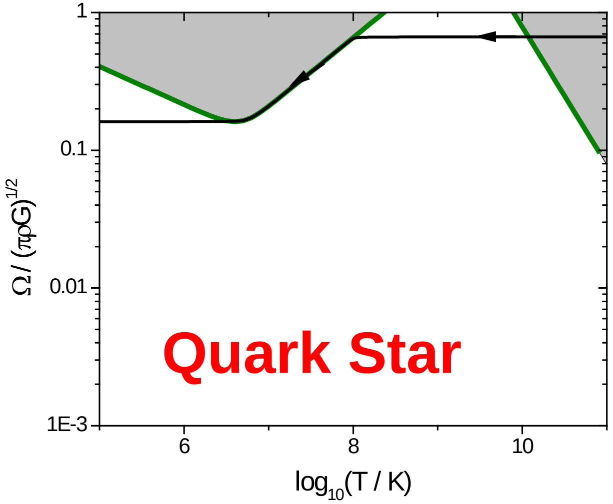
Ultra-high magnetic fields could play a crucial role in driving a relativistic jet to produce GRB emission.

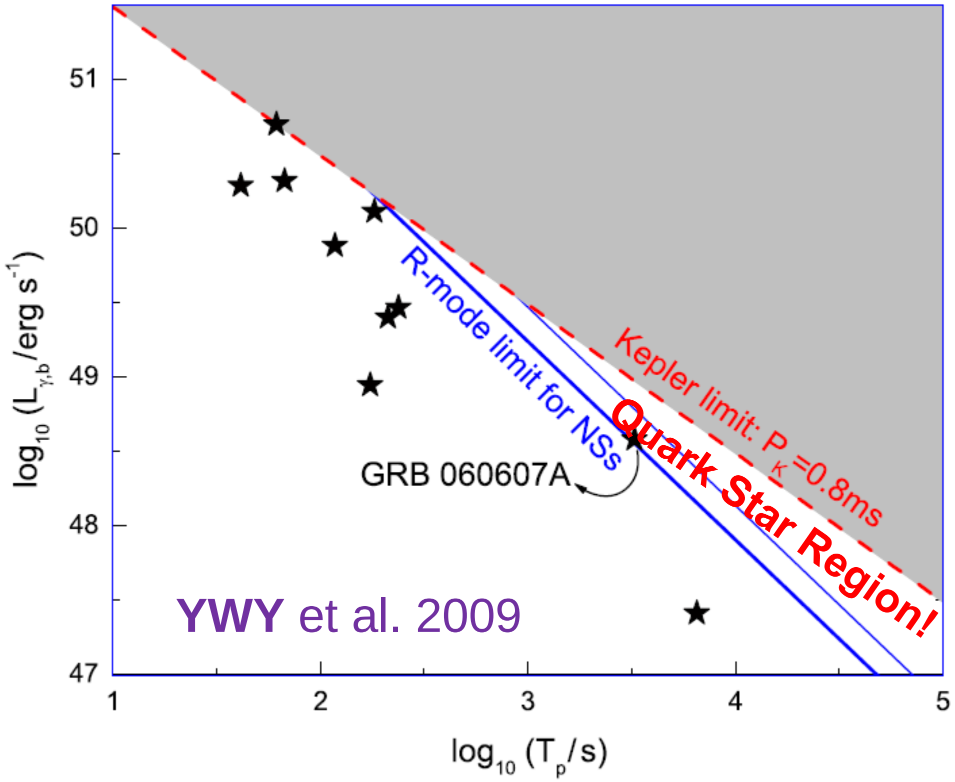
Lu & Zhang 2014, ApJ, 785, 74

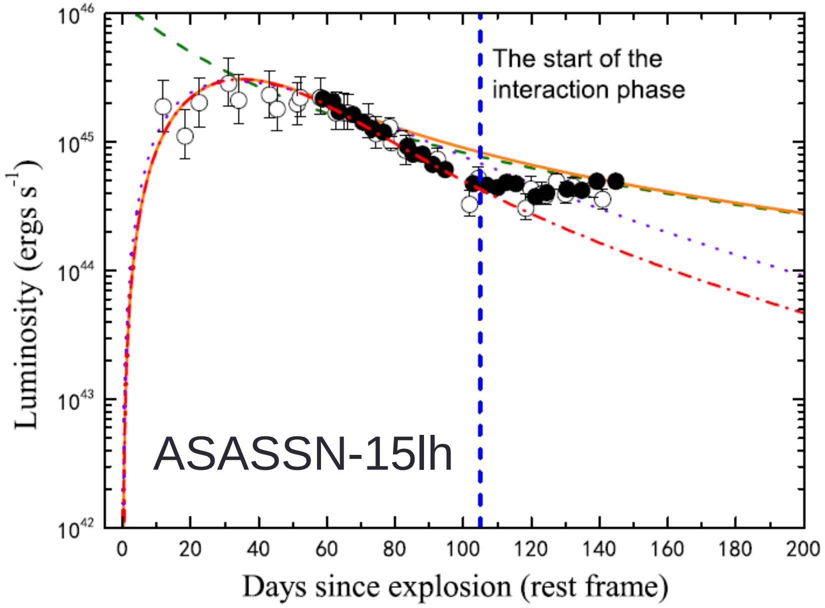
YWY, Zhu, Li et al. 2017

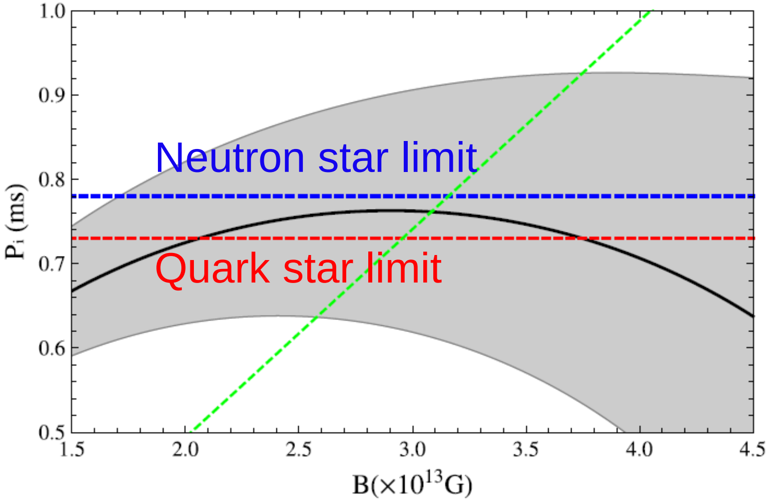
Strange quark star candidate?









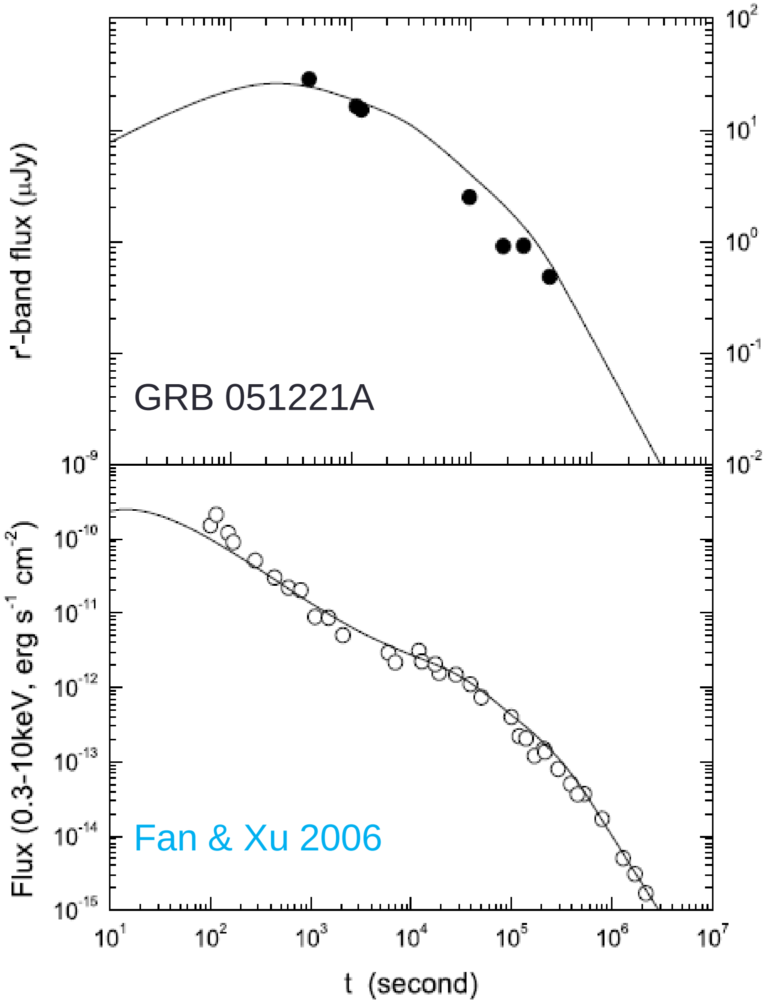


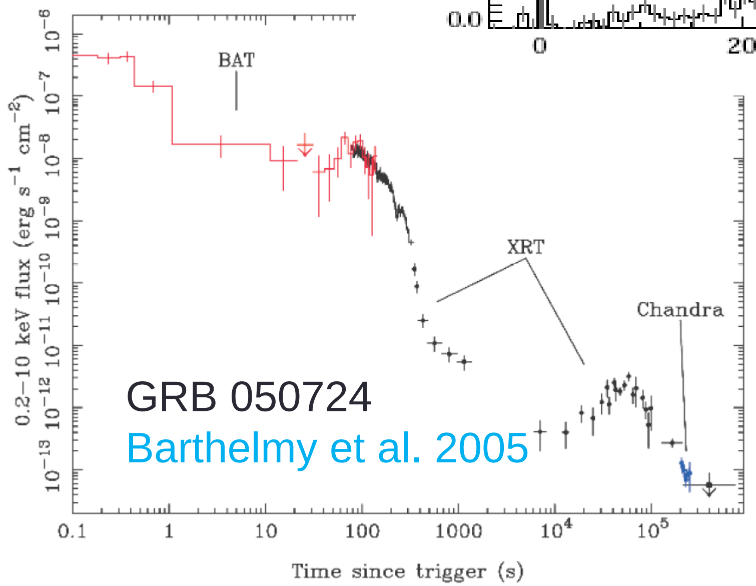
Dai et al. 2016

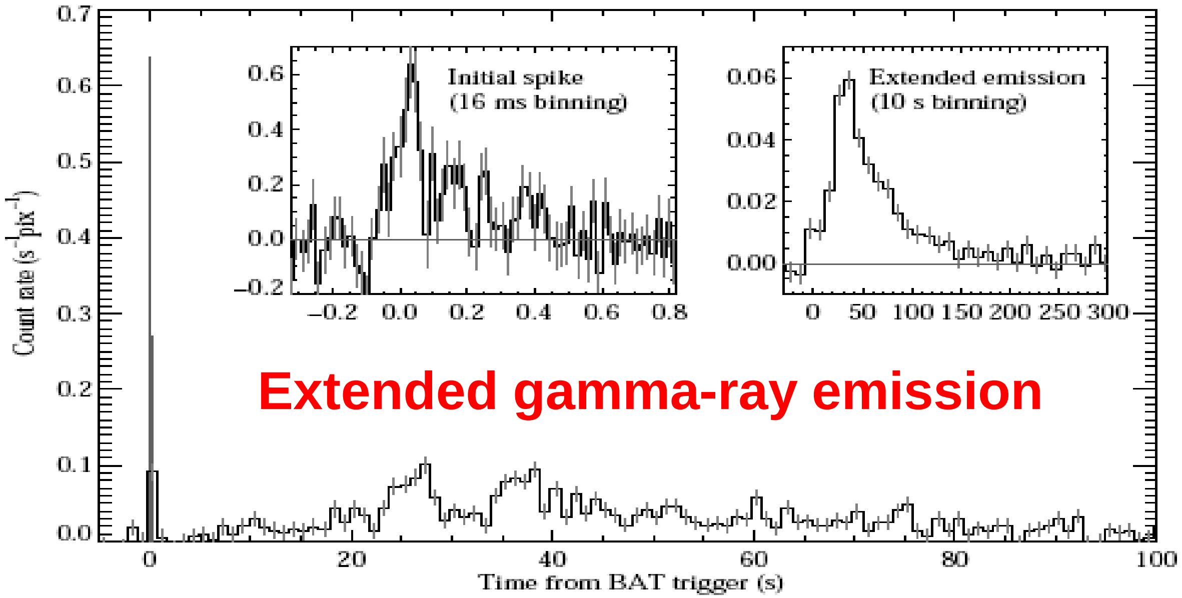
Short GRBs

The remnant of a NS-NS merger could be long-lived massive NS

Shallow-decay afterglows

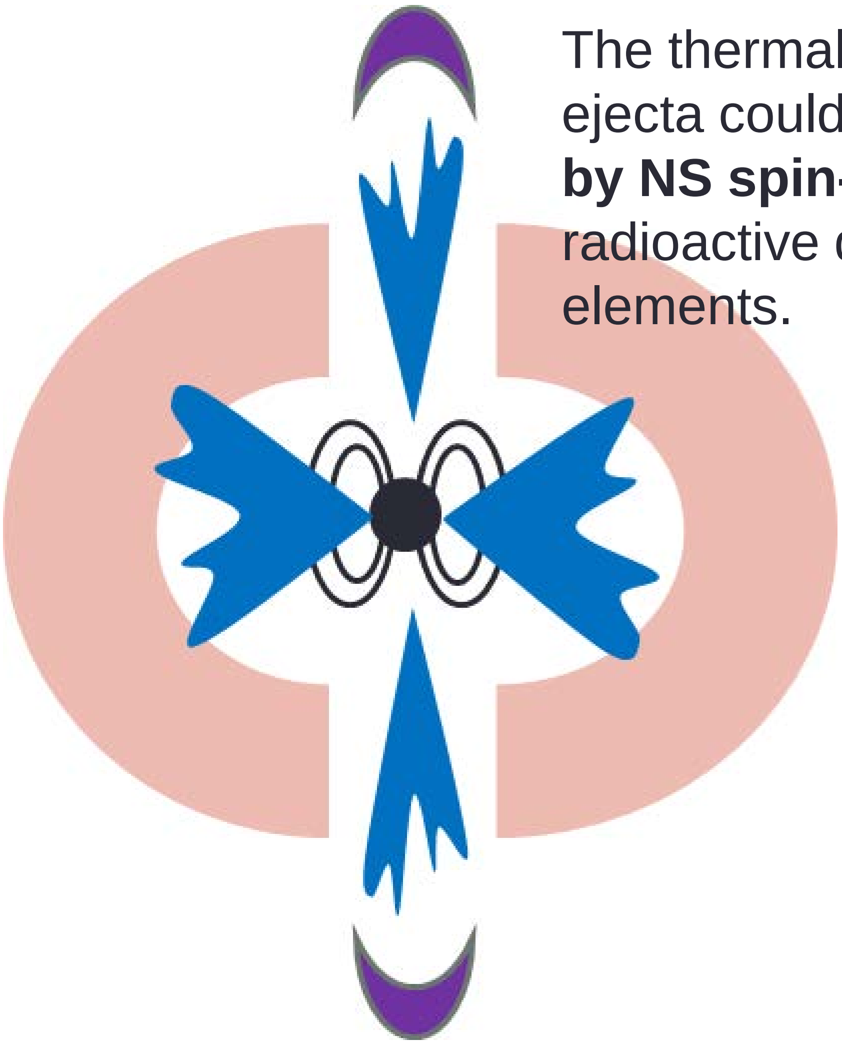




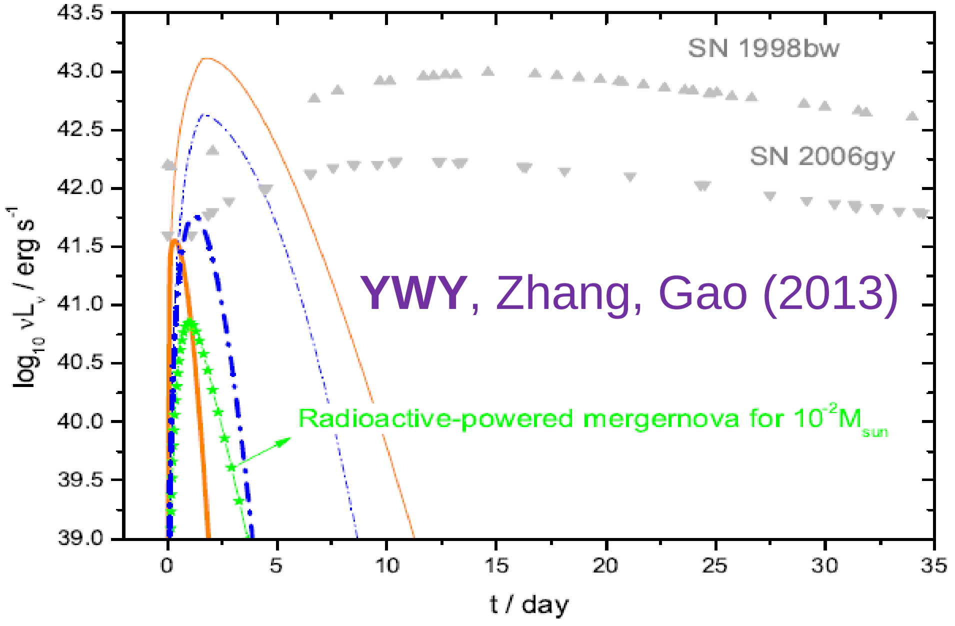


X-ray afterglow flares

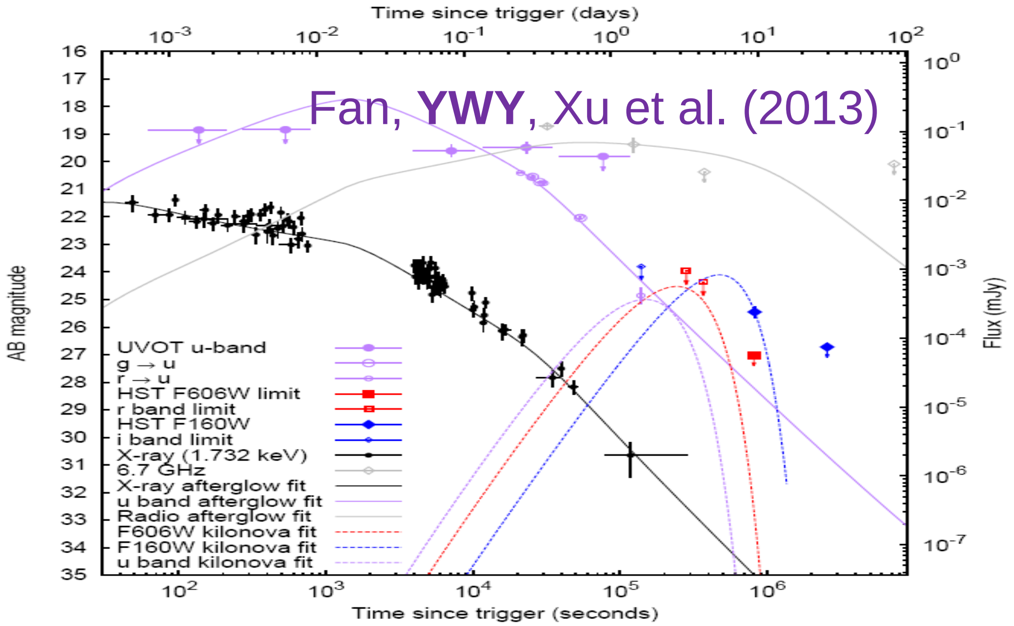
NS-powered mergernovae



The thermal emission of a merger ejecta could be **primarily powered by NS spin-down**, rather than by radioactive decays of r-process elements.

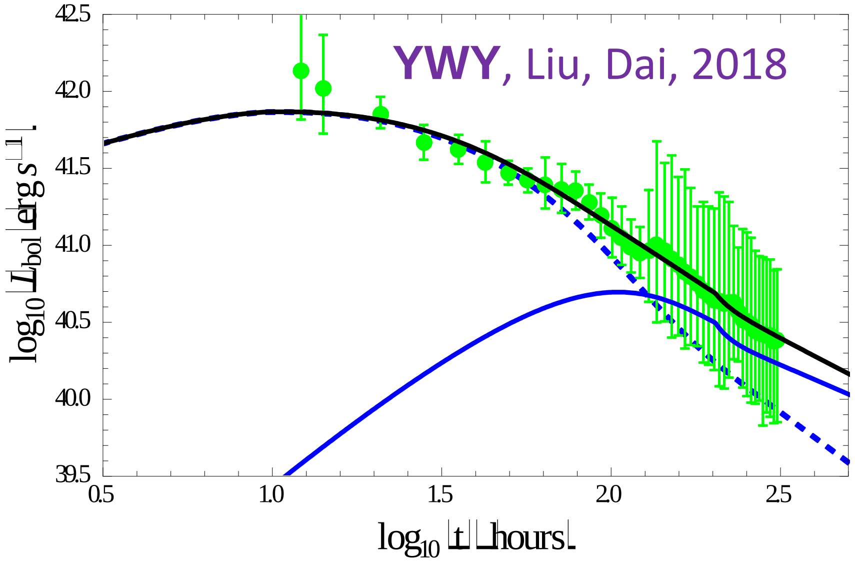


GRB 130603B:
A spin-down power can naturally explain the multi-wavelength afterglow emissions and the associated kilonova emission.



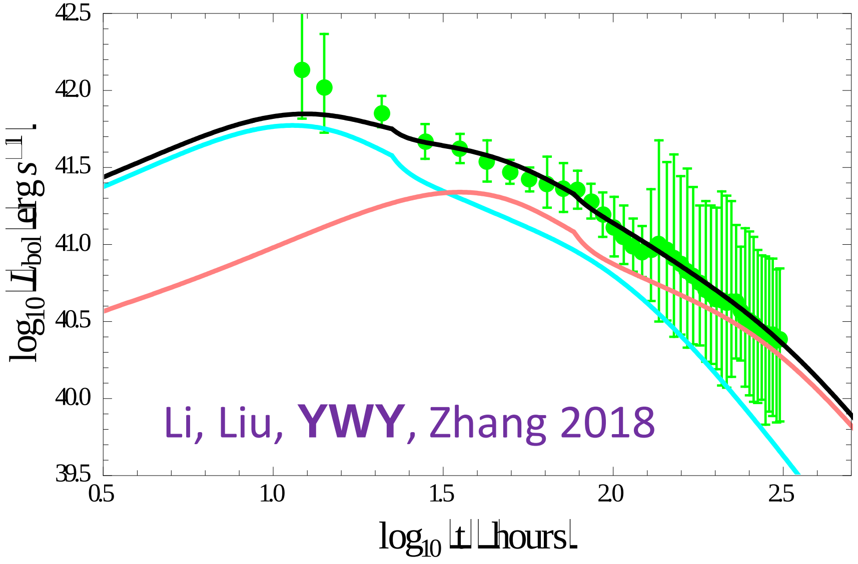
GW 170817 and a post-merger NS

Kilonova AT2017gfo could be powered by radioactivity at early phase and by NS spin-down at late phase



The existence of **a post-merger massive NS** is beneficial for (1) reducing the high requirement on **the ejecta masses** and (2) reconciling the **opacity** values.

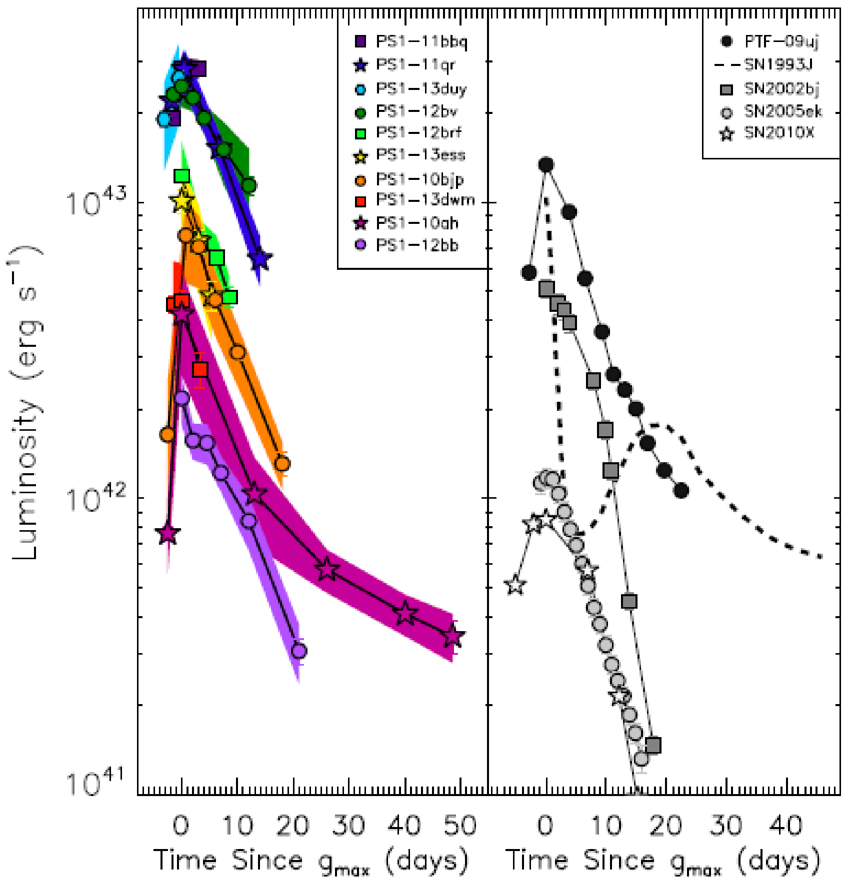
Kilonova AT2017gfo could be powered NS spin-down all the time.



In the future, (1) we need **more samples**, in particular, the more luminous or more faint samples. (2) It is useful to detect the **increasing phase** of the kilonova emission. (3) **On-axis observation** is also helpful.

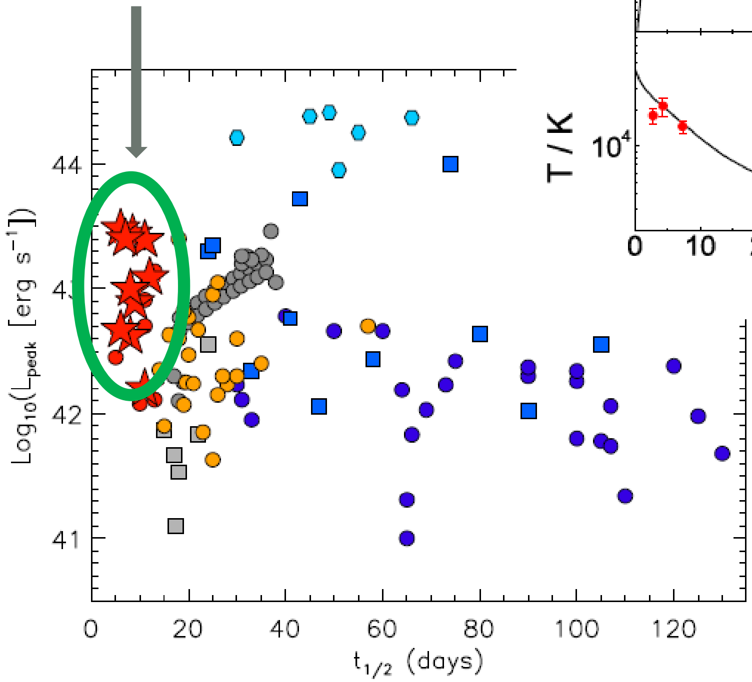
Fast evolving luminous transients

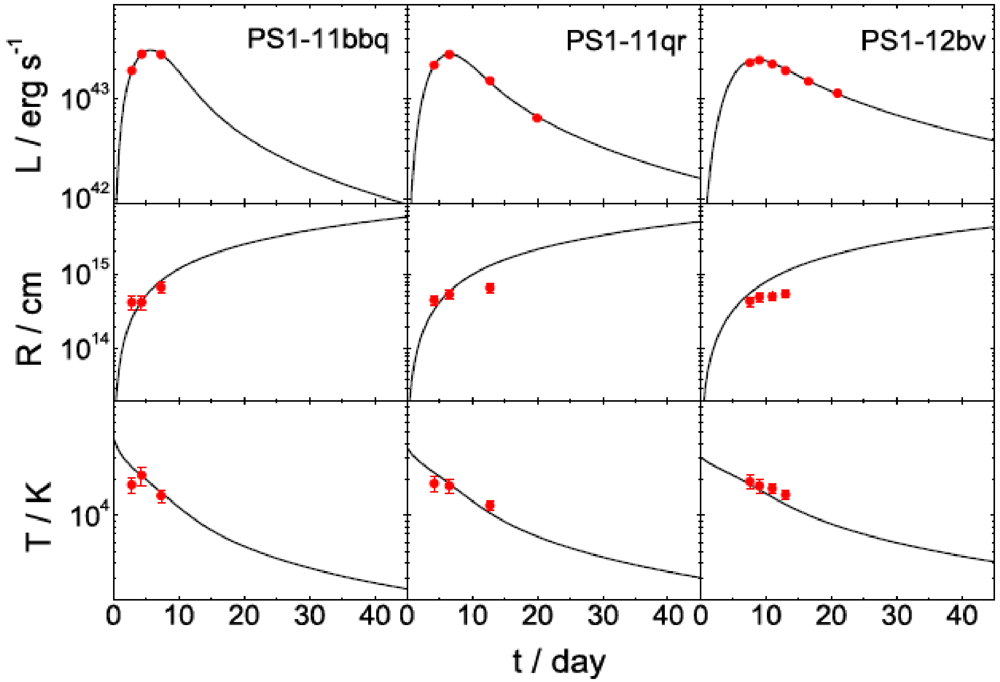
YWY, Li, Dai (2015)



Drout et al. 2014

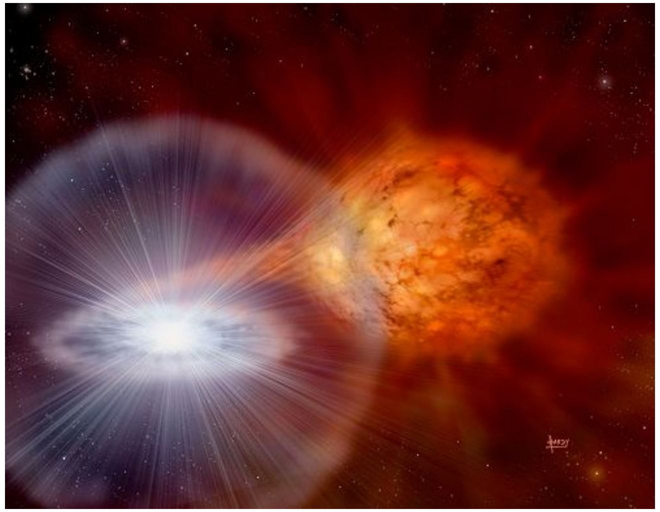
Very different from typical supernovae

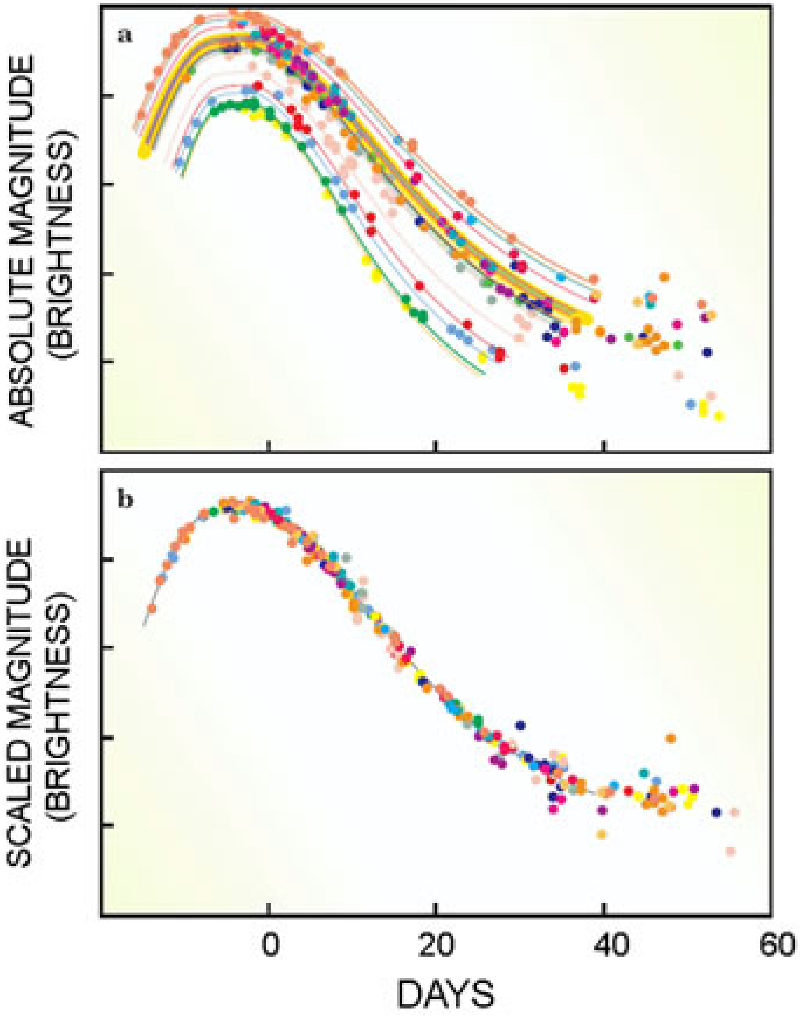


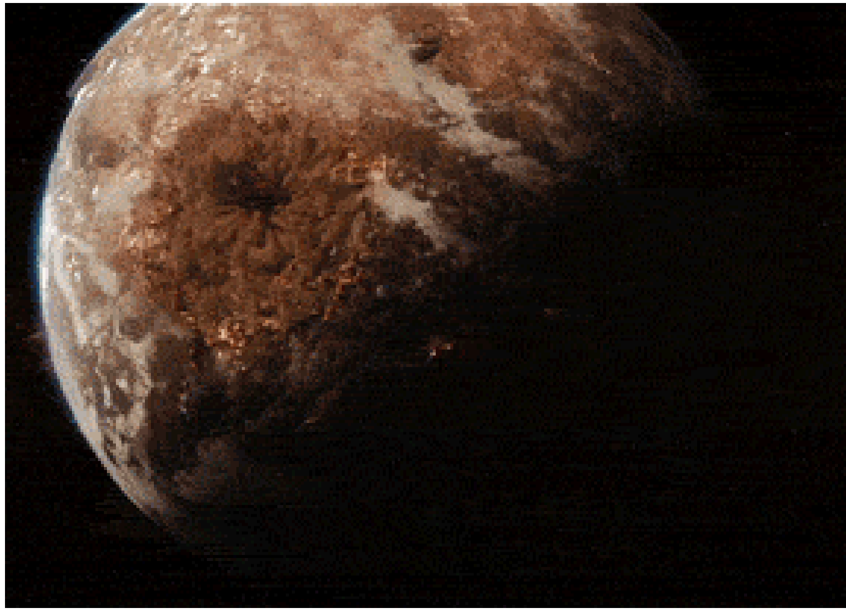


These FELTs can be explained by **a magnetar engine** and **a low-mass ejecta.**

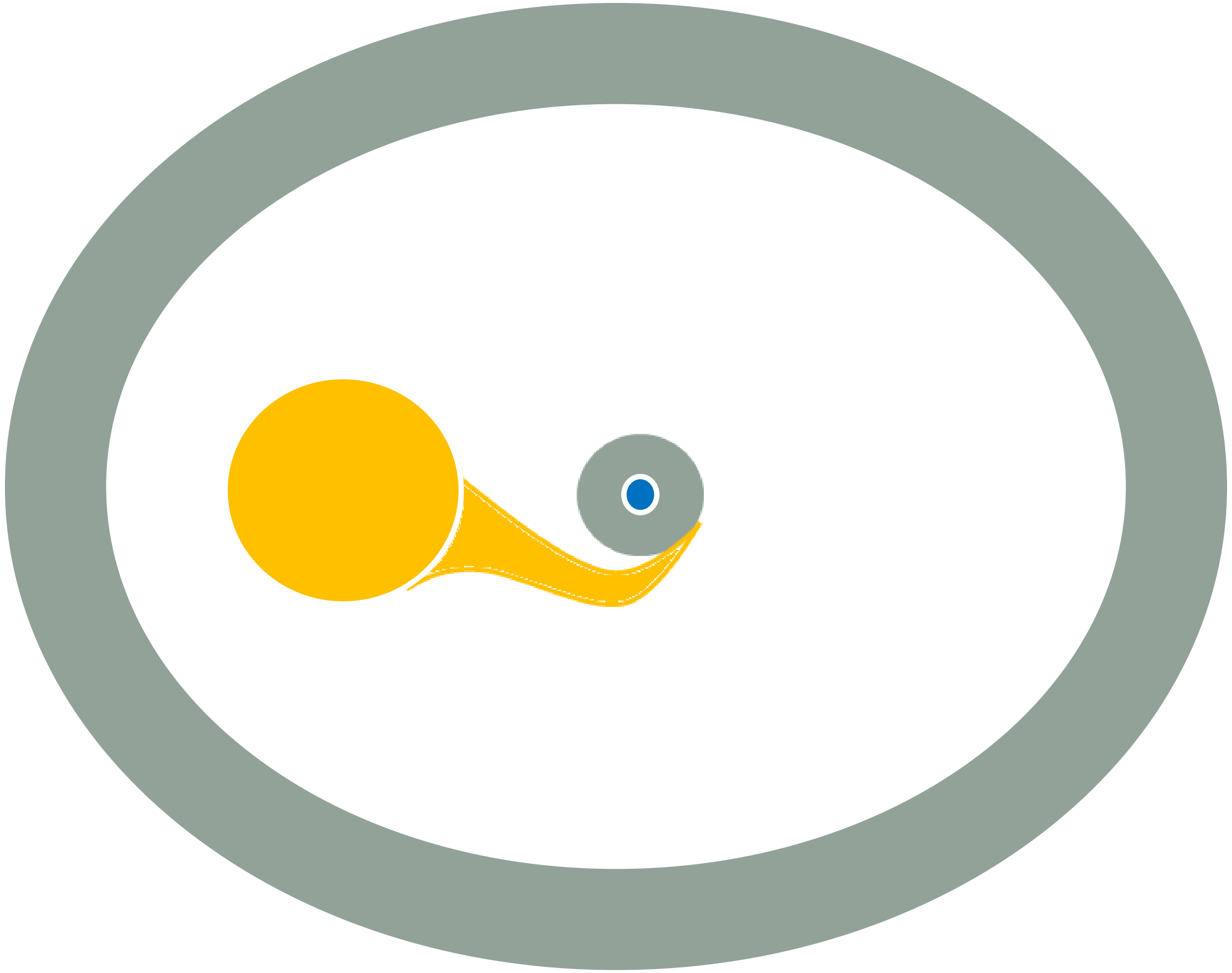
Accretion-induced collapse (AIC)

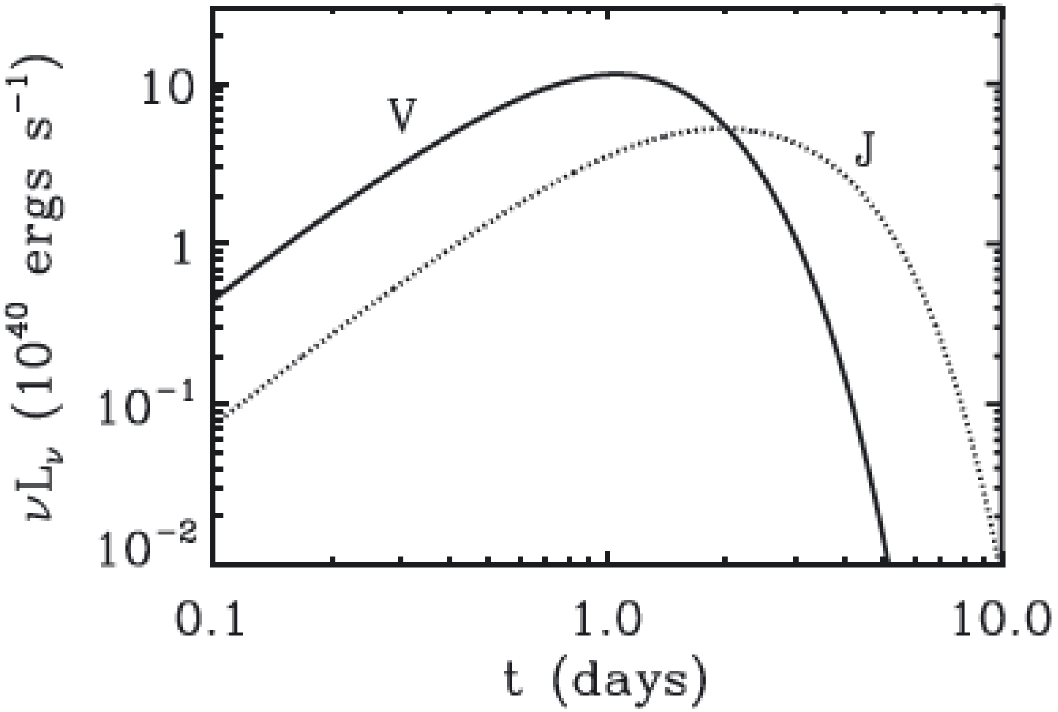






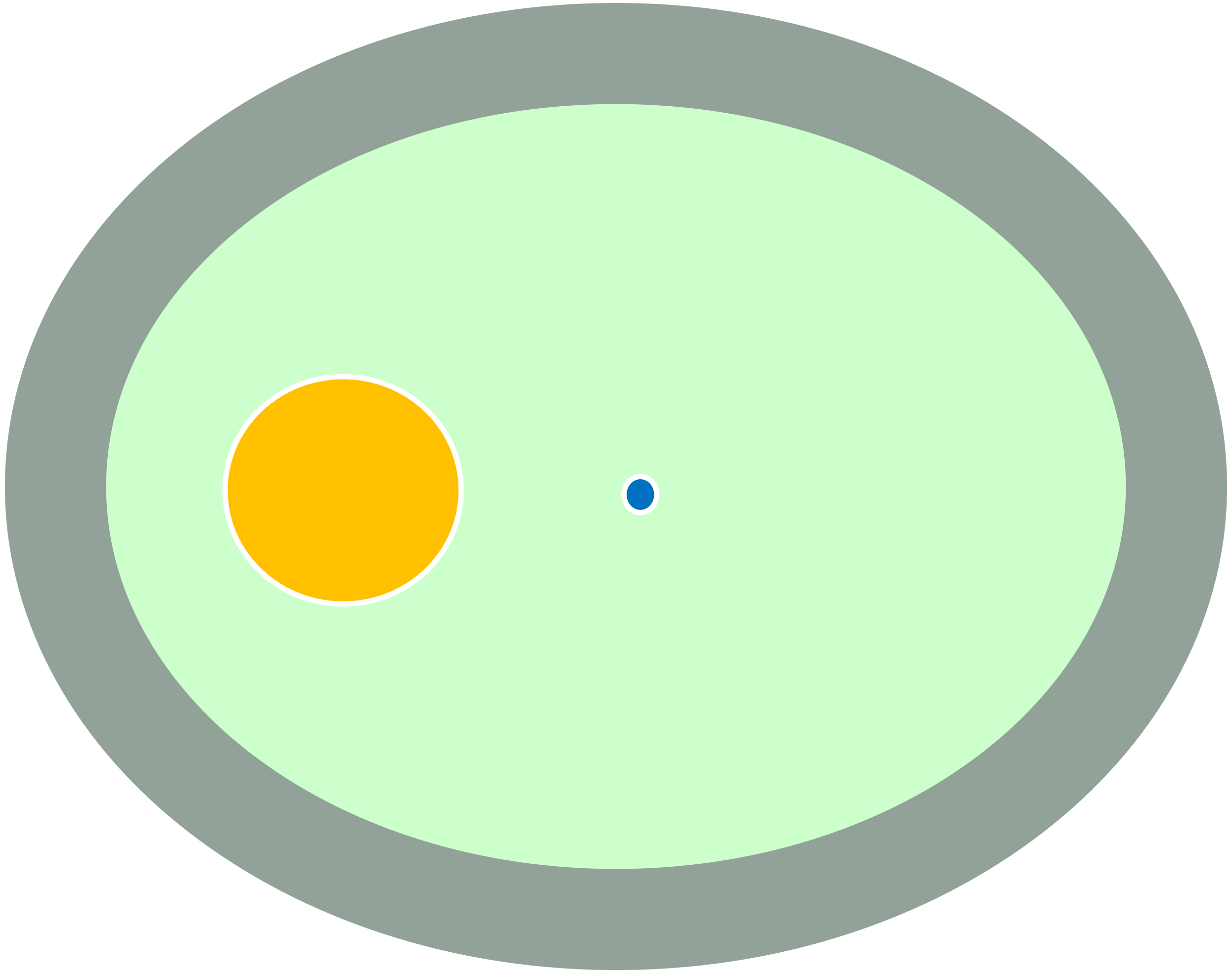
Accretion-induced collapse of white dwarfs



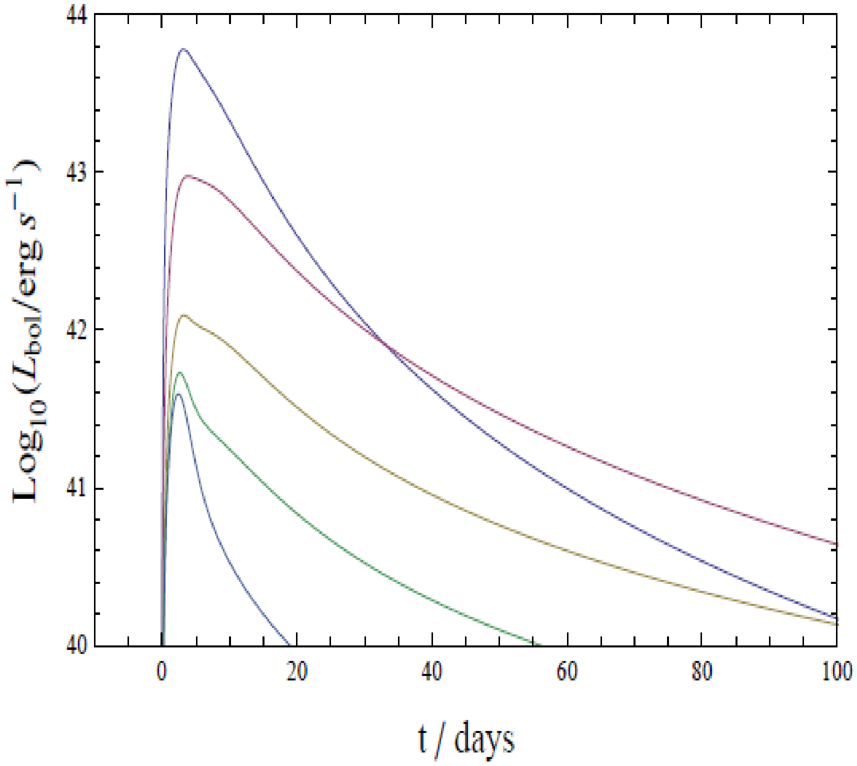


Metzger et al. 2009

Accretion-induced collapse of white dwarfs

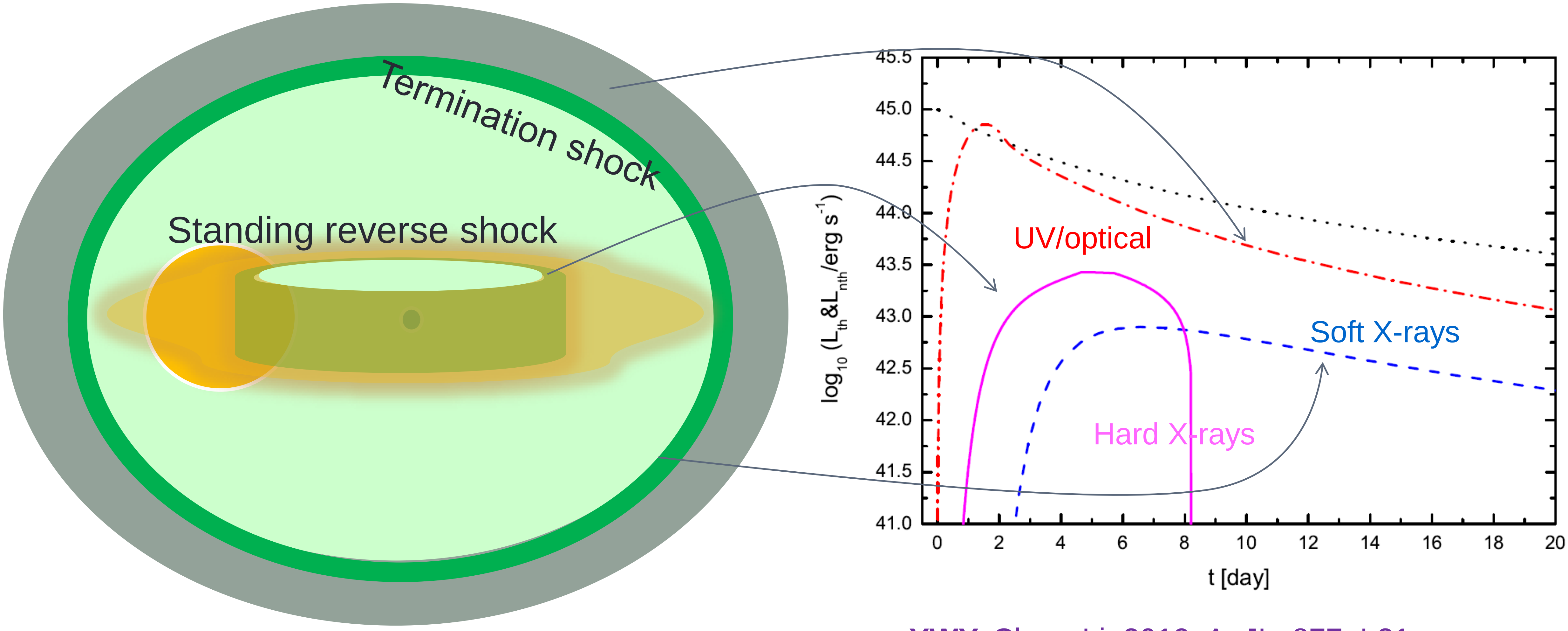


$$L_{\rm sd} = f_{\rm X} \frac{E_{\rm rot}}{t_{\rm sd}} \left(1 + \frac{t}{t_{\rm sd}}\right)^{-2}$$



YWY, Chen, Wang, 2019

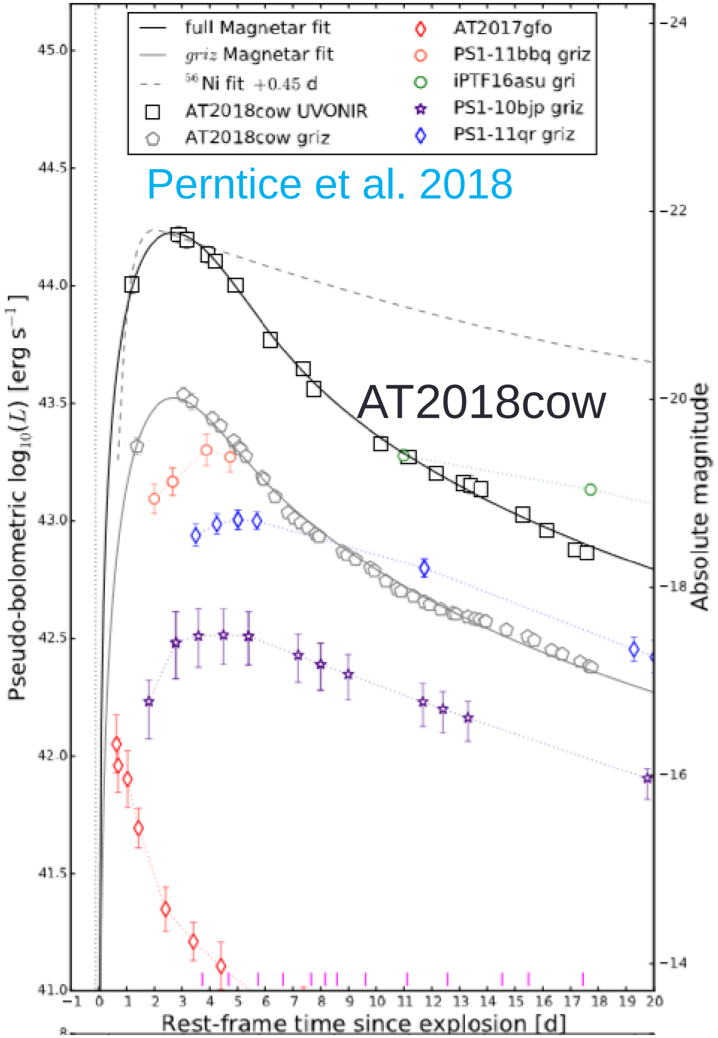
Accretion-induced collapse of white dwarfs



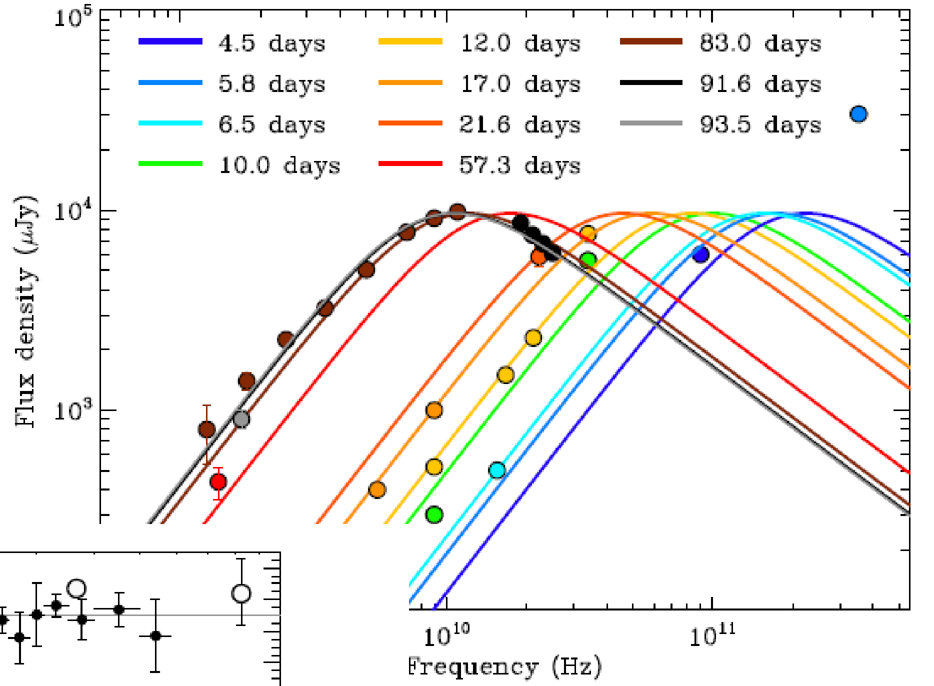
YWY, Chen, Li, 2019, ApJL, 877, L21

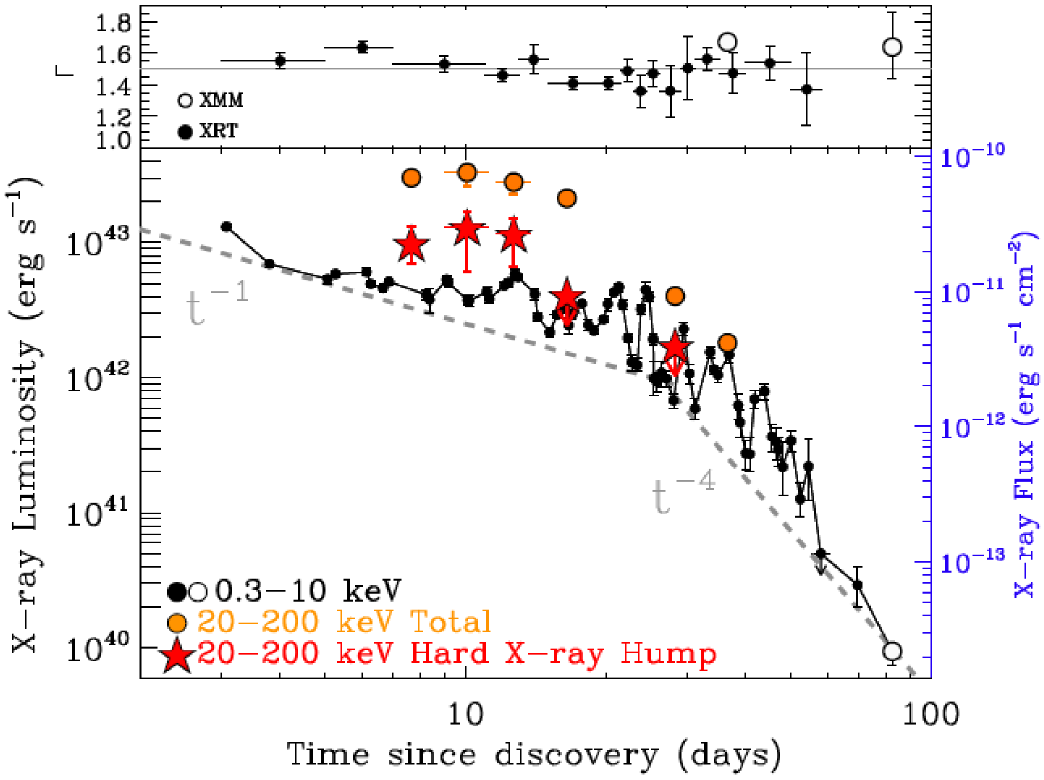
AT 2018cow

Perntice et al. 2018

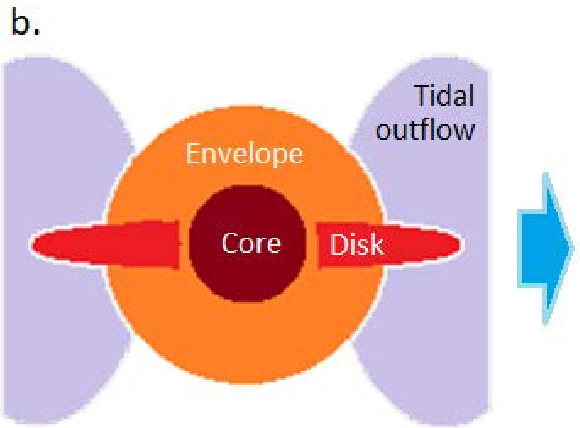


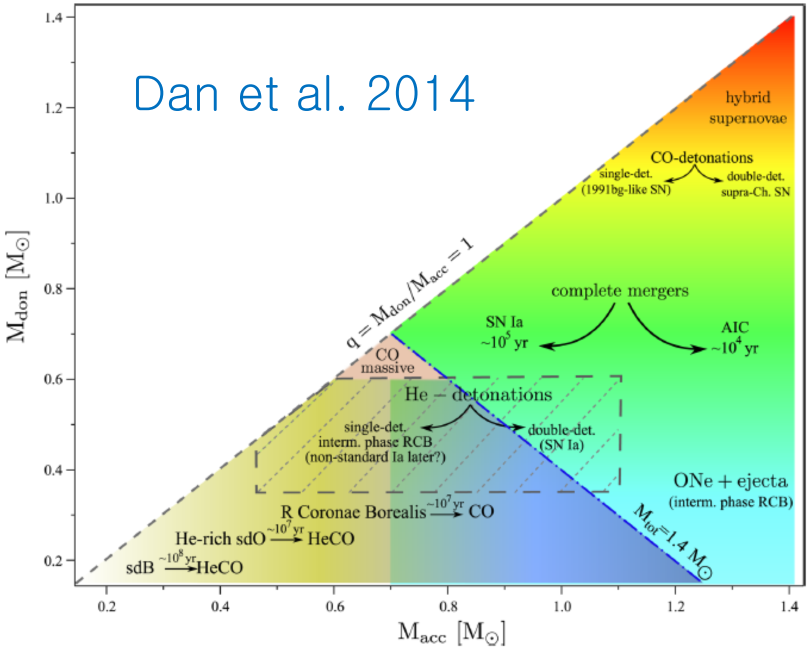
Margutti et al. 2018



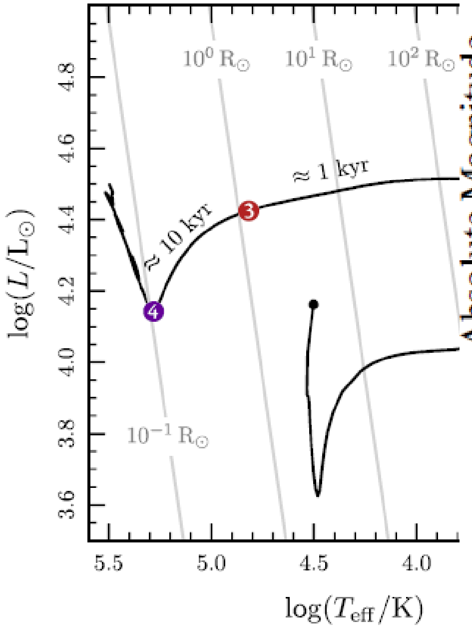


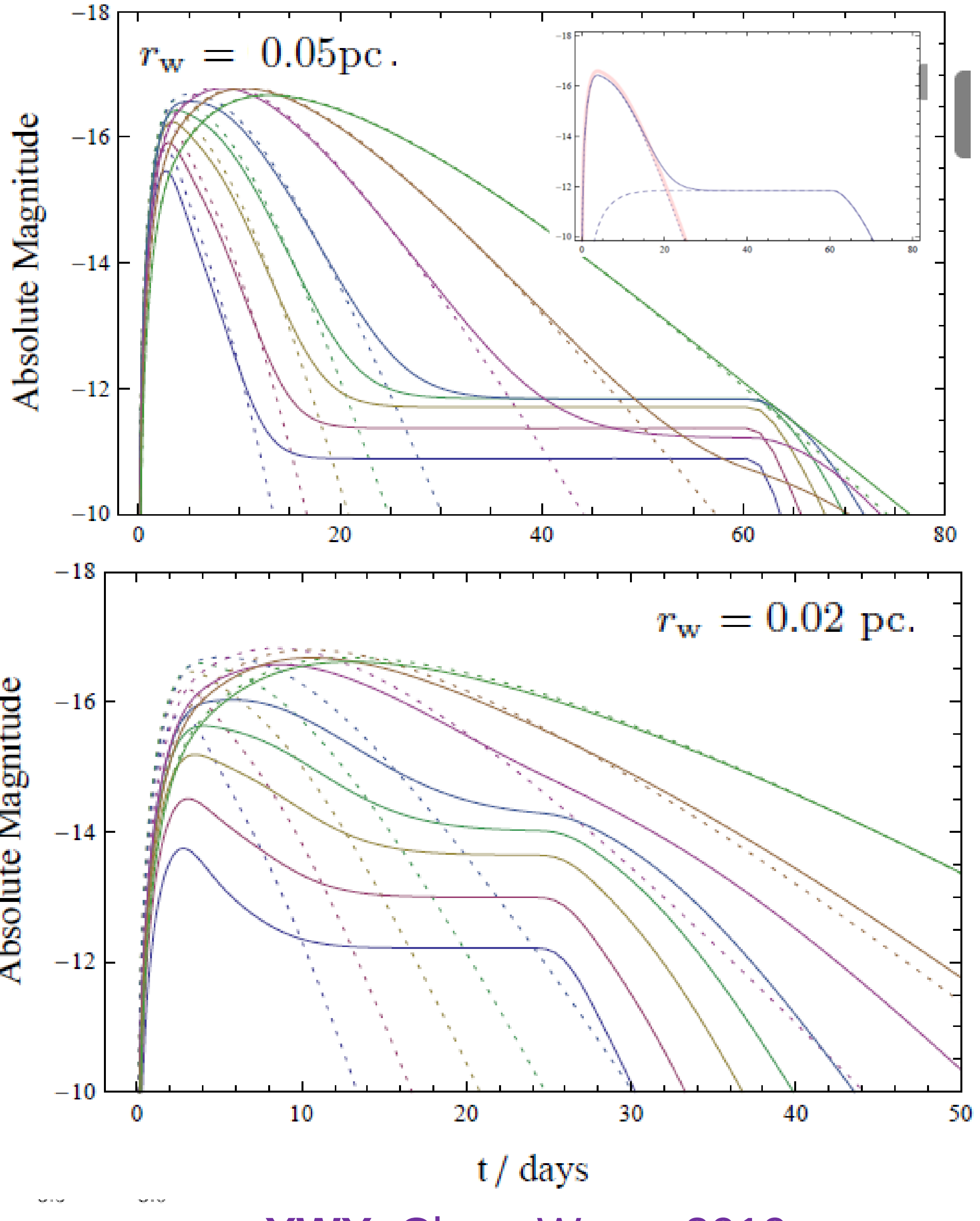
Evolution of WDM remnants





Dan et al. 2014





YWY, Chen, Wang, 2019

Summary

- NSs in the universe could have very different origins. Different masses? different EOSs?
- SLSNe and some long GRBs could have a uniform origin model, whose differences are caused by the different magnetic fields of the magnetar engines.
- A long-lived massive NS could exist in some short GRBs/NSMs (e.g. GW170817).
- The collapses of super-Chand WDs into a NS will be a very interesting target of transient surveys.
- Current and future transient surveys open a new era for researches on newborn NSs.