



# UNDERSTANDING VARIOUS OPTICAL TRANSIENT PHENOMENA WITH THE MAGNETAR ENGINE MODEL

---

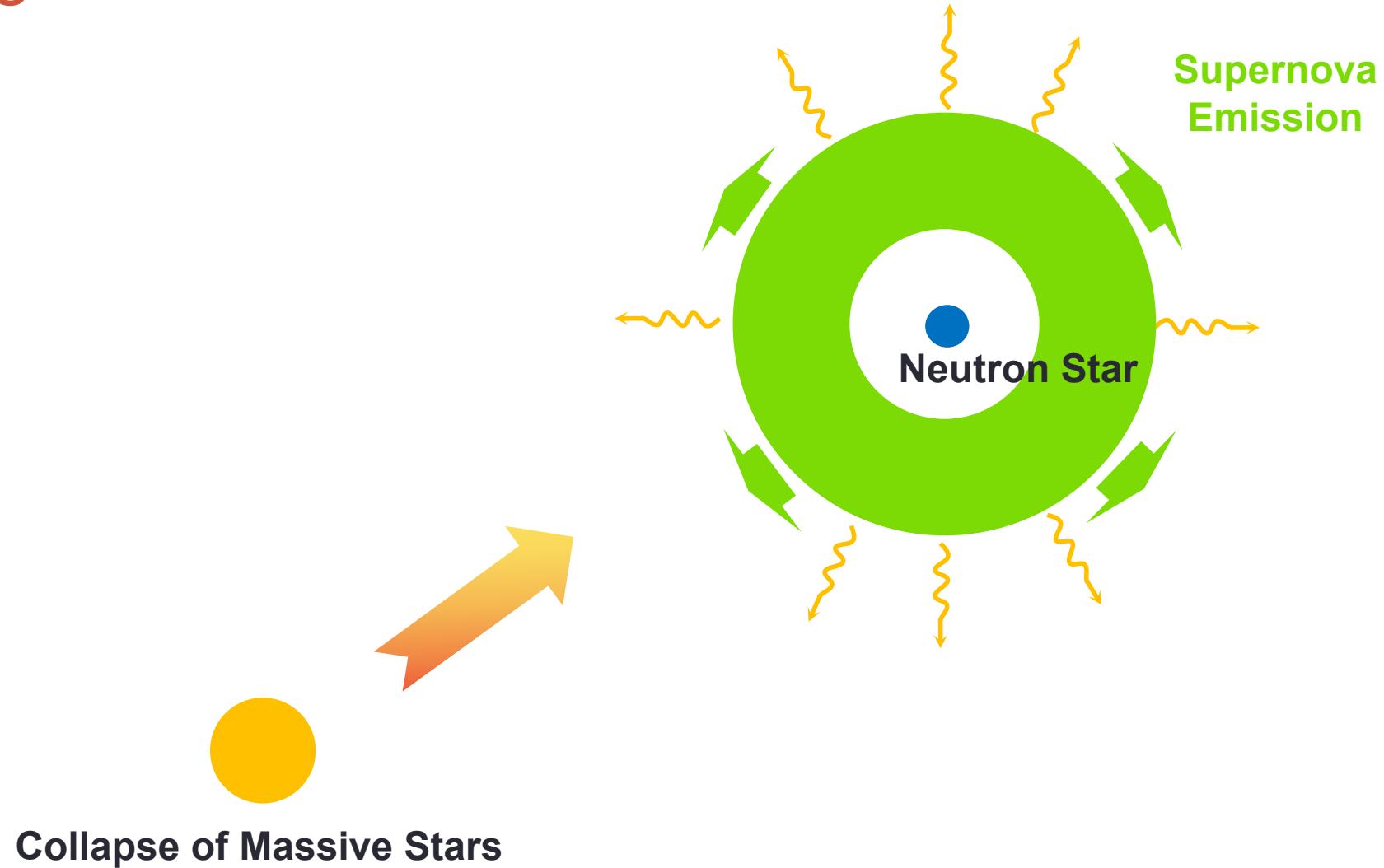
Yun-Wei YU

Central China Normal University (CCNU)

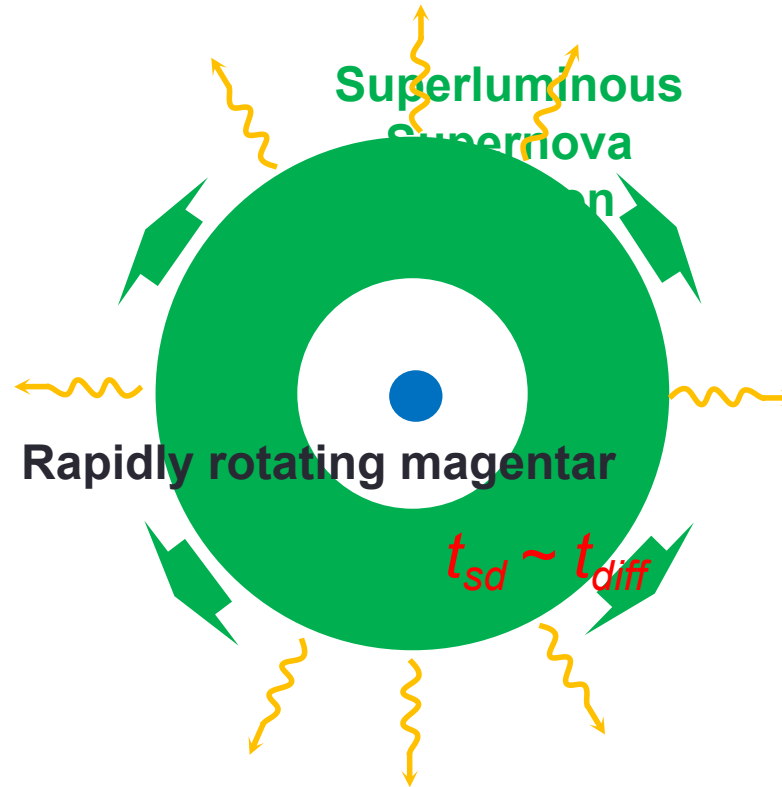
Collaborators: Aming Chen, Zi-Gao Dai, Shao-Ze Li, Liang-Duan Liu, Guang-Lei

Wu, Zhen-Dong Zhang, Jin-Ping Zhu

# Formation of rapidly rotating magnetars and different transients



# Formation of rapidly rotating magnetars and different transients



SN emission is powered by  
the Spin-down + decays of  $^{56}\text{Ni}$

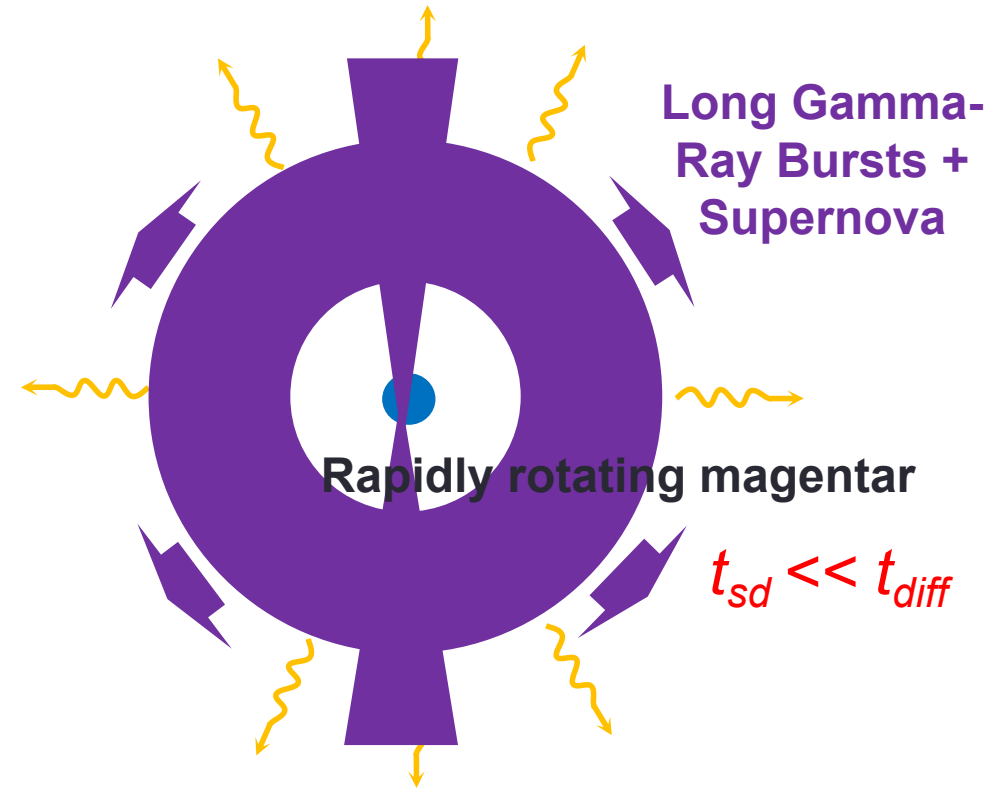
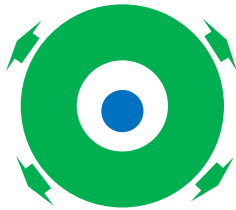
Collapse of Massive Stars

$B \sim 10^{14}\text{G}$ ,  $P \sim (1-10)\text{ms}$   
Kasen & Bildsten (2010);  
Yu et al. (2017)

# Formation of rapidly rotating magnetars and different transients



**SLSN**  
 $B \sim 10^{14} \text{G}$ ,  $P \sim (1-10) \text{ms}$   
*Kasen & Bildsten (2010);*  
*Yu et al. (2017)*



**SN emission is powered by  
 the Spin-down + decays of  $^{56}\text{Ni}$**

**Collapse of Massive Stars**

*Usov (1992); Dai & Lu (1998a,b)*  
*Zhang, Yu, Liu (2022)*

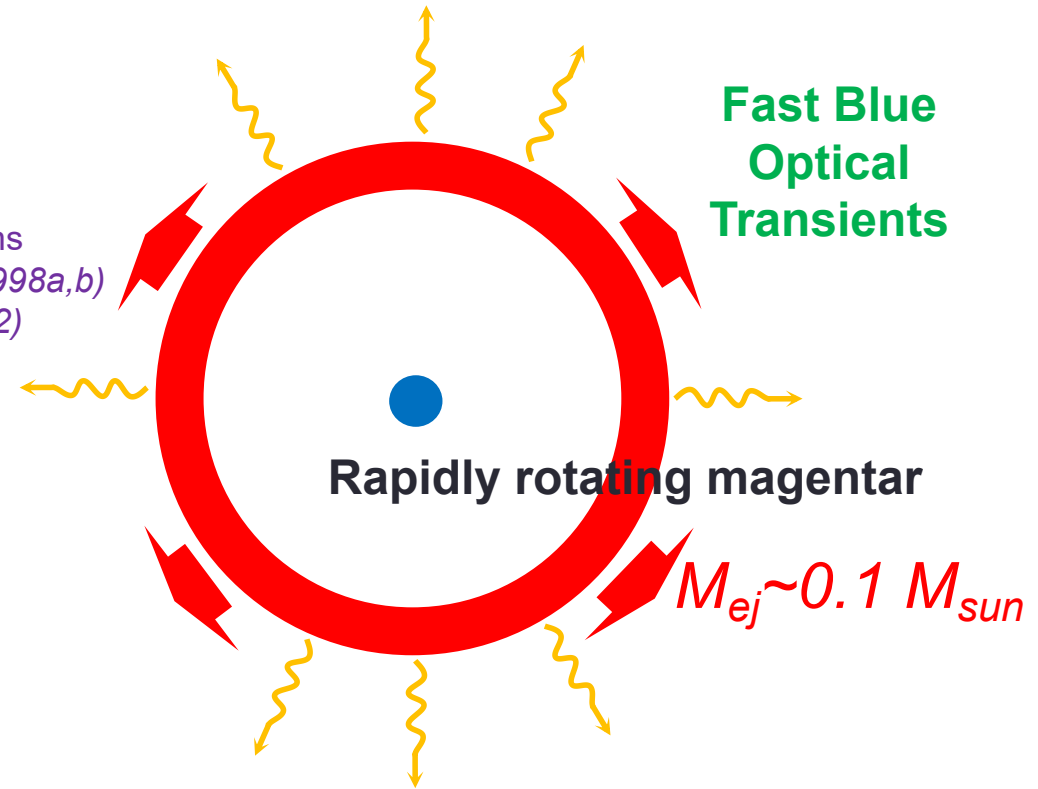


# Formation of rapidly rotating magnetars and different transients

**SLSN**  
 $B \sim 10^{14} \text{G}$ ,  $P \sim (1-10) \text{ms}$   
*Kasen & Bildsten (2010);*  
*Yu et al. (2017)*



**LGRB + SN**  
 $B \sim 10^{15} \text{G}$ ,  $P \sim (1-10) \text{ms}$   
*Usov (1992); Dai & Lu (1998a,b)*  
*Zhang, Yu, Liu (2022)*

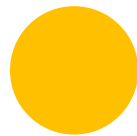


**Fast Blue  
 Optical  
 Transients**

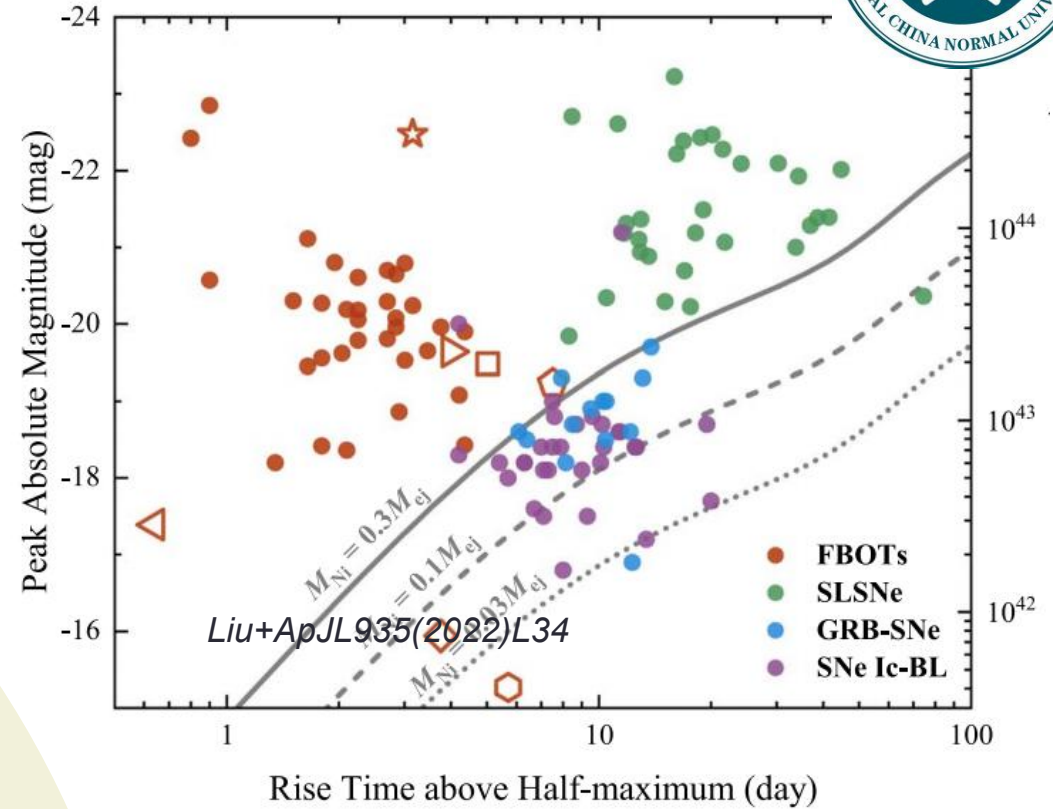
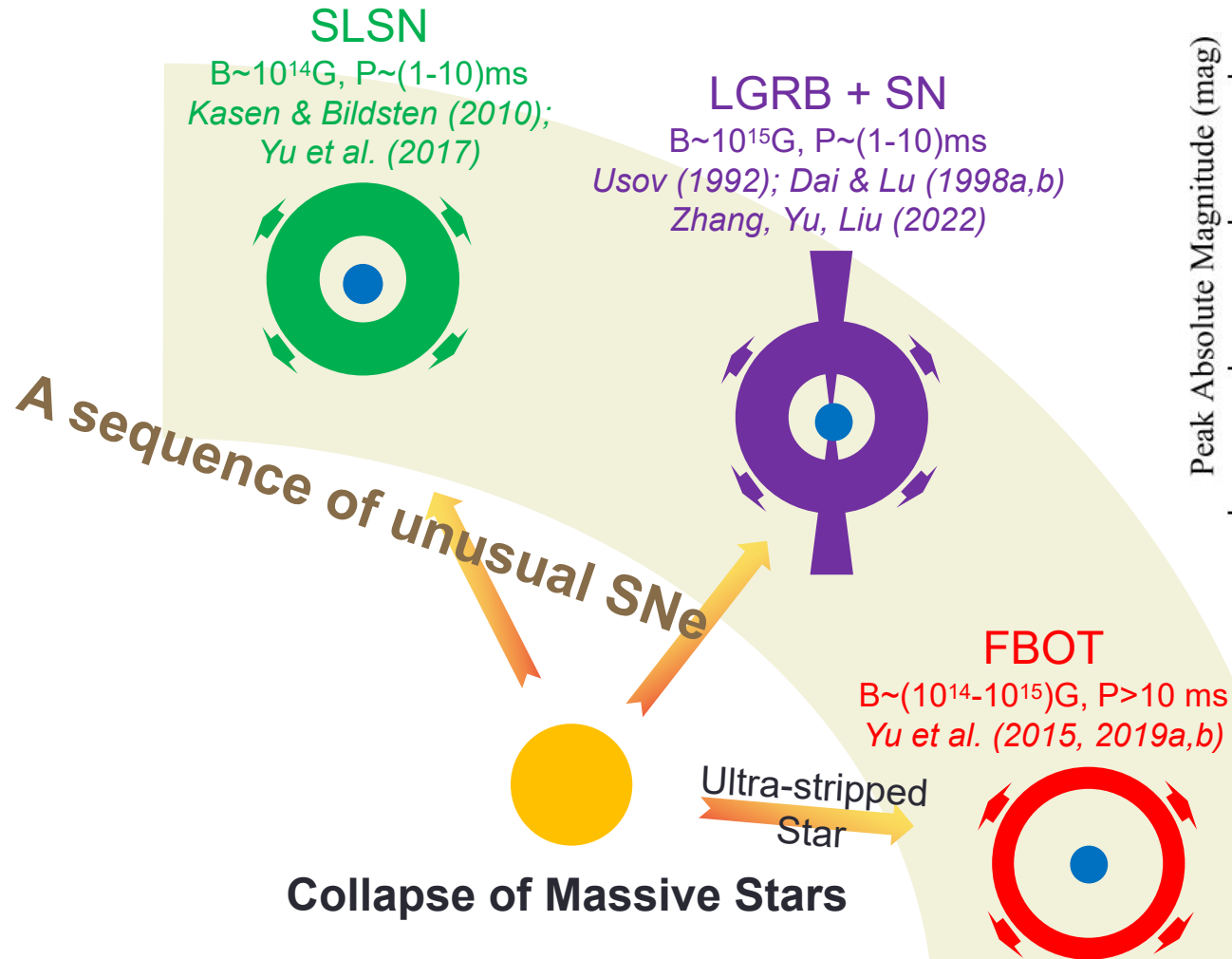
**SN emission is powered by  
 the Spin-down + decays of  $^{56}\text{Ni}$**

$B \sim (10^{14}-10^{15}) \text{G}$ ,  $P > 10 \text{ms}$   
*Yu et al. (2015, 2019a,b); Liu+2022*

**Collapse of Massive Stars**



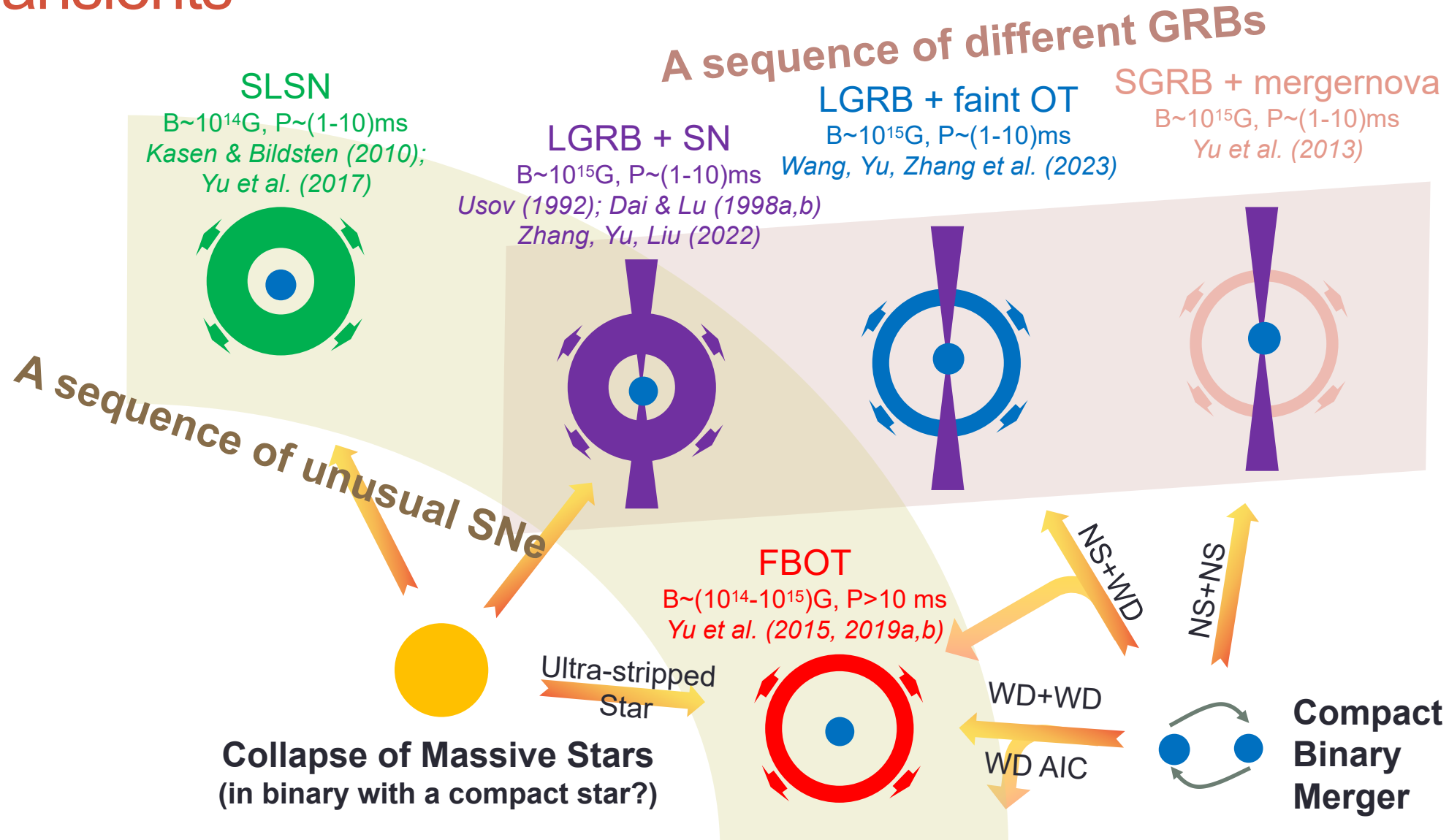
# Formation of rapidly rotating magnetars and different transients



(in binary with a compact star?)  
 see Jin-Ping Zhu's talk



# Formation of rapidly rotating magnetars and different transients



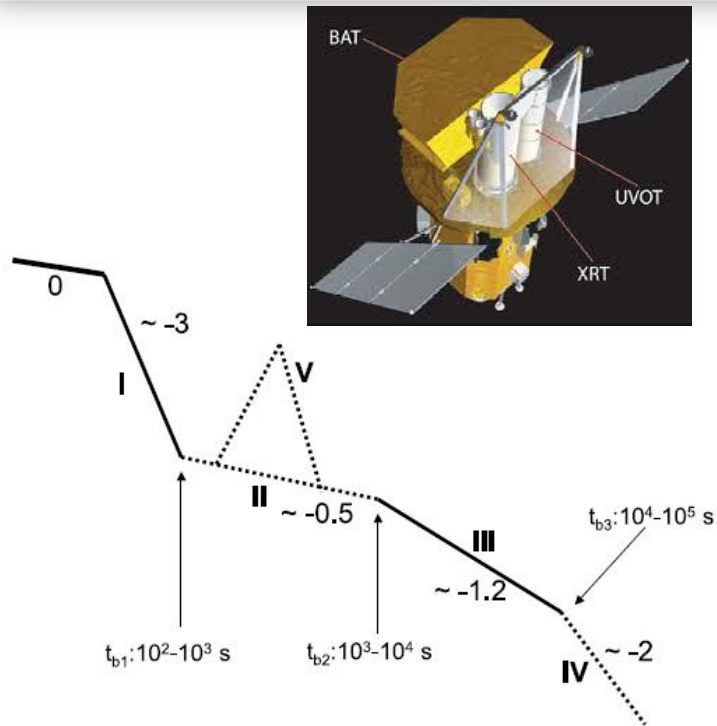
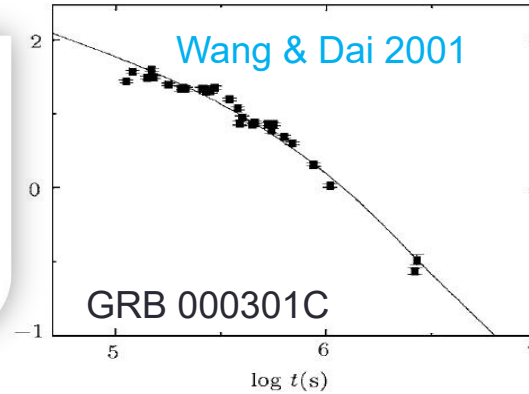


# Do such rapidly rotating magnetars exist? Implication from GRB afterglows

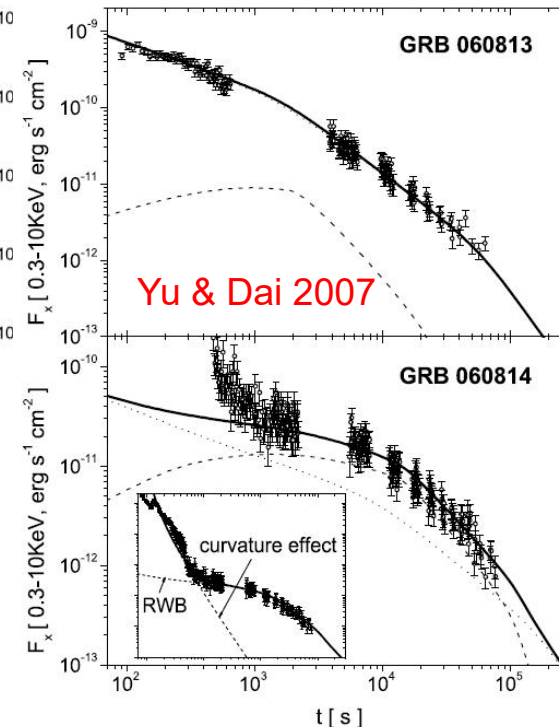
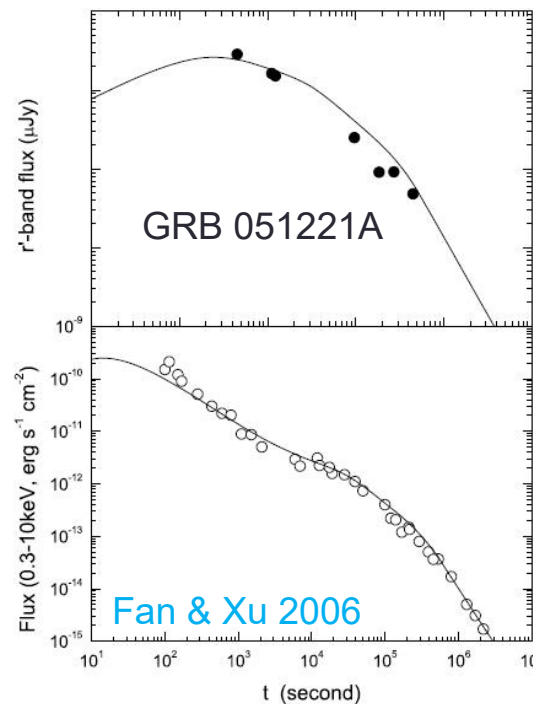
VOLUME 81, NUMBER 20      PHYSICAL REVIEW LETTERS      16 NOVEMBER 1998

**$\gamma$ -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)



Zhang et al. 2006

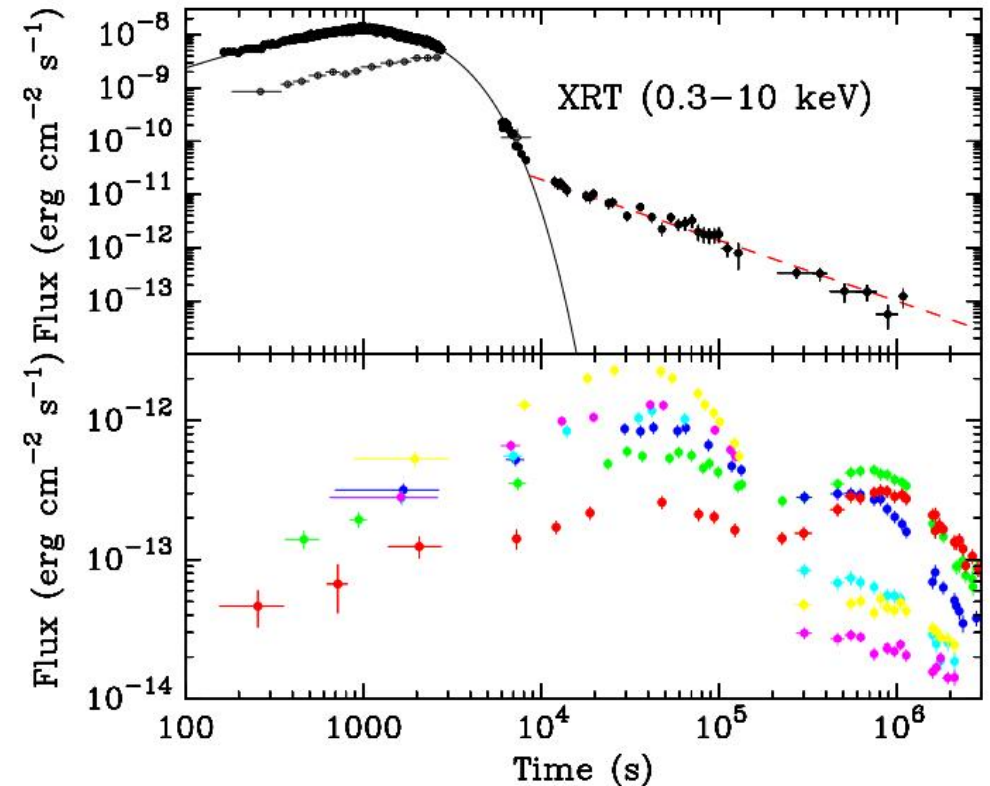
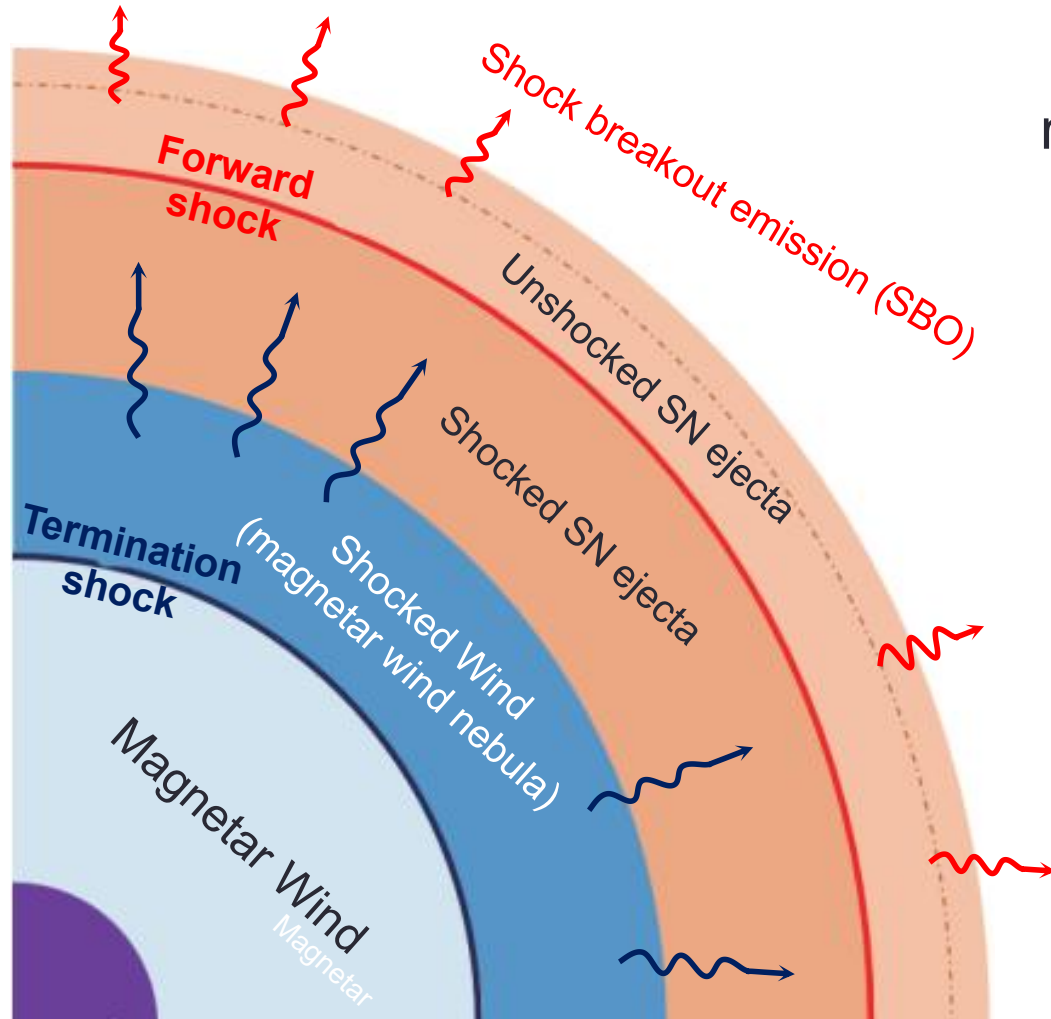




# How does the spin-down energy affect the SN emission?

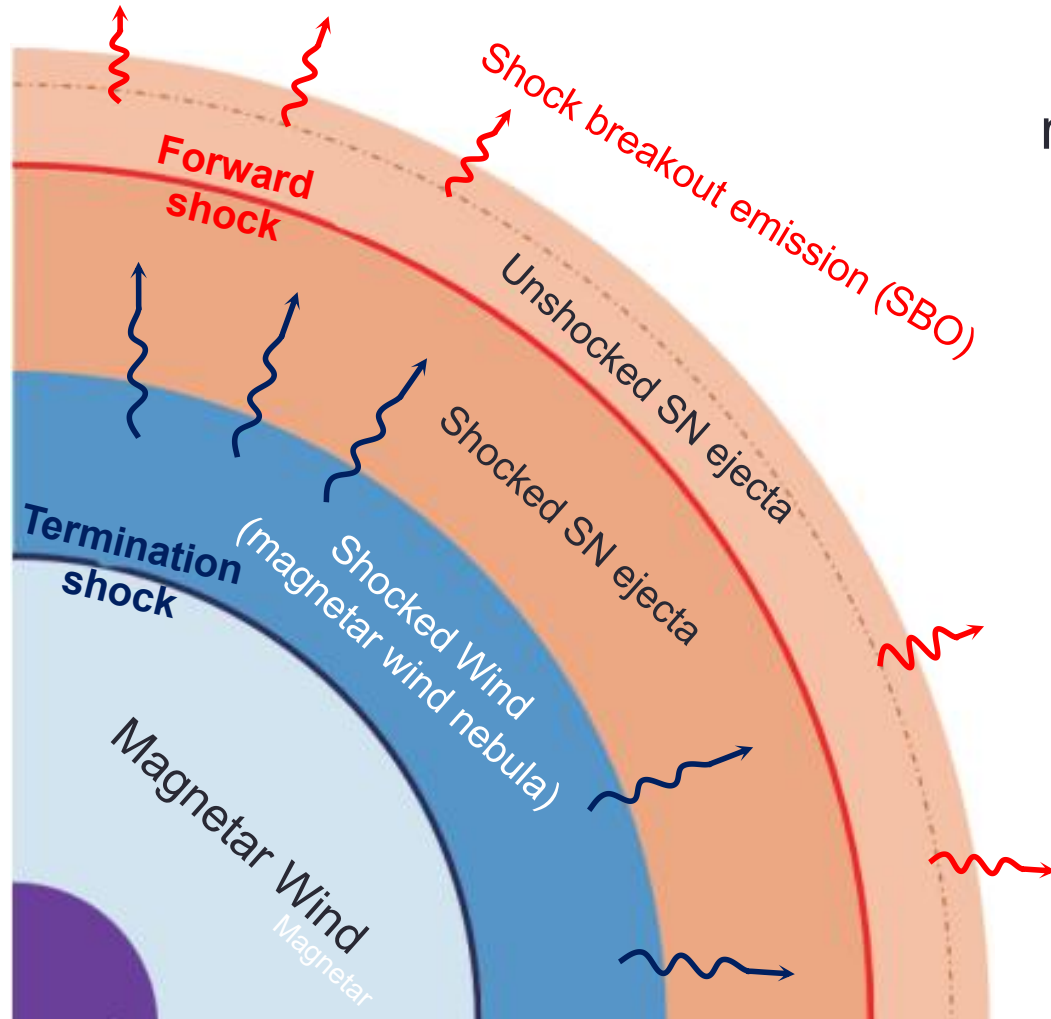


The interaction between the magnetar wind and the SN ejecta

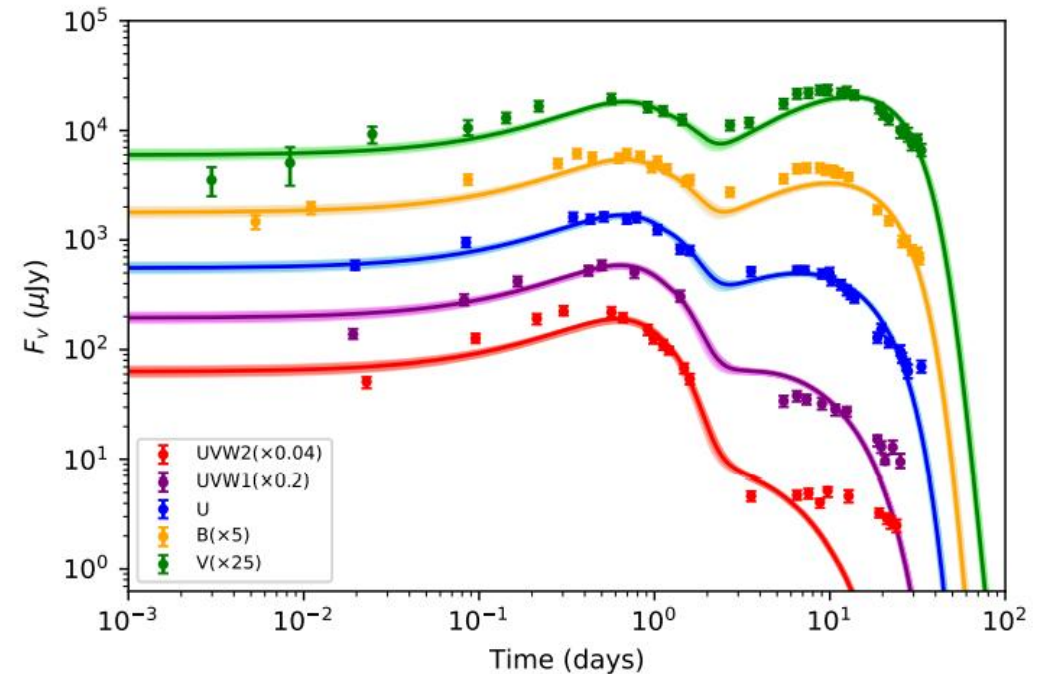




# How does the spin-down energy affect the SN emission?



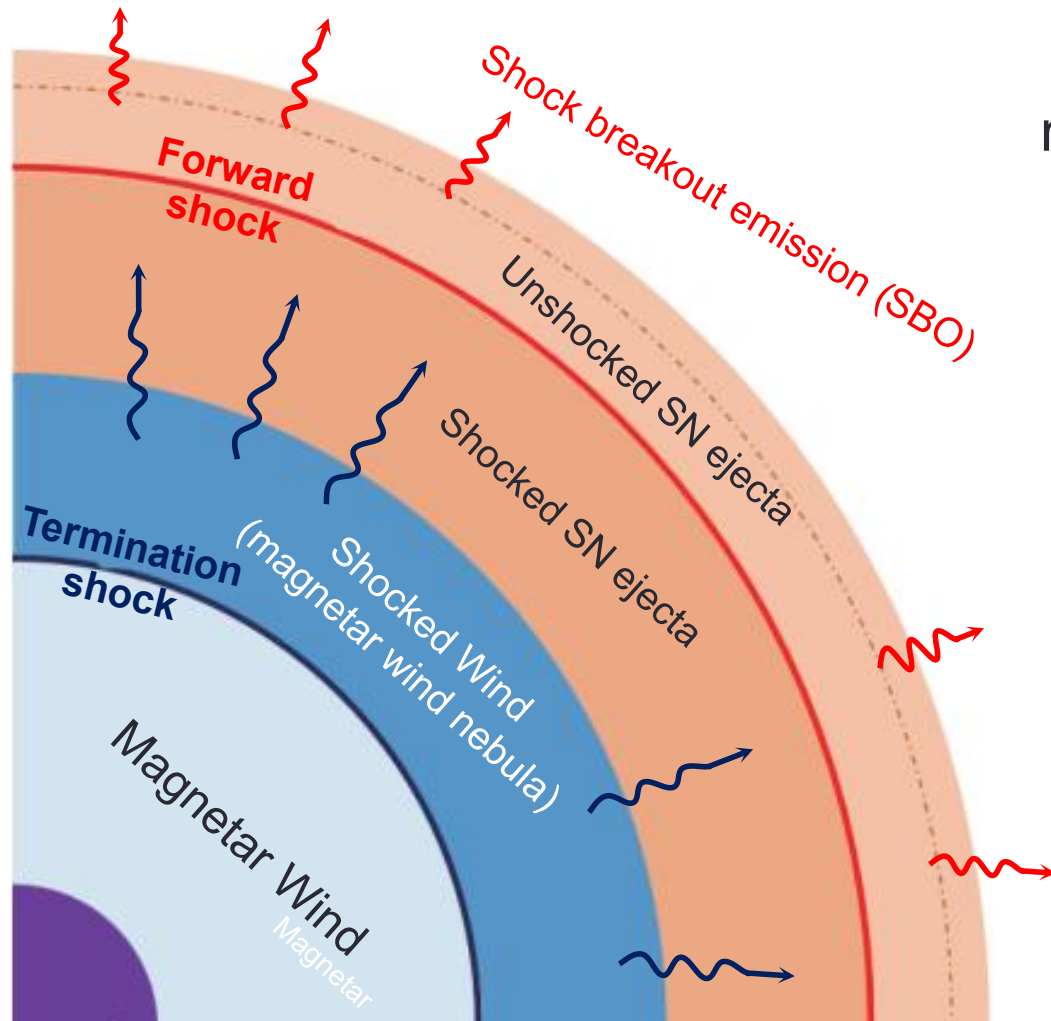
The interaction between the magnetar wind and the SN ejecta



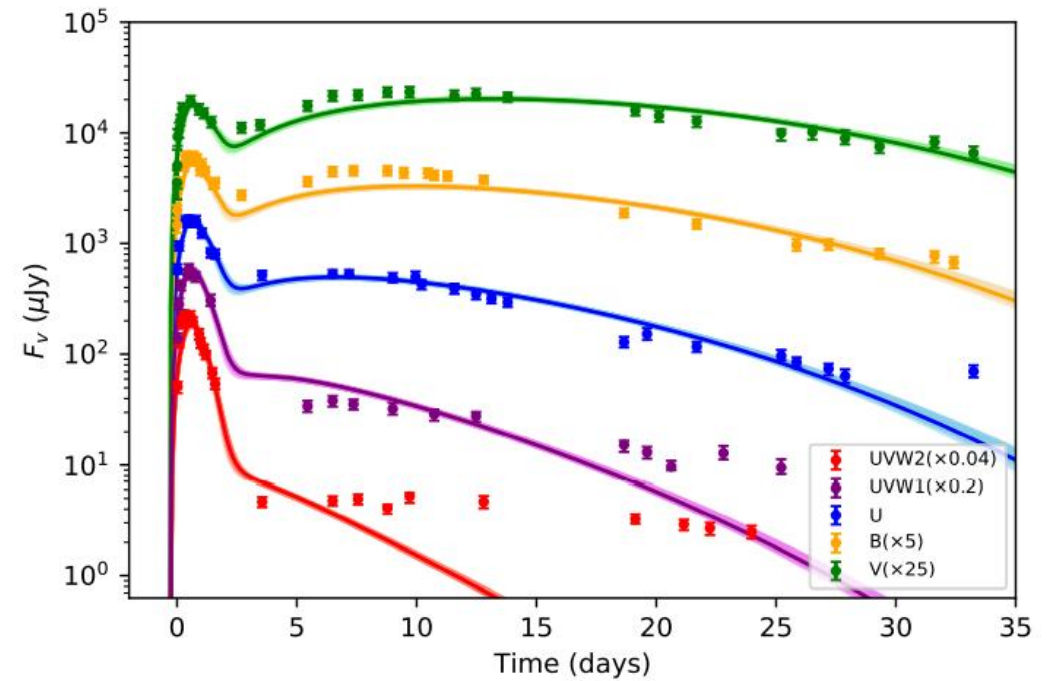
Zhang et al. 2022, ApJ, 936, 54



# How does the spin-down energy affect the SN emission?



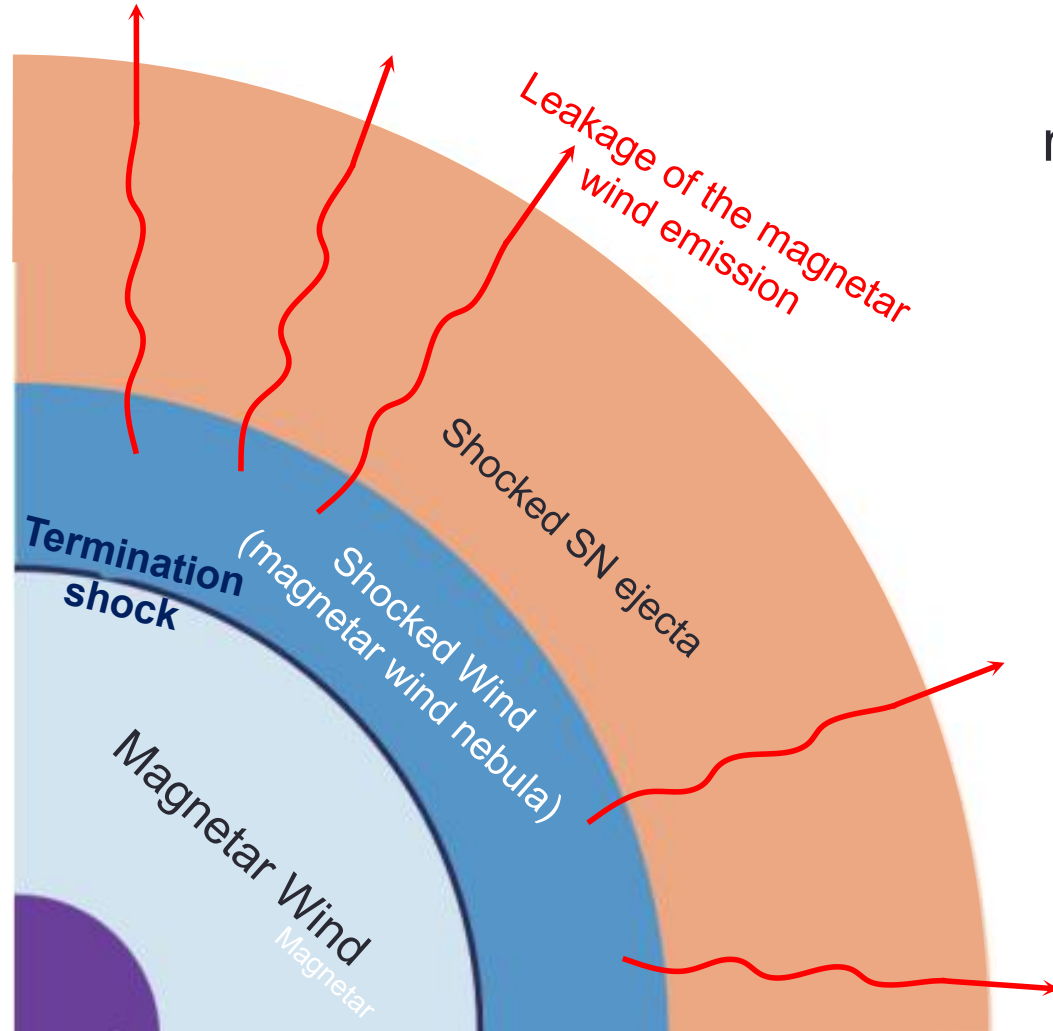
The interaction between the magnetar wind and the SN ejecta



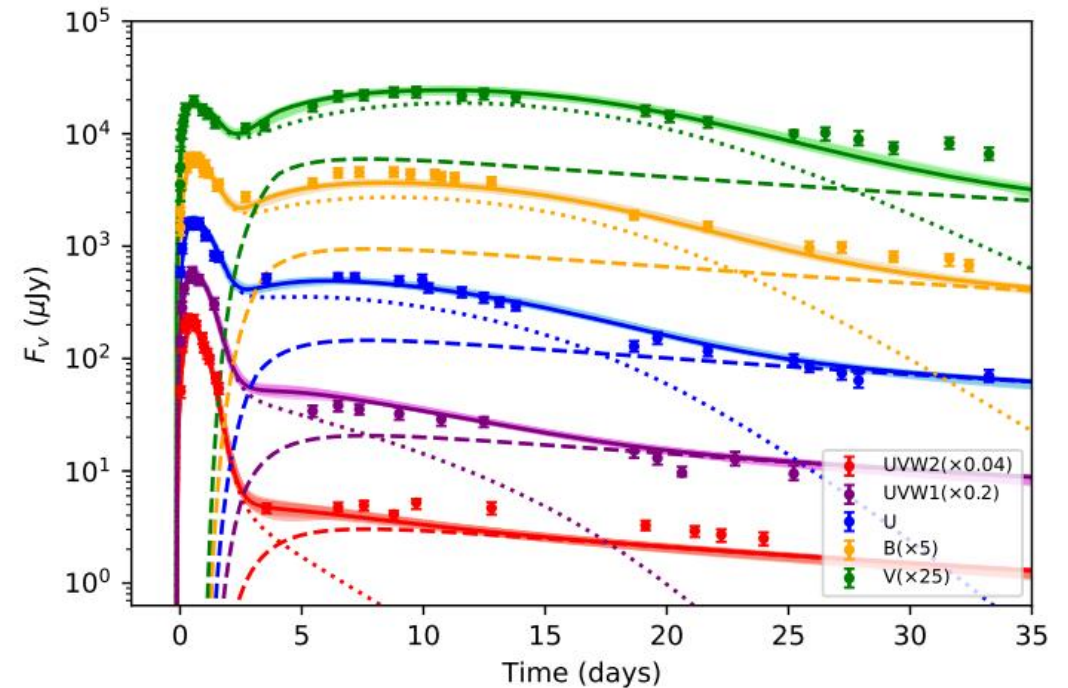
Zhang et al. 2022, ApJ, 936, 54



# How does the spin-down energy affect the SN emission?



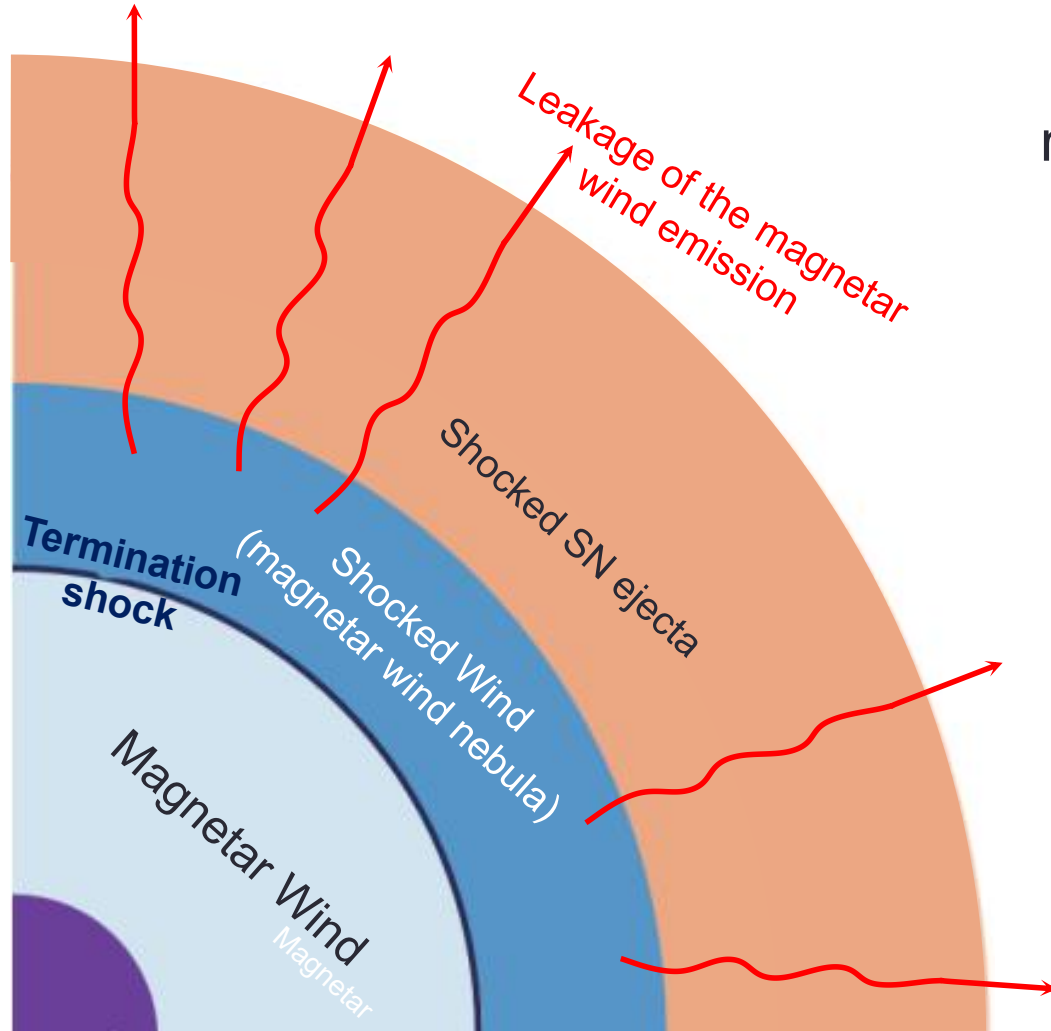
The interaction between the magnetar wind and the SN ejecta



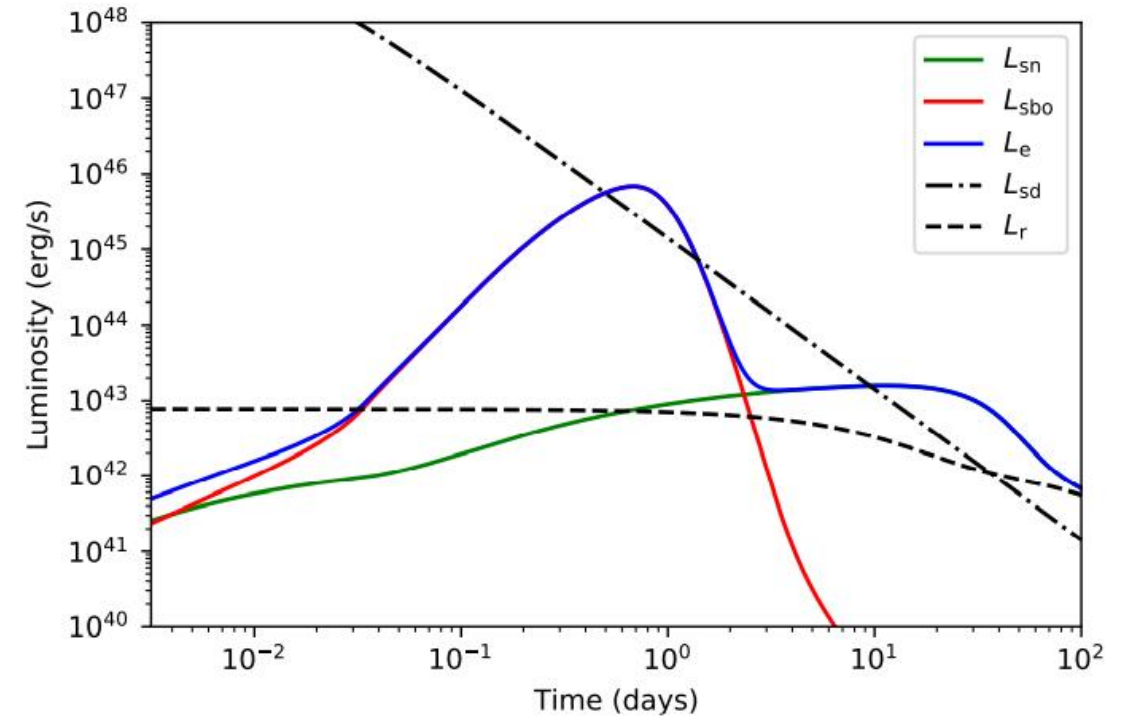
Zhang et al. 2022, ApJ, 936, 54



# How does the spin-down energy affect the SN emission?



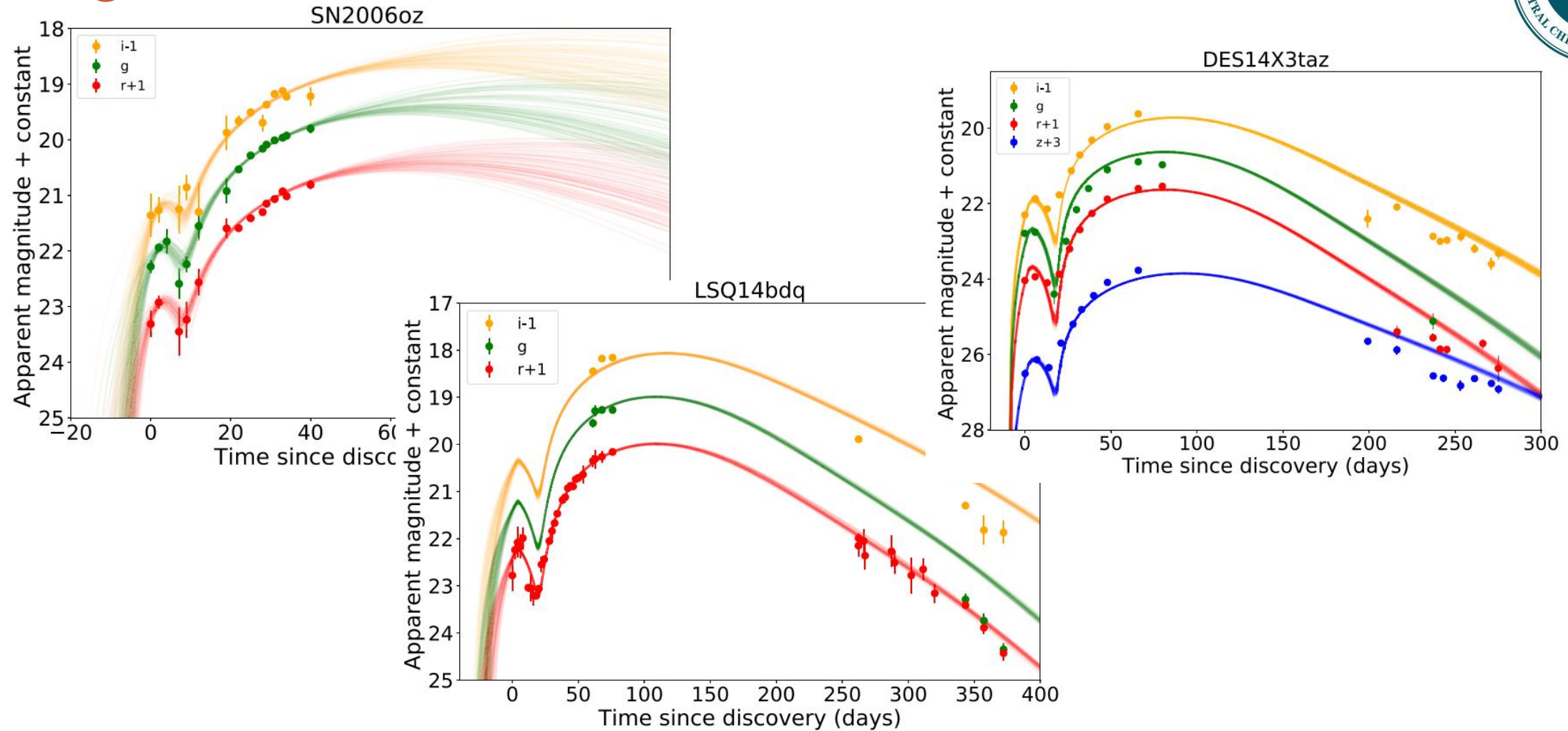
The interaction between the magnetar wind and the SN ejecta



Zhang et al. 2022, ApJ, 936, 54

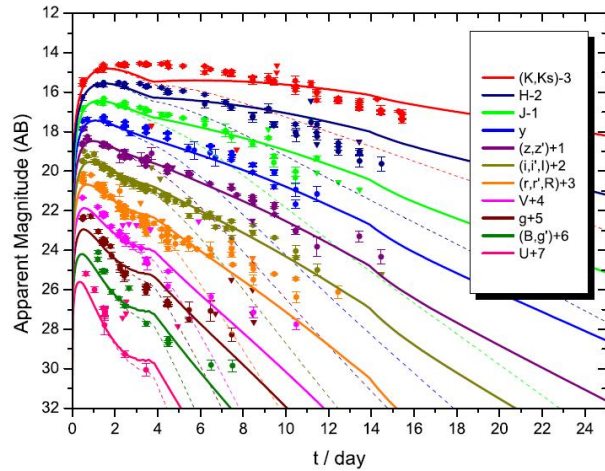


# Magnetar wind-driven SBO in SLSNe

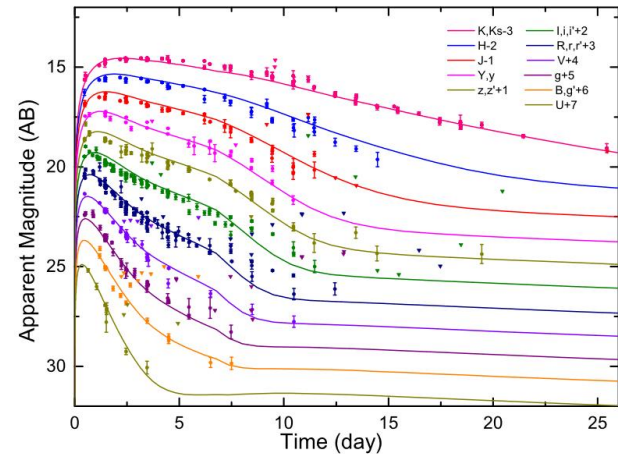




# Non-thermal component in mergernvoa emissio



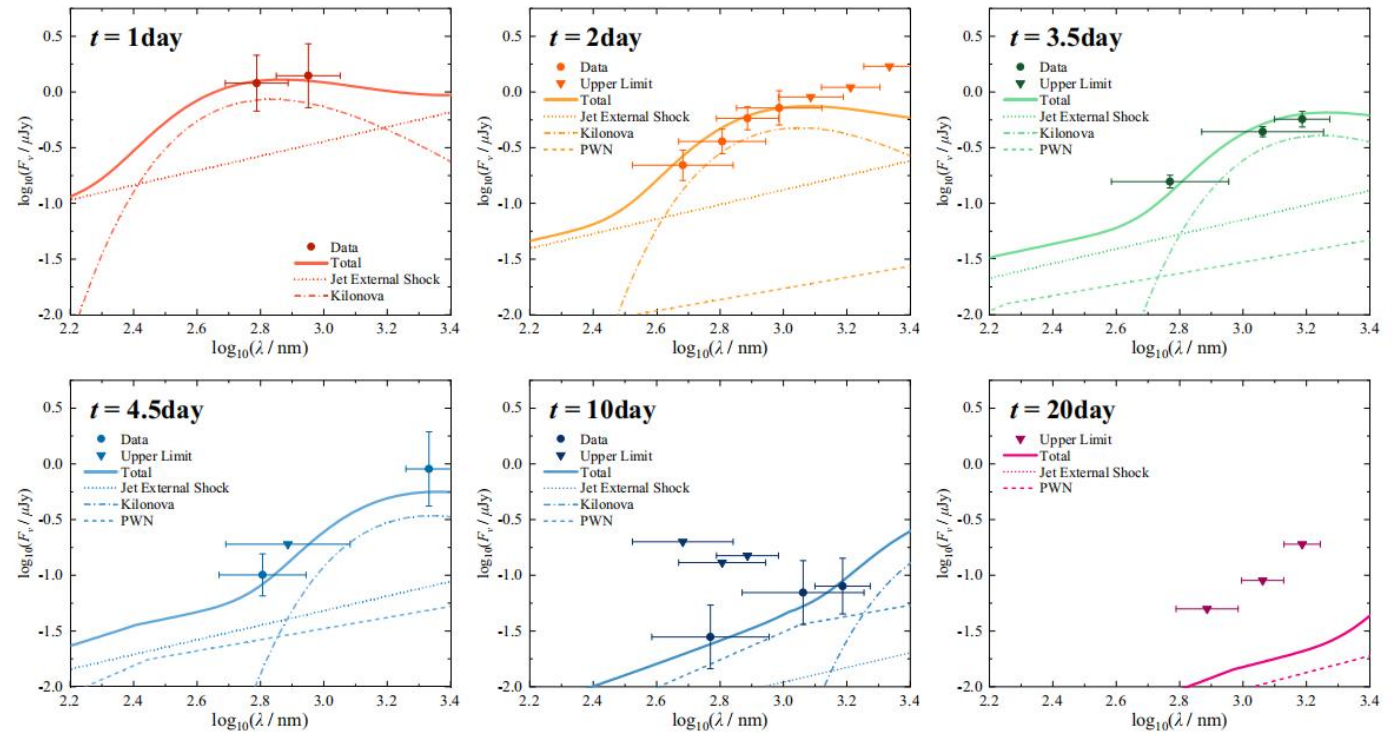
YWY, Liu, Dai, 2018, ApJ, 861, 114



Ren et al. 2019, ApJ, 885, 60

AT2017gfo emission after GRB 170817A

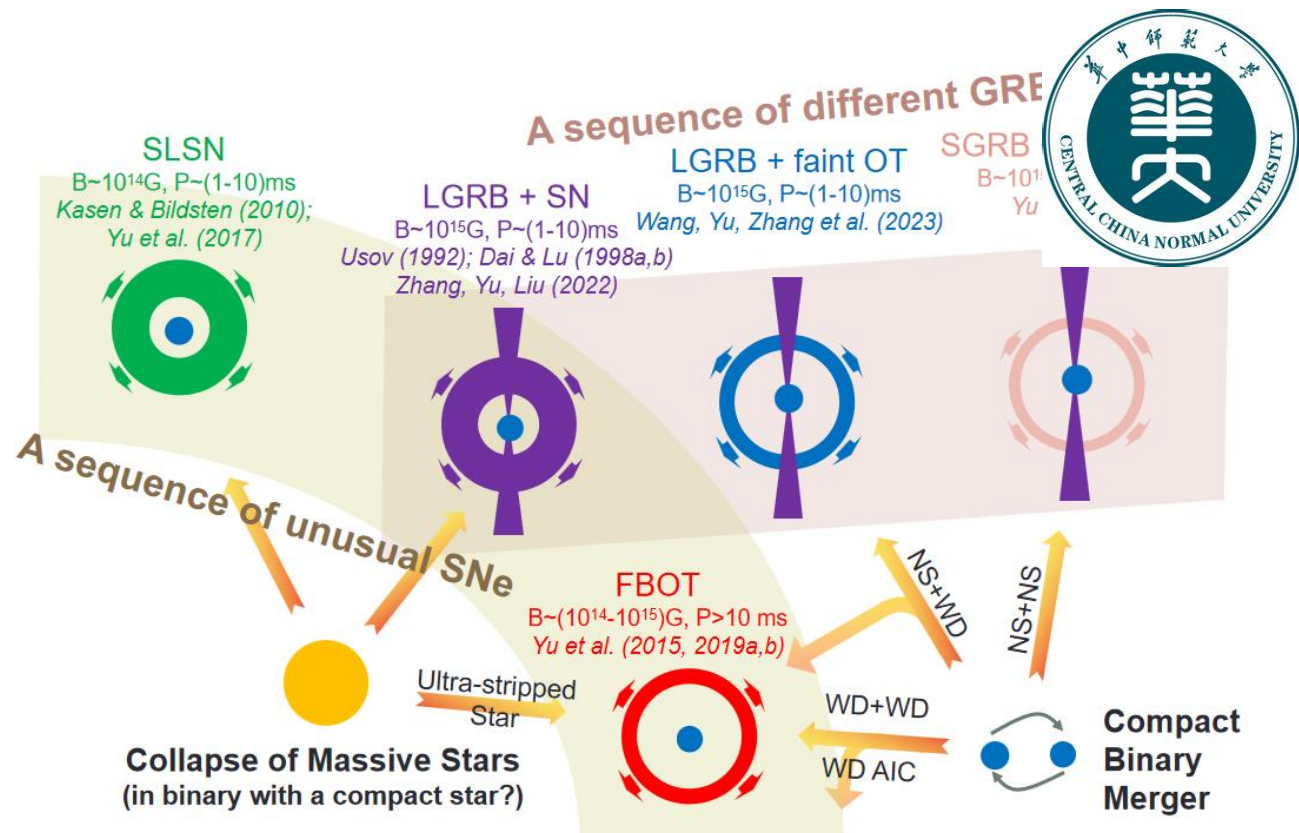
Optical excess in the afterglow of GRB 160821B



Wu, Yu, Zhu\_AA654(2021)A124

# Summary

- Formation of a rapidly rotating magnetar can substantially influence the optical transient emission from the ejecta material during the explosion/merger event.
- The magnetar engine can provide an explanation for a remarkable fraction of GRBs and associated SNe/mergernovae(kilonovae), SLSNe, and FBOTs.



- The interaction between the magnetar wind and the ejecta needs to be investigated in more detail, in confront with more observational constraints.
- In the magnetar engine model, the different GRB, SLSN, and FBOT phenomena could have an united origin and explosion mechanism, the progenitors of which may be in a binary with a close companion star.