

# MAGNETARS AND THE TRANSIENT HIGH ENERGY SKY

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European Research Council

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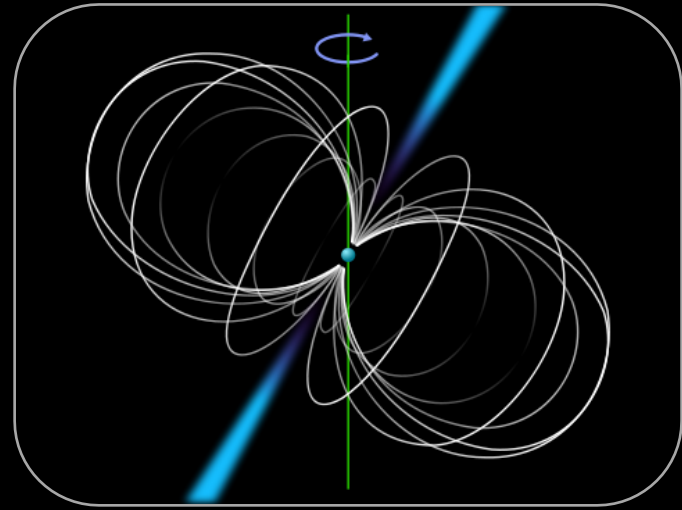


GOBIERNO  
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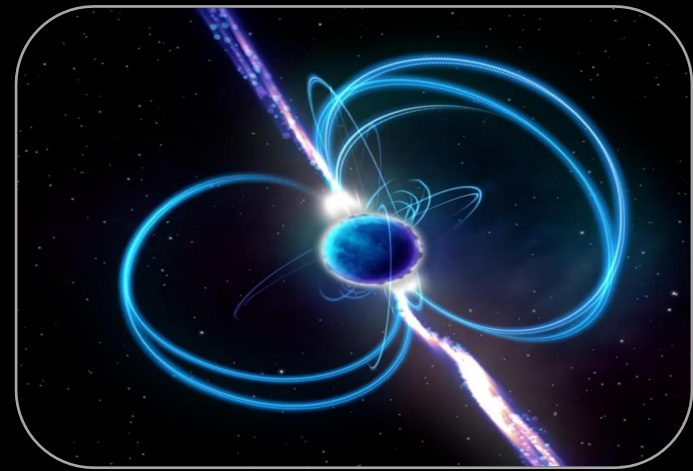
MINISTERIO  
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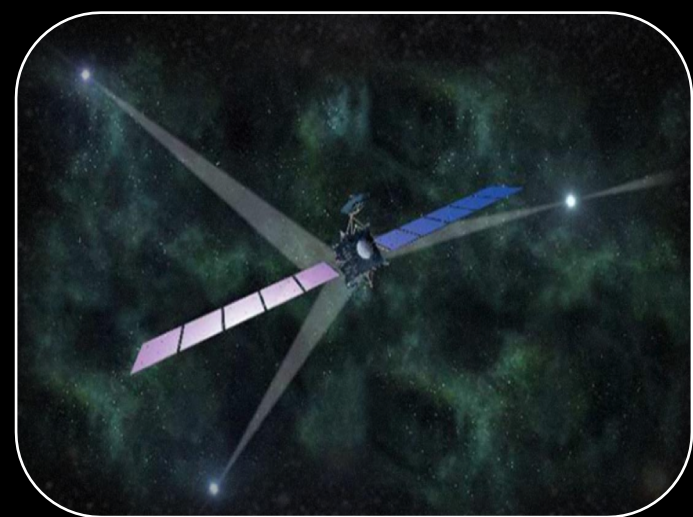




This is not a real pulsar... stop dreaming about dipoles.



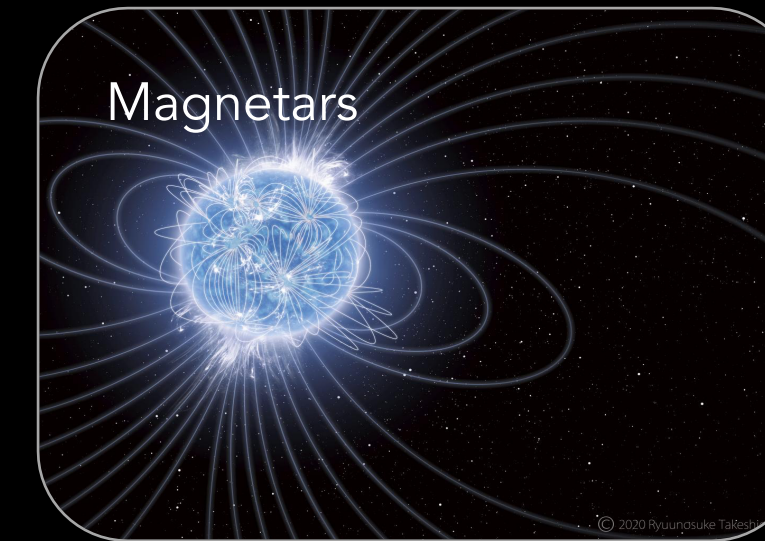
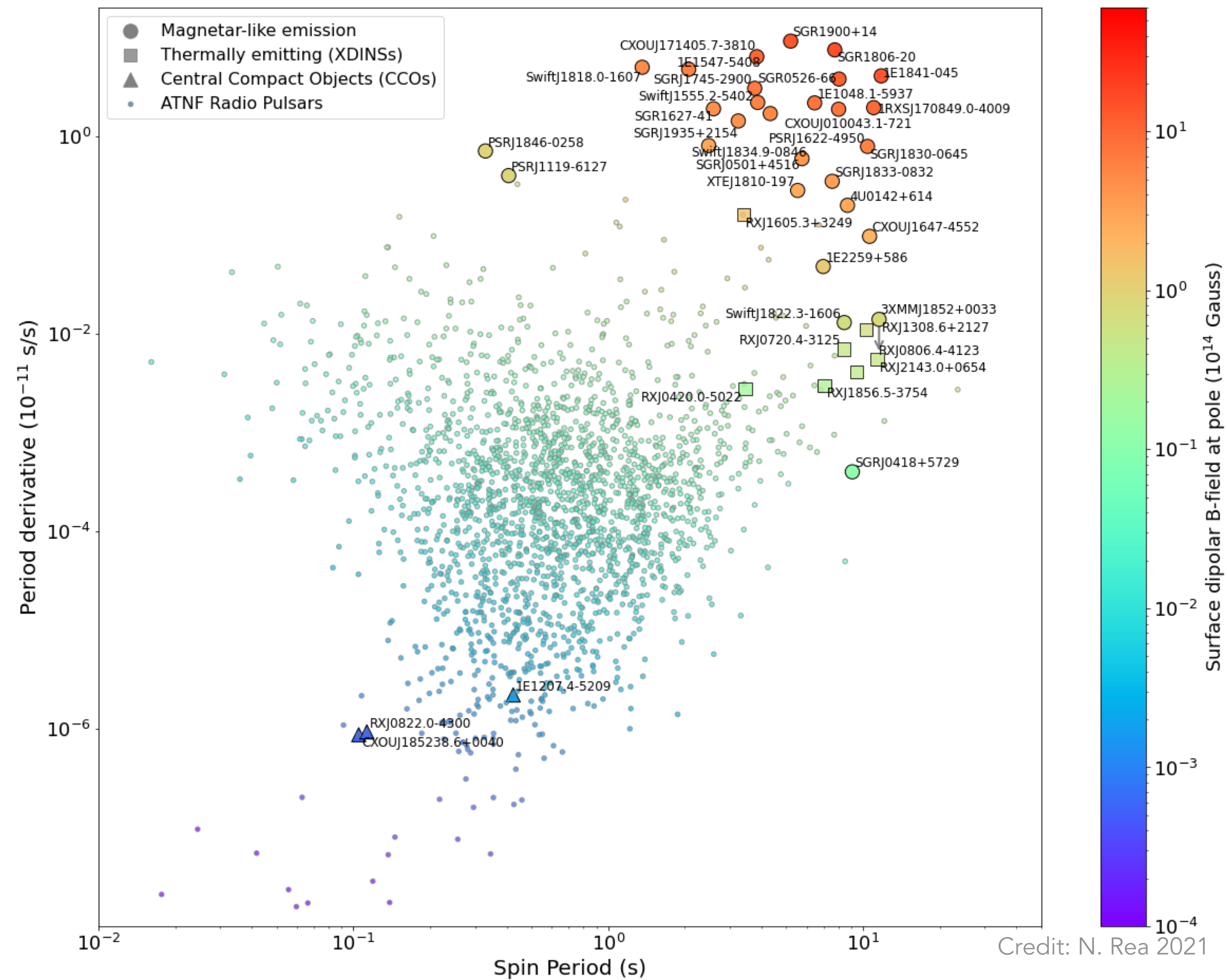
Newly discovered long periodic radio transients are challenging our understanding of pulsars.



We will soon be able to travel beyond the Solar System and come back to tell the next generations.

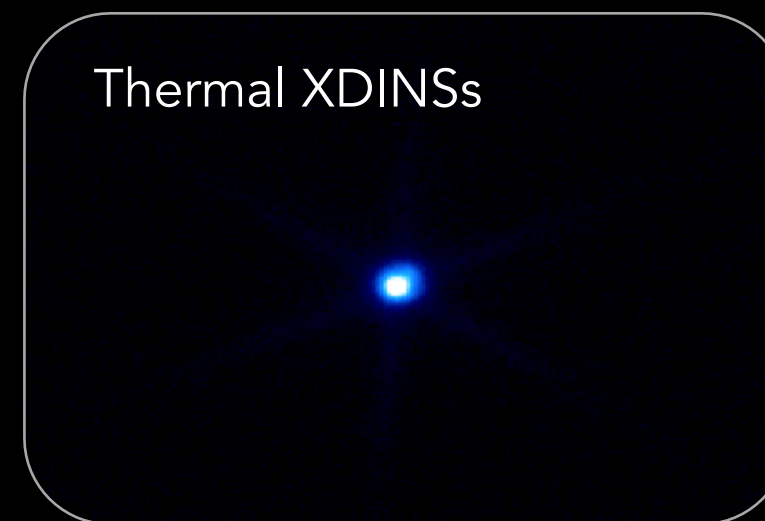


# THE ISOLATED PULSAR POPULATION



# MAGNETARS

Powered by magnetic energy.  
Characterized by outbursts and  
flares. Typically emitting in X-rays.



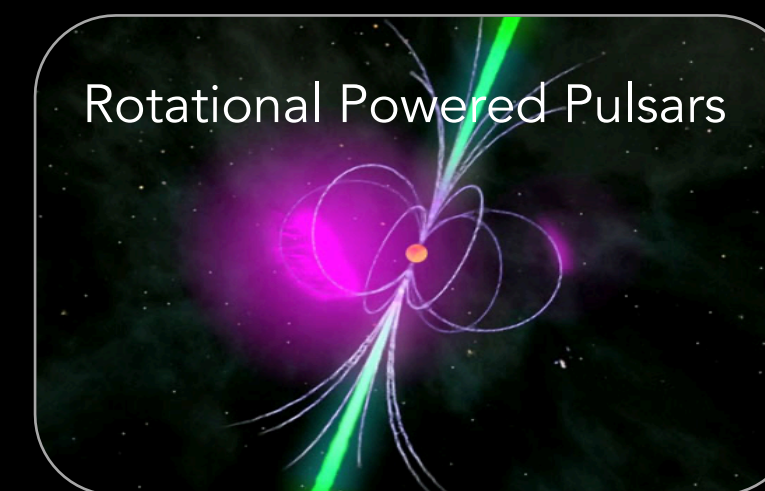
## THERMAL NSs (XDINS)

Powered by magnetic energy.  
Old, almost pure blackbodies.  
Typically emitting in the X-rays.



## CENTRAL COMPACT OBJECTS

Powered by magnetic energy.  
Young, with bright SNRs.  
Typically emitting in the X-rays.

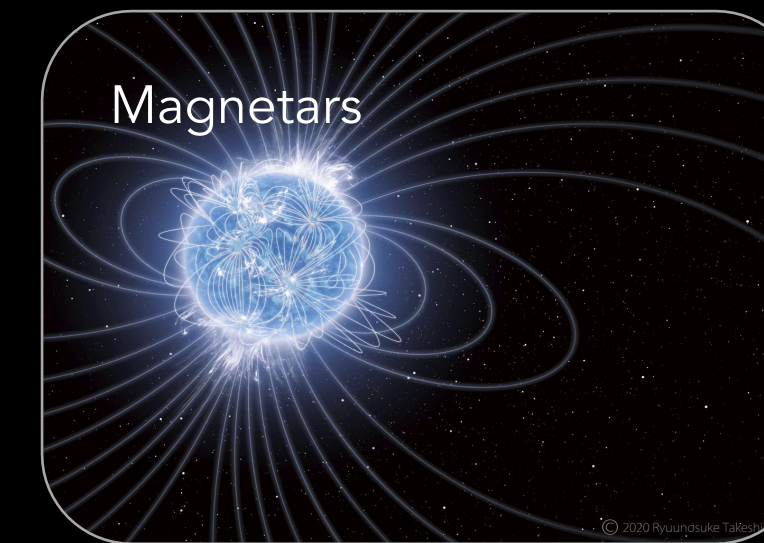
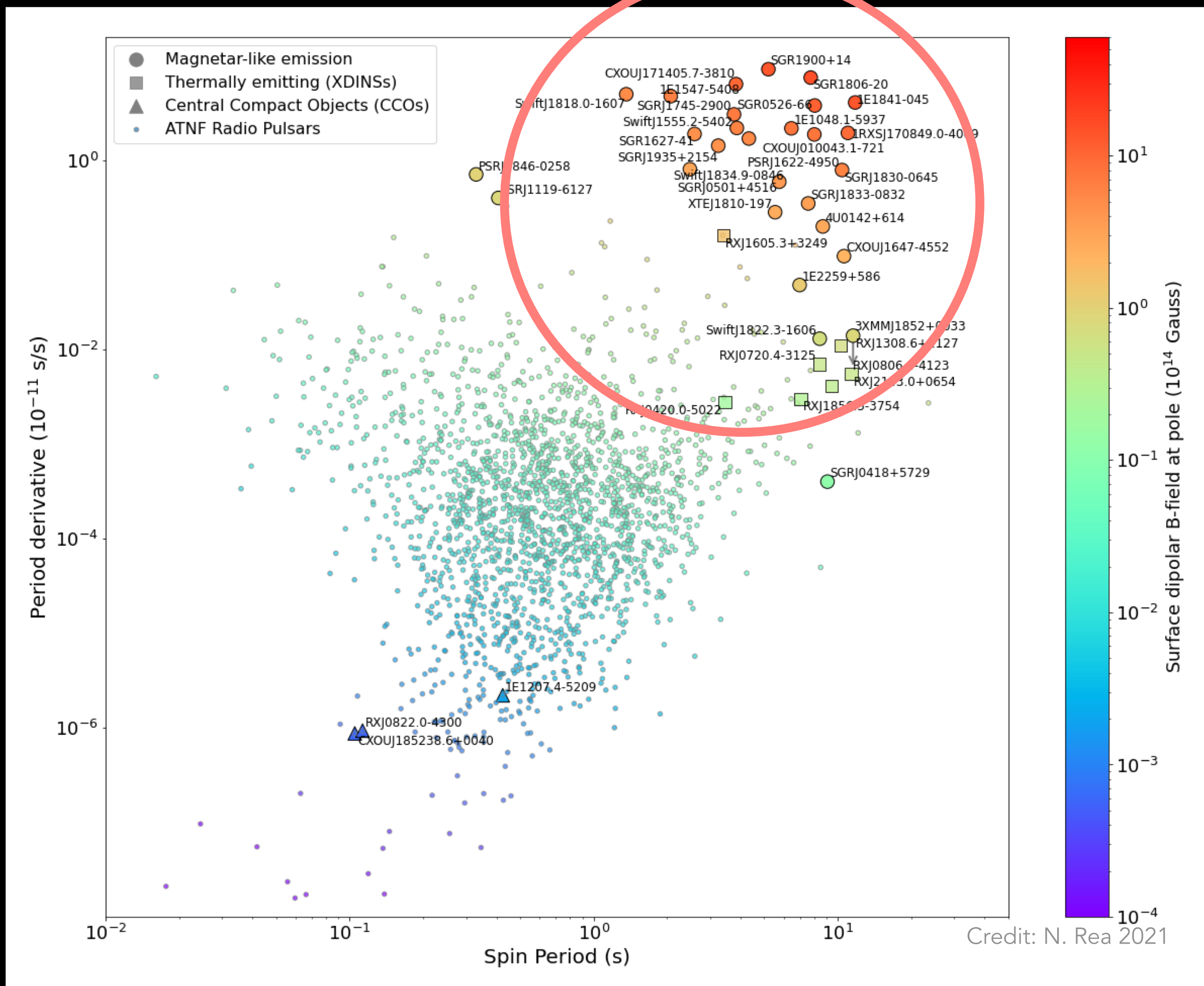


## ROTATIONAL POWERED PULSARS

Powered by rotational energy.  
Typically emitting in radio.



# THE ISOLATED PULSAR POPULATION



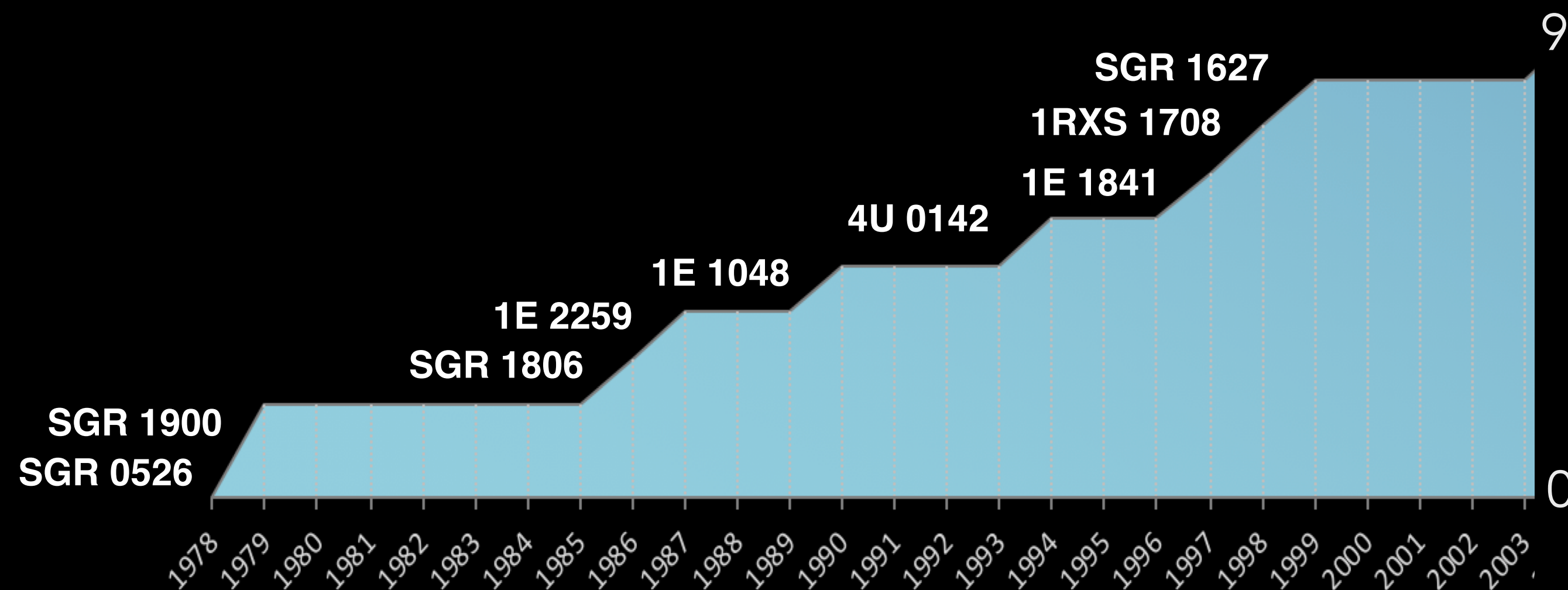
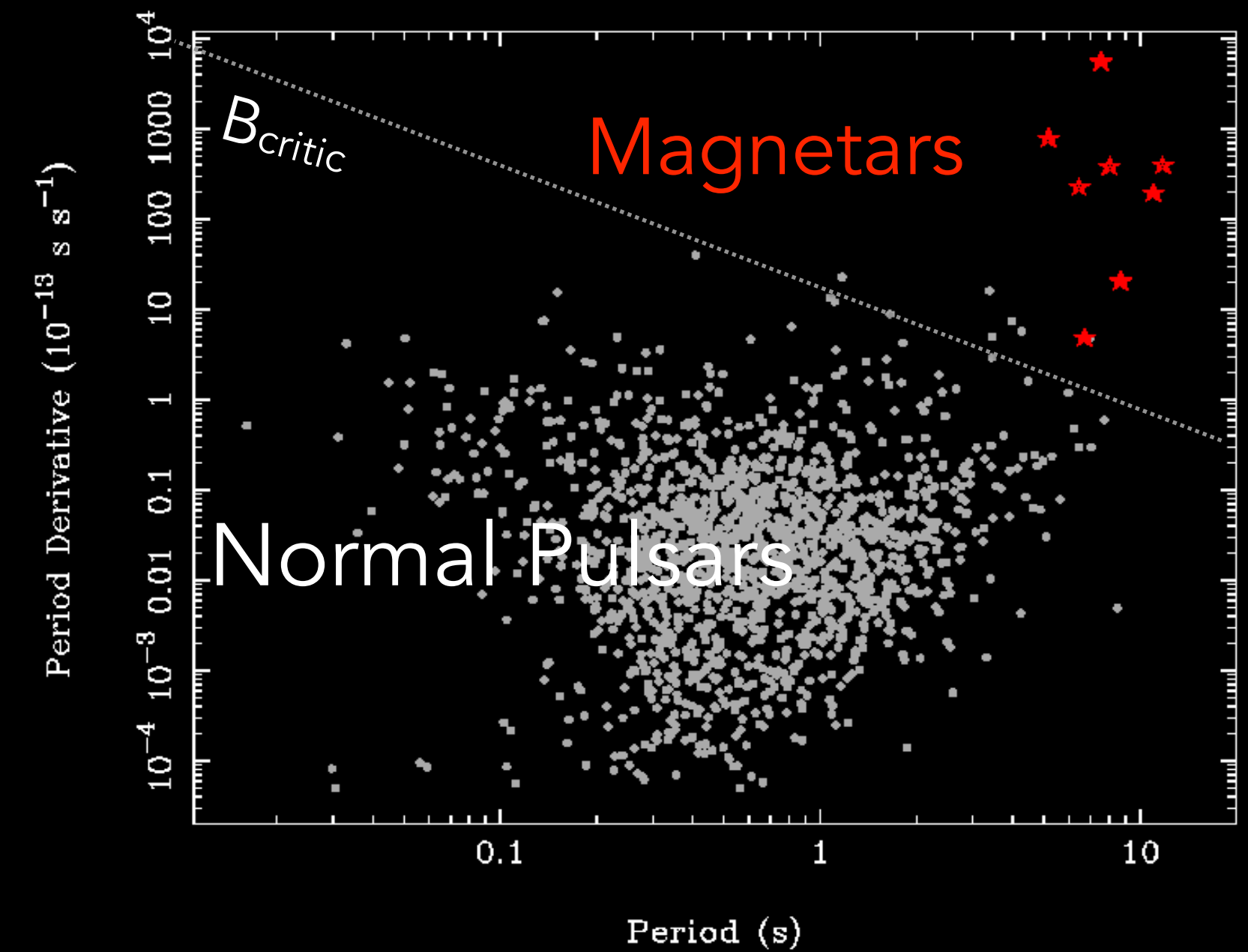
# MAGNETARS

Powered by magnetic energy.  
Characterized by outbursts and  
flares. Typically emitting in X-rays.



# MAGNETARS AT CEFALU' CONFERENCE IN 2004

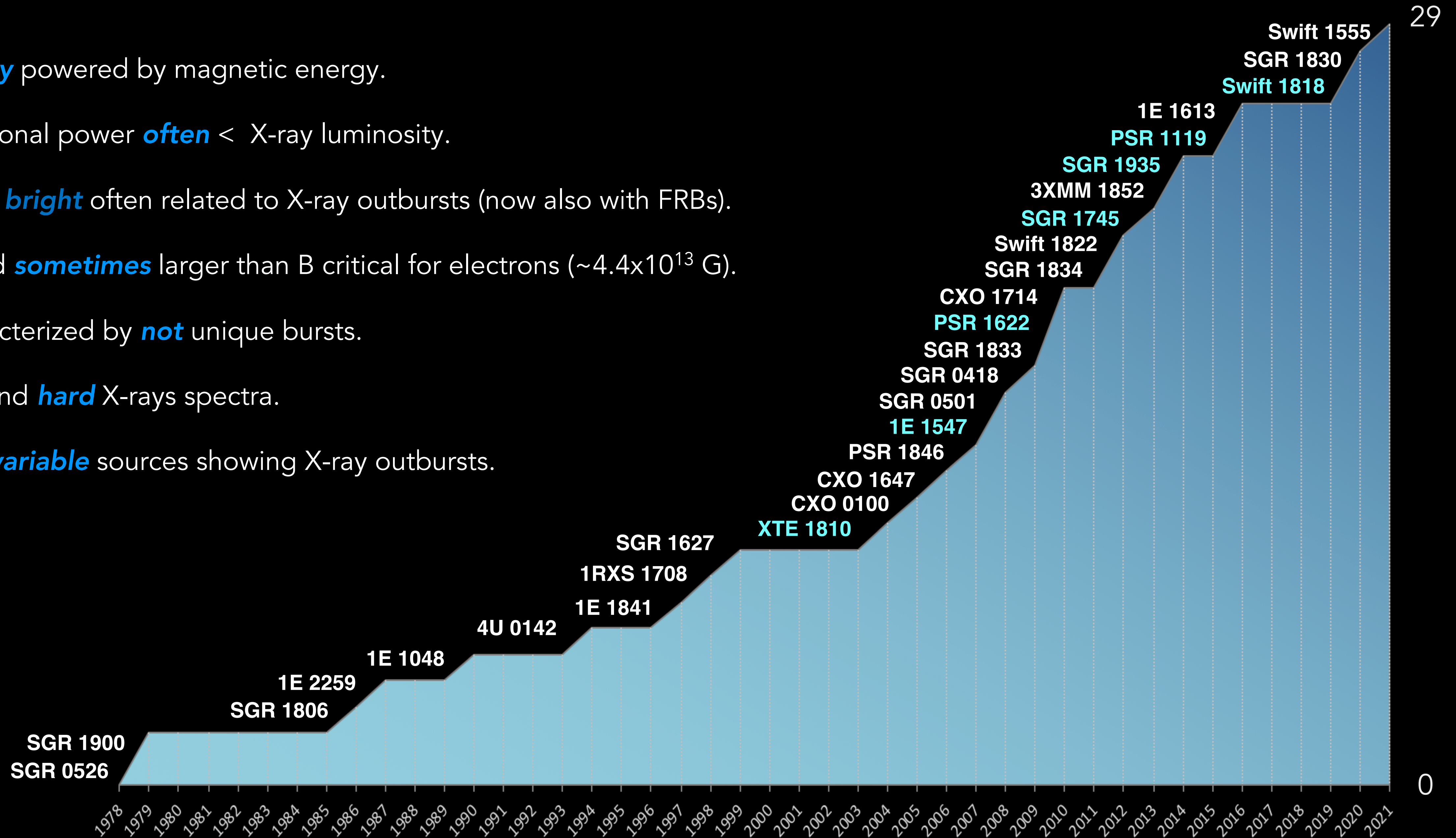
- Powered by magnetic energy.
- Rotational power < X-ray luminosity.
- Radio *off*.
- B-field larger than B critical for electrons ( $\sim 4.4 \times 10^{13}$  G).
- Characterized by unique bursts.
- Soft X-rays spectra.
- *Very stable sources used as X-ray calibrator.*





# MAGNETARS AT CEFALU' CONFERENCE IN 2022

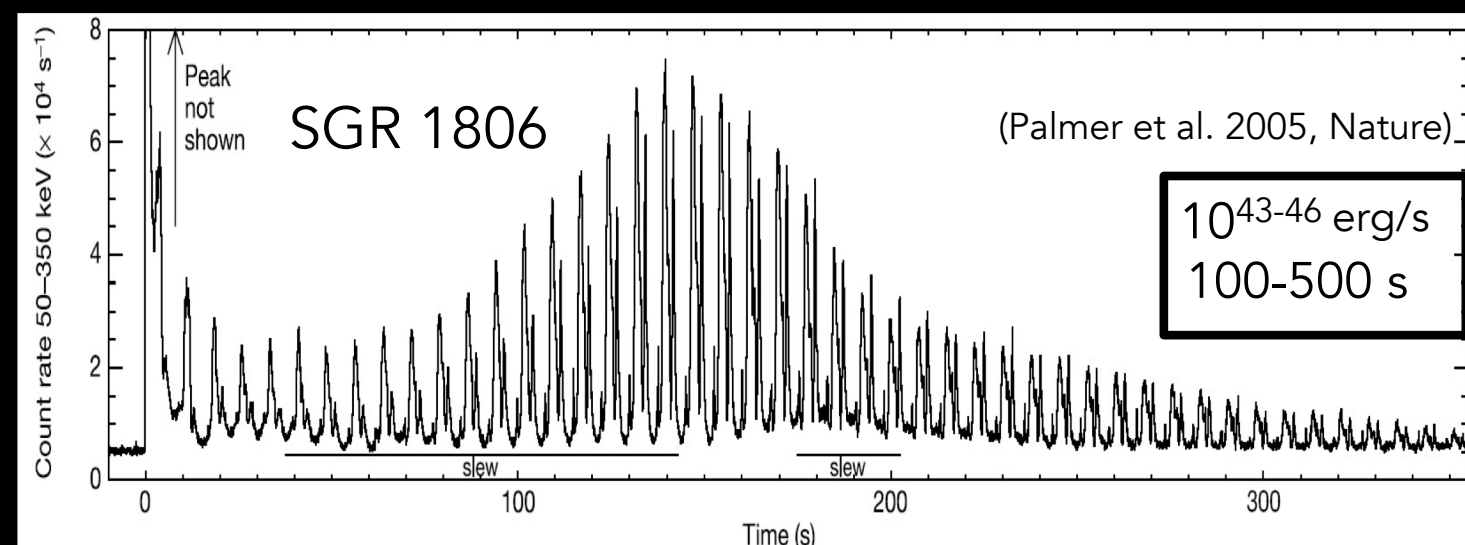
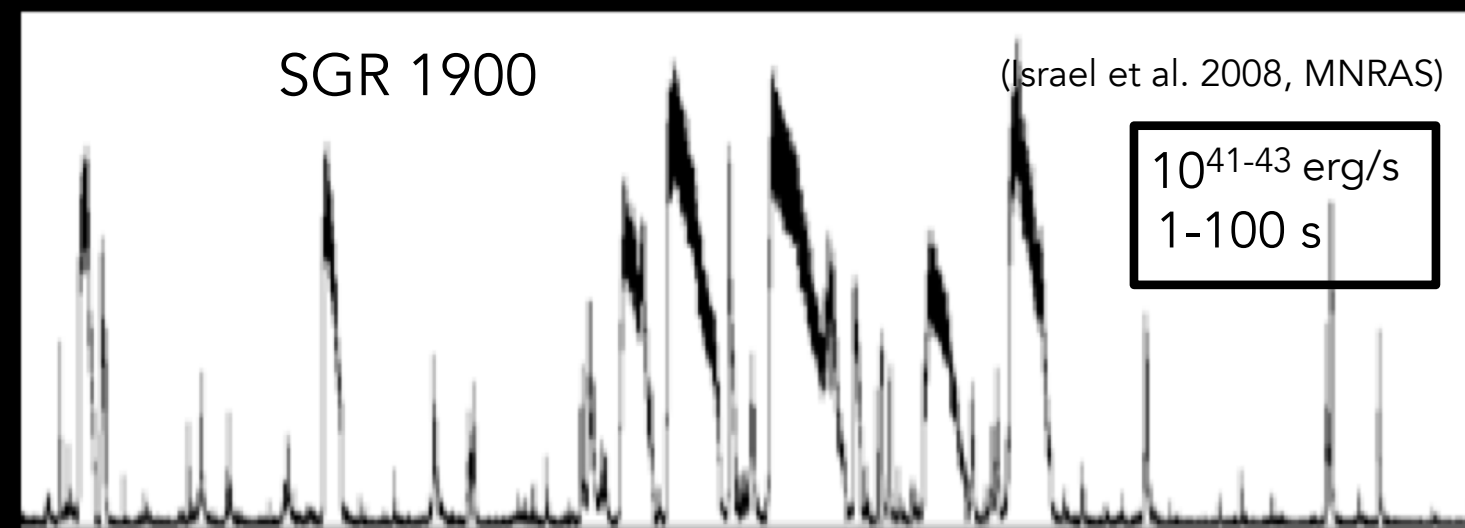
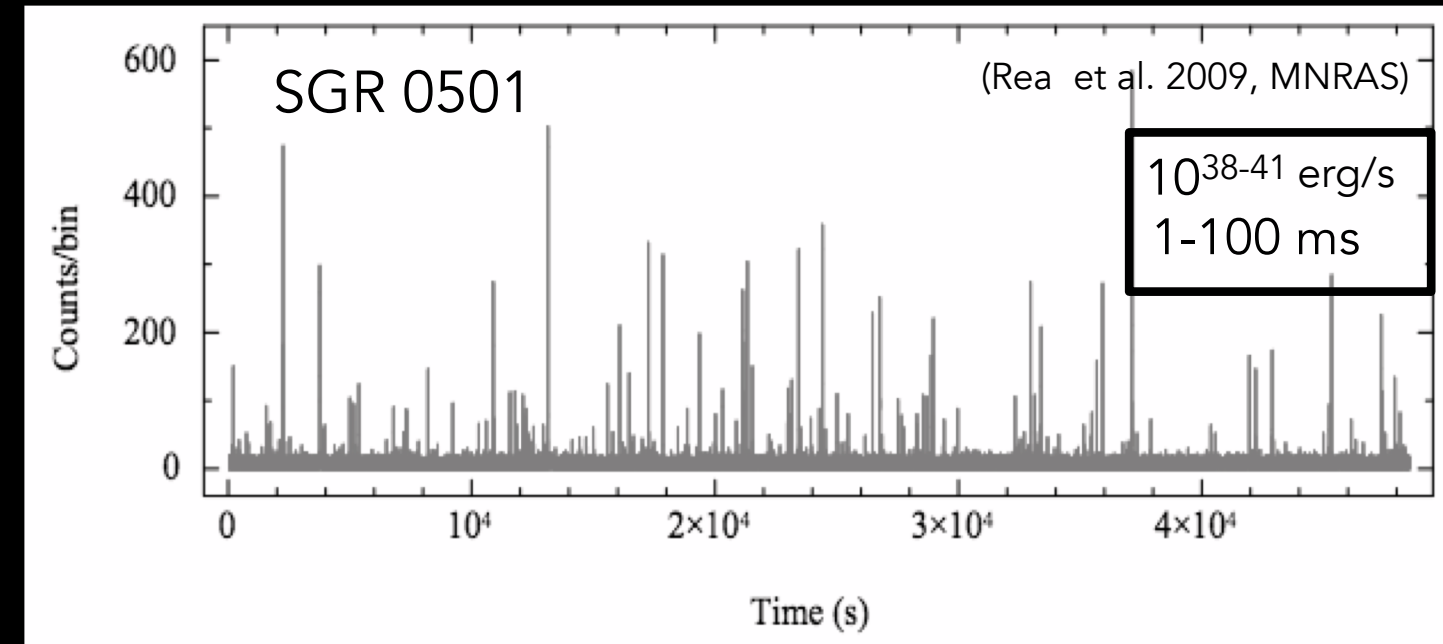
- **Mostly** powered by magnetic energy.
- Rotational power **often** < X-ray luminosity.
- Radio **bright** often related to X-ray outbursts (now also with FRBs).
- B-field **sometimes** larger than B critical for electrons ( $\sim 4.4 \times 10^{13}$  G).
- Characterized by **not** unique bursts.
- Soft and **hard** X-rays spectra.
- Very **variable** sources showing X-ray outbursts.



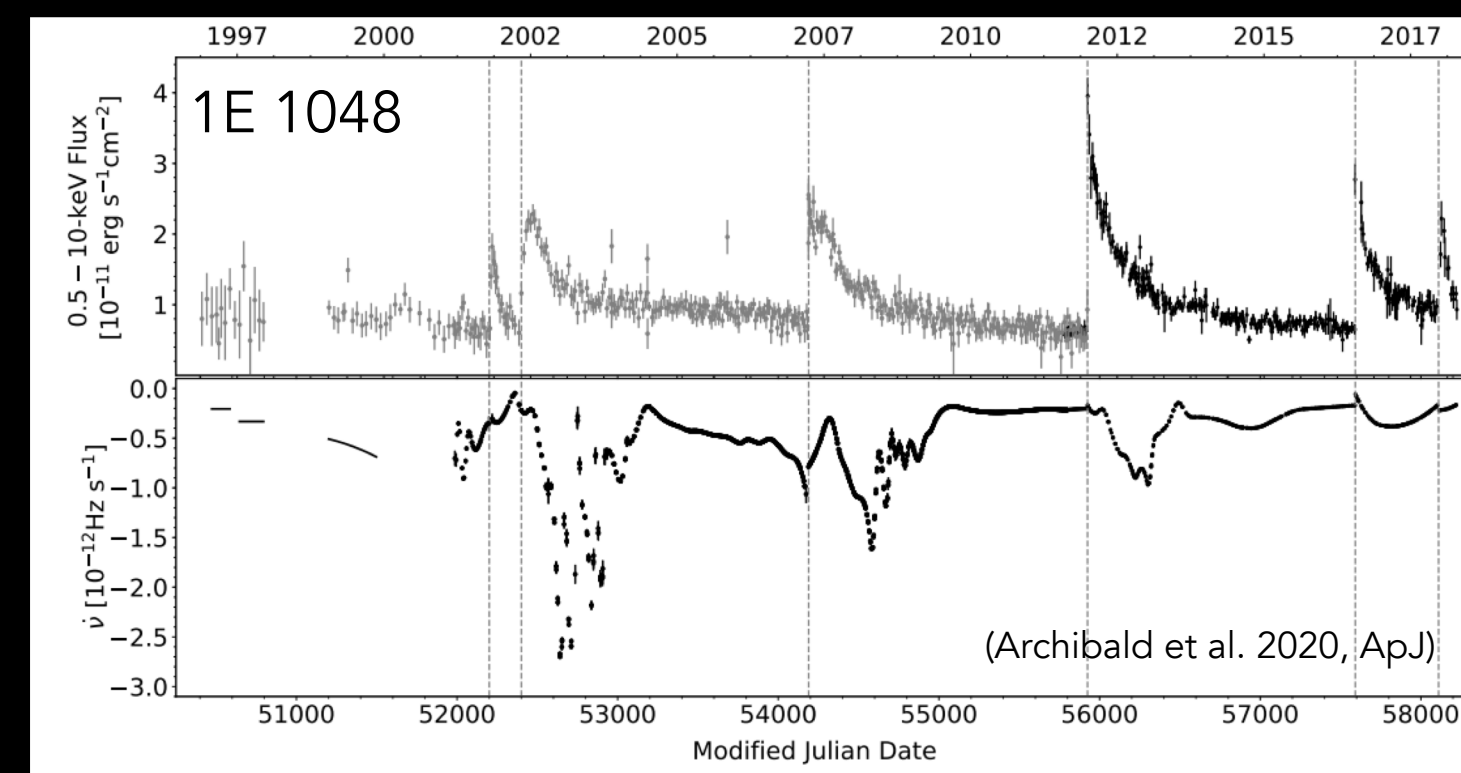
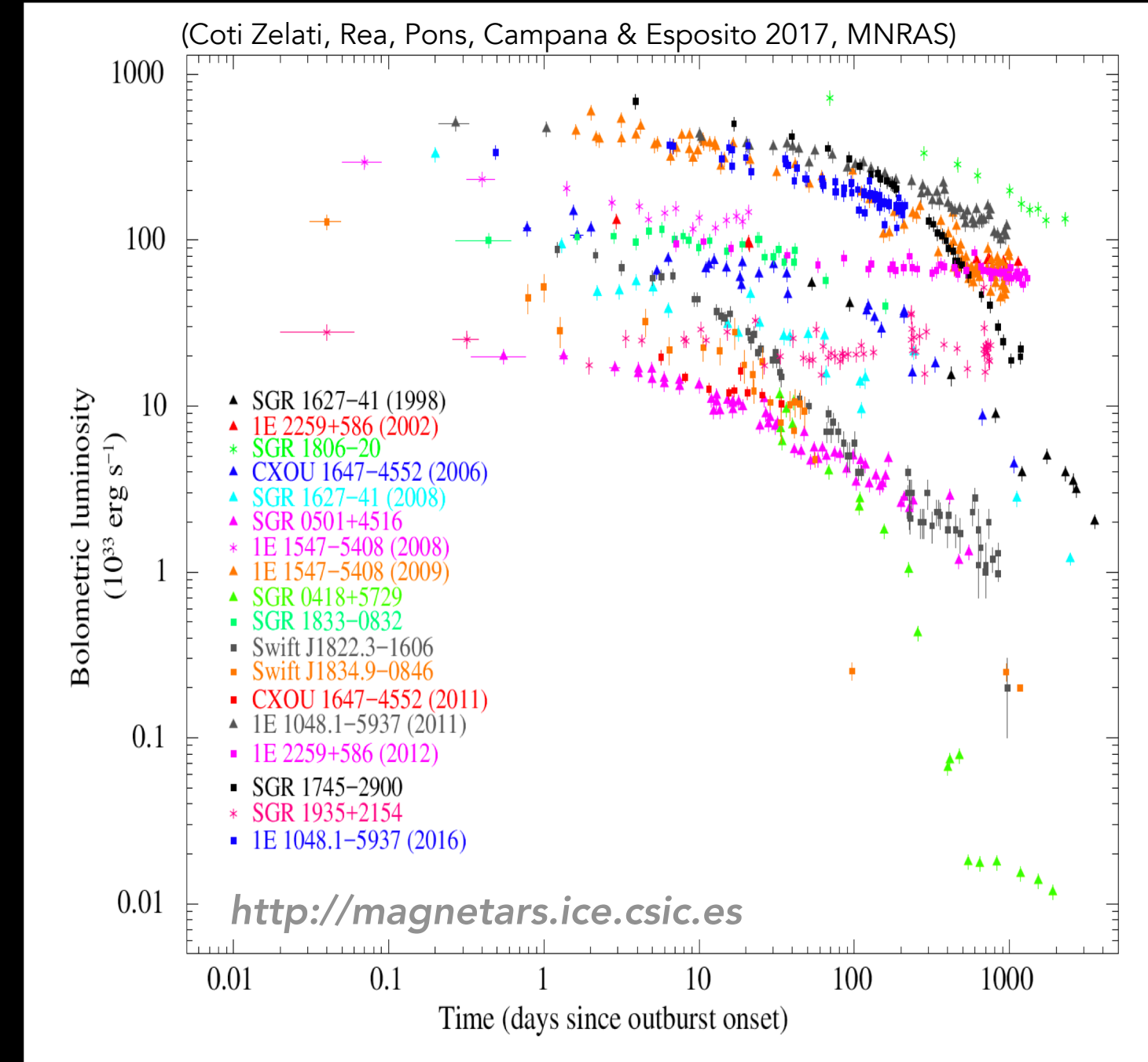


# MAGNETAR OUTBURSTS AND FLARES

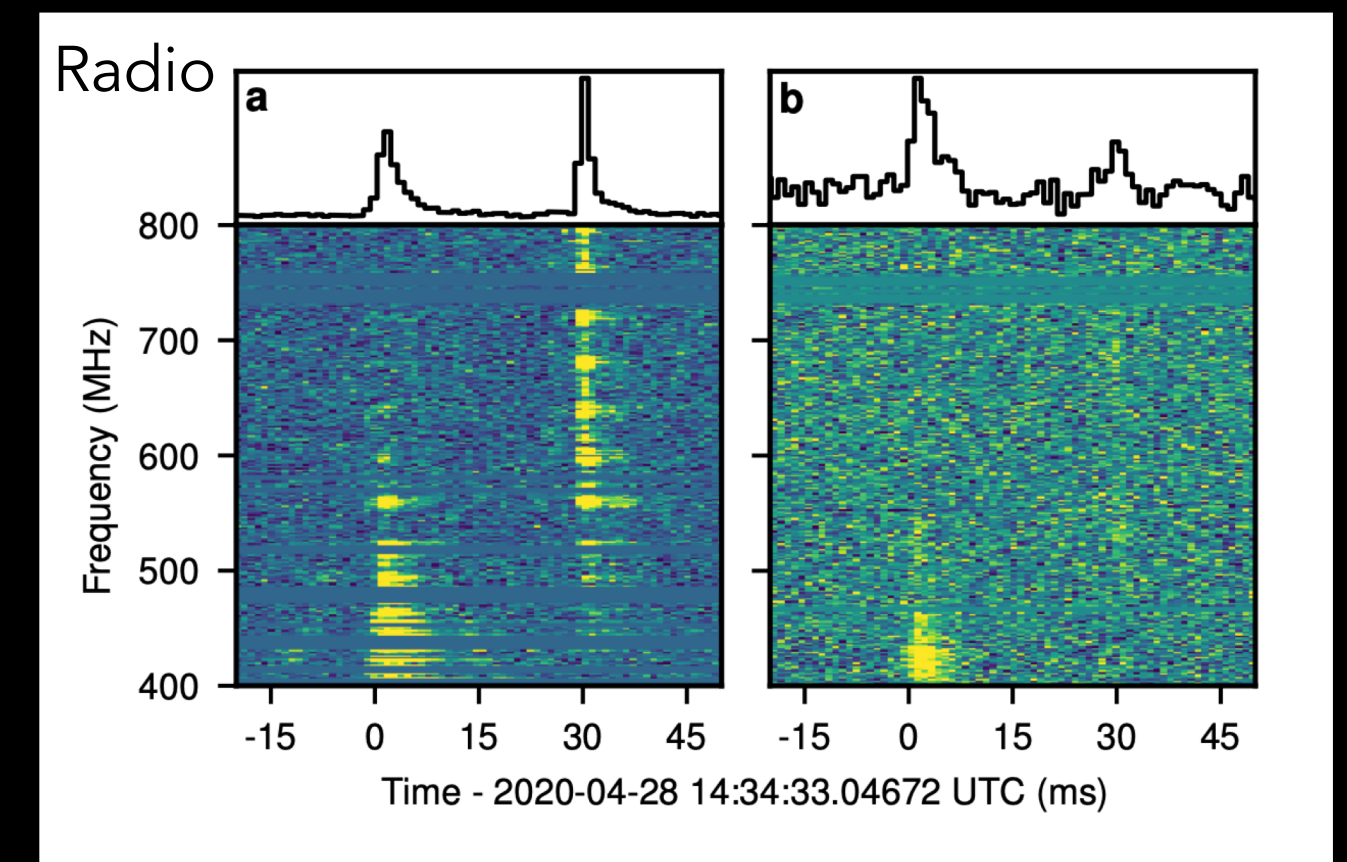
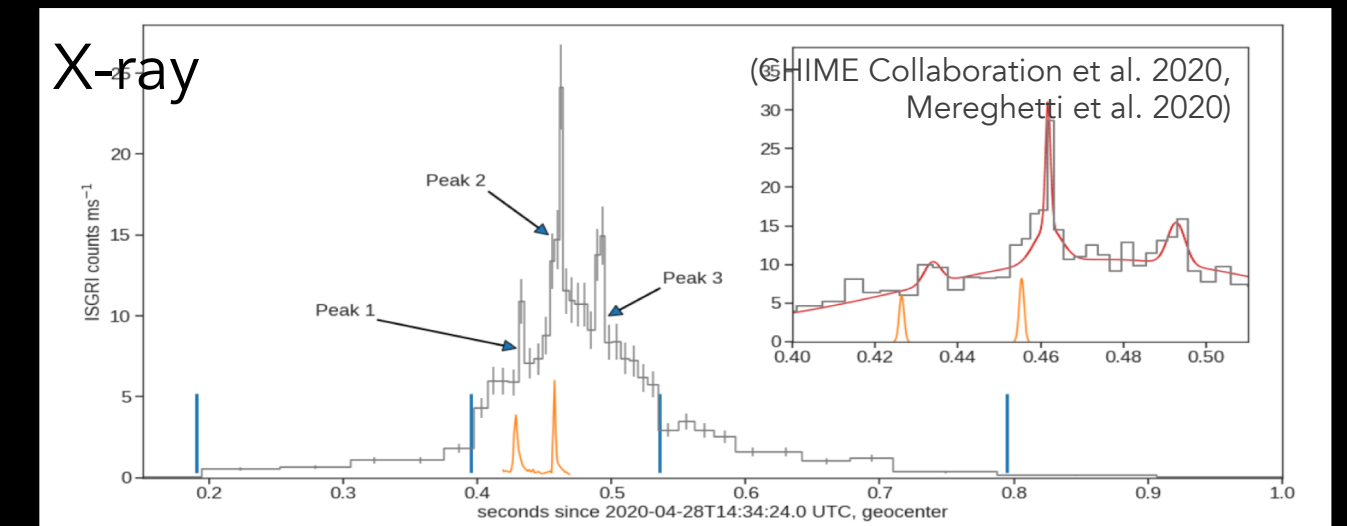
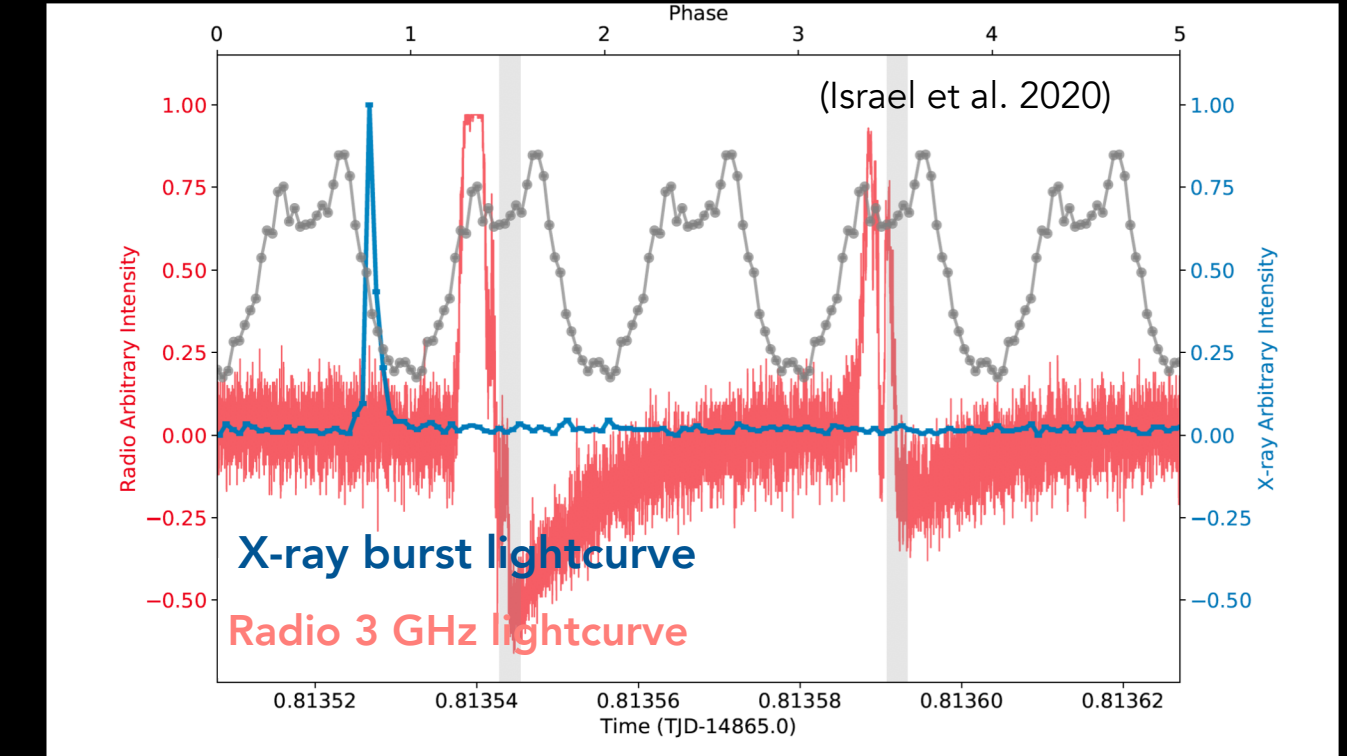
## FLARING ACTIVITY



## OUTBURST ACTIVITY



## RADIO ACTIVITY



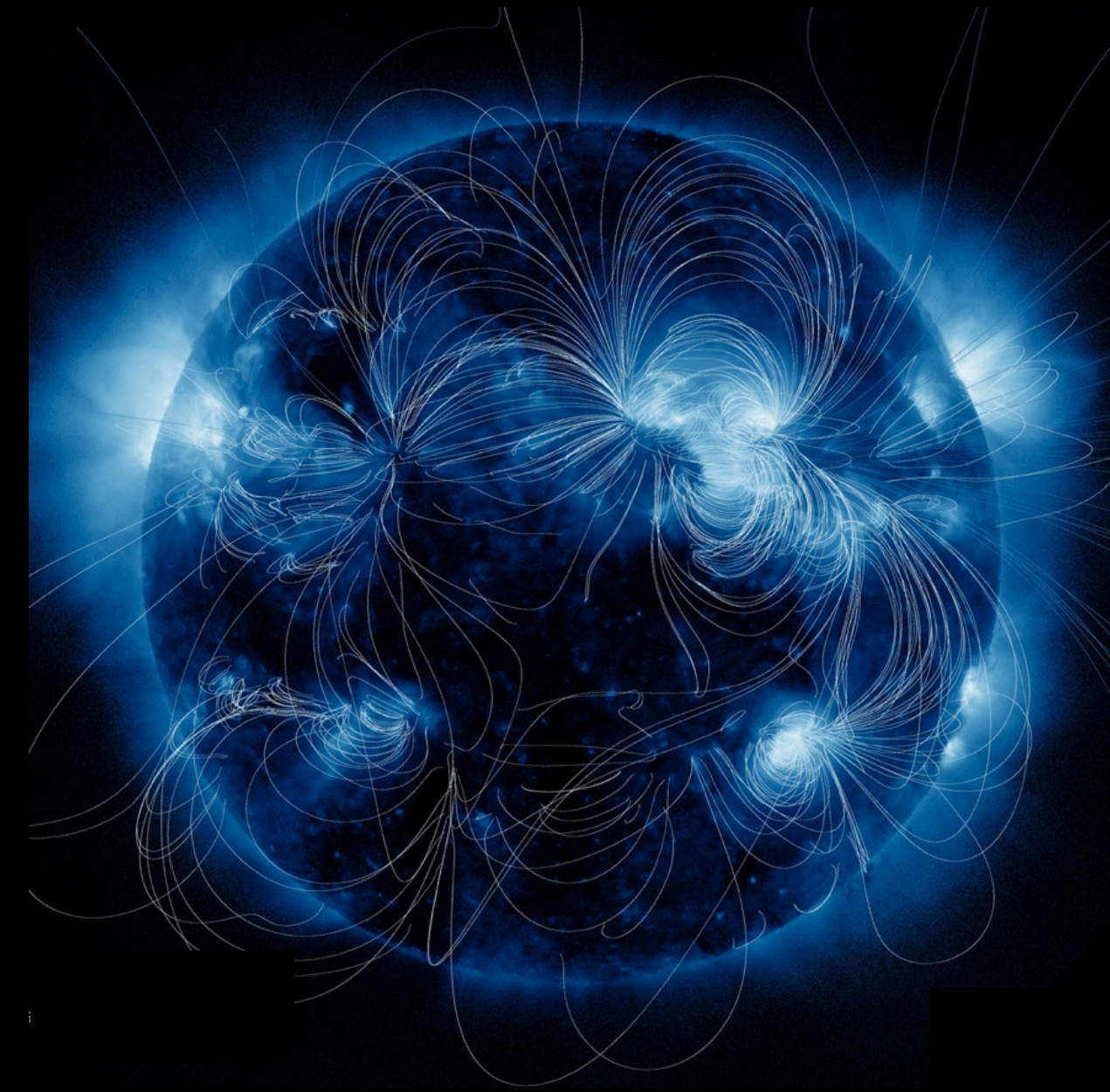
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SGR 1935+2154

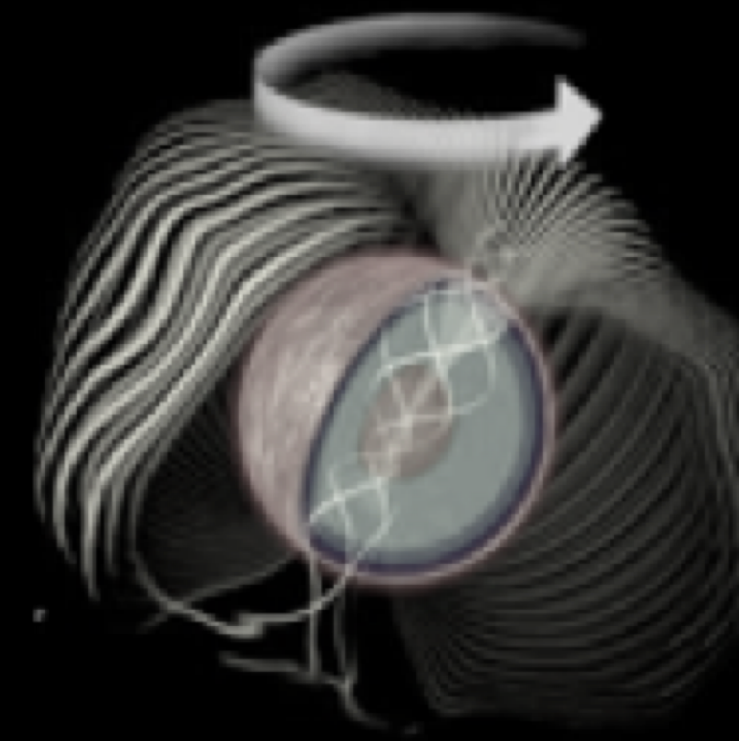


# MAGNETARS

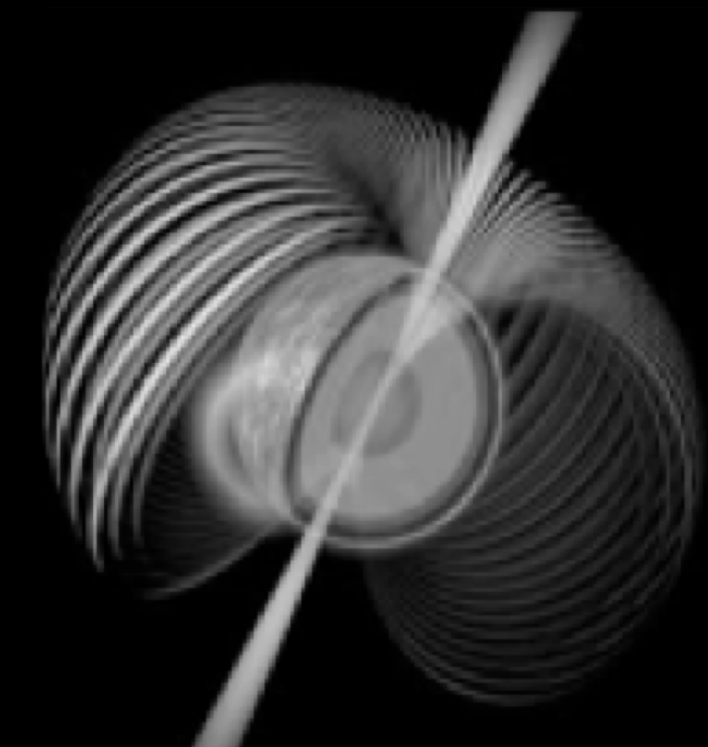
- **TANGLED FIELDS** Magnetars have highly twisted and complex magnetic field morphologies, both inside and outside the star.
- **STEADY EMISSION** Magnetar magnetospheres are filled by charged particles trapped in the twisted field lines, interacting with the surface thermal emission through resonant cyclotron scattering.
- **FLARES** Twisted magnetic fields might locally (or globally) stress the crust (either from the inside or from the outside). Plastic motions and/or returning currents convert into crustal heating causing large outbursts.



Magnetars



Normal Pulsars



(Rea & Esposito 2011; Kaspi & Beloborodov 2017; Esposito, Rea & Israel 2021)