Extragalactic magnetars: millisecond radio burst

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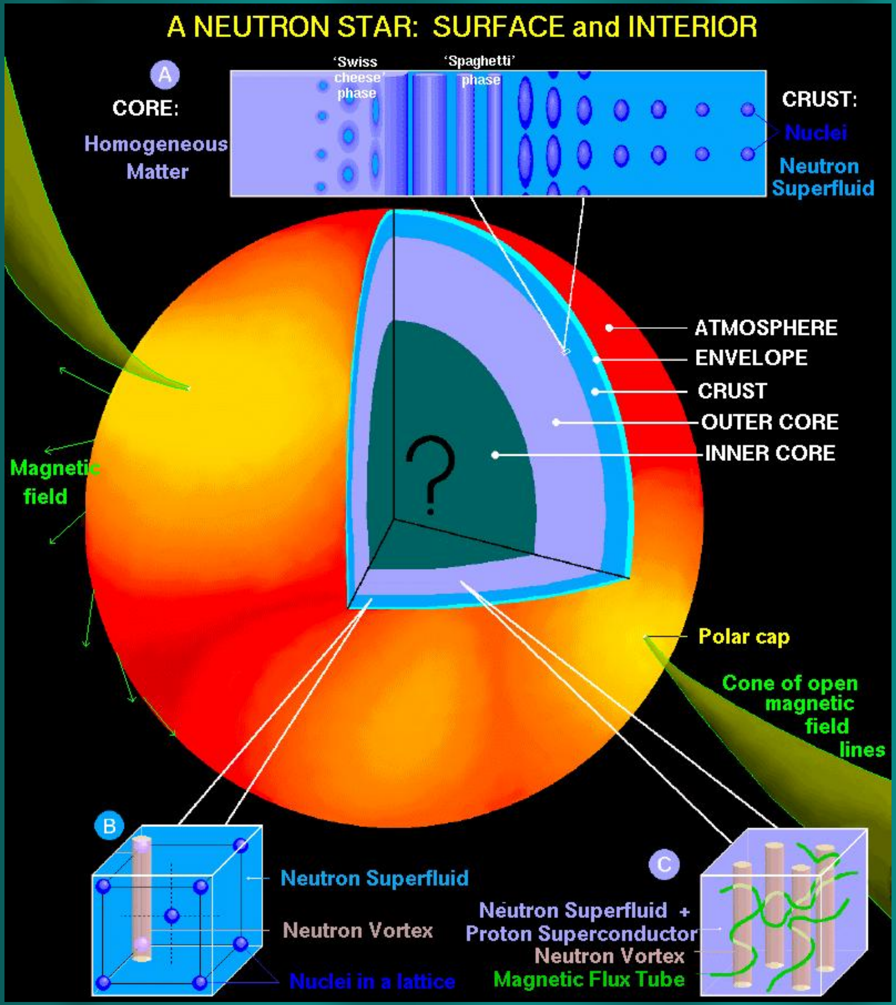
Neutron stars



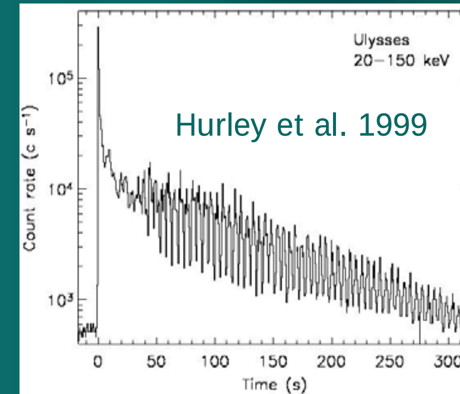
(by Dany Page)

Mass ~1-2 solar masses
Radius ~10-15 km

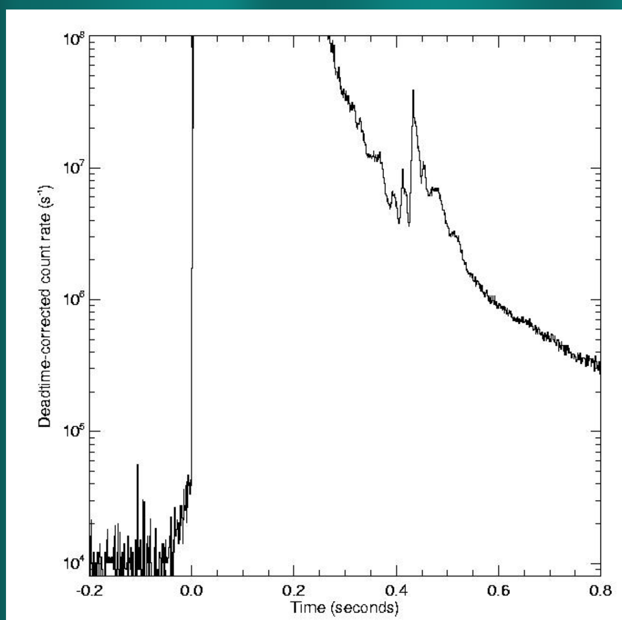
Observed as:

- Radio pulsars
- Accreting in binaries
- Compact central X-ray sources in supernova remnants.
- Anomalous X-ray pulsars
- Soft gamma repeaters
- The Magnificent Seven
- Transient radio sources (RRATs)
- Gamma-ray pulsars

Magnetars



- $dE/dt > dE_{rot}/dt$
- The energy of the magnetic field is released

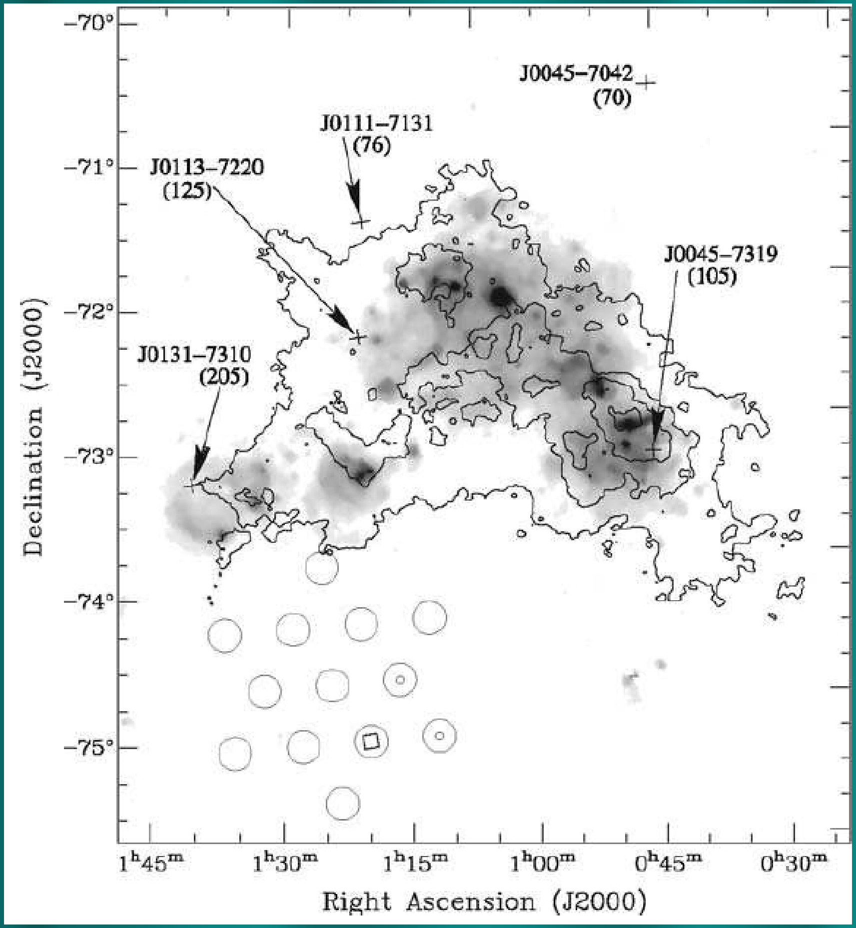


Giant flare in Dec. 2004
Palmer et al. 2005

Magnetic fields 10^{14}–10^{15} G

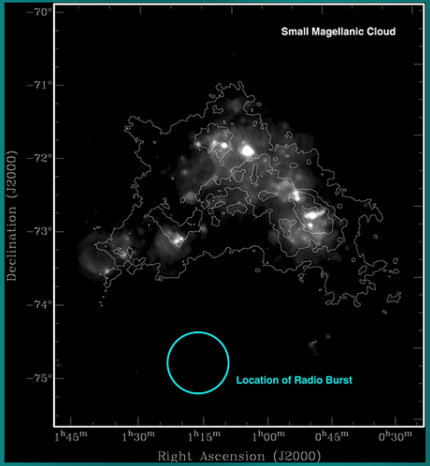
Weak bursts. $L<10^{42}$ erg/s
Intermediate. $L\sim10^{42}$–10^{43} erg/s
Giant. $L<10^{45}$ erg/s
Hyperflares. $L>10^{46}$ erg/s

mERB: millisecond extragalactic radio burst

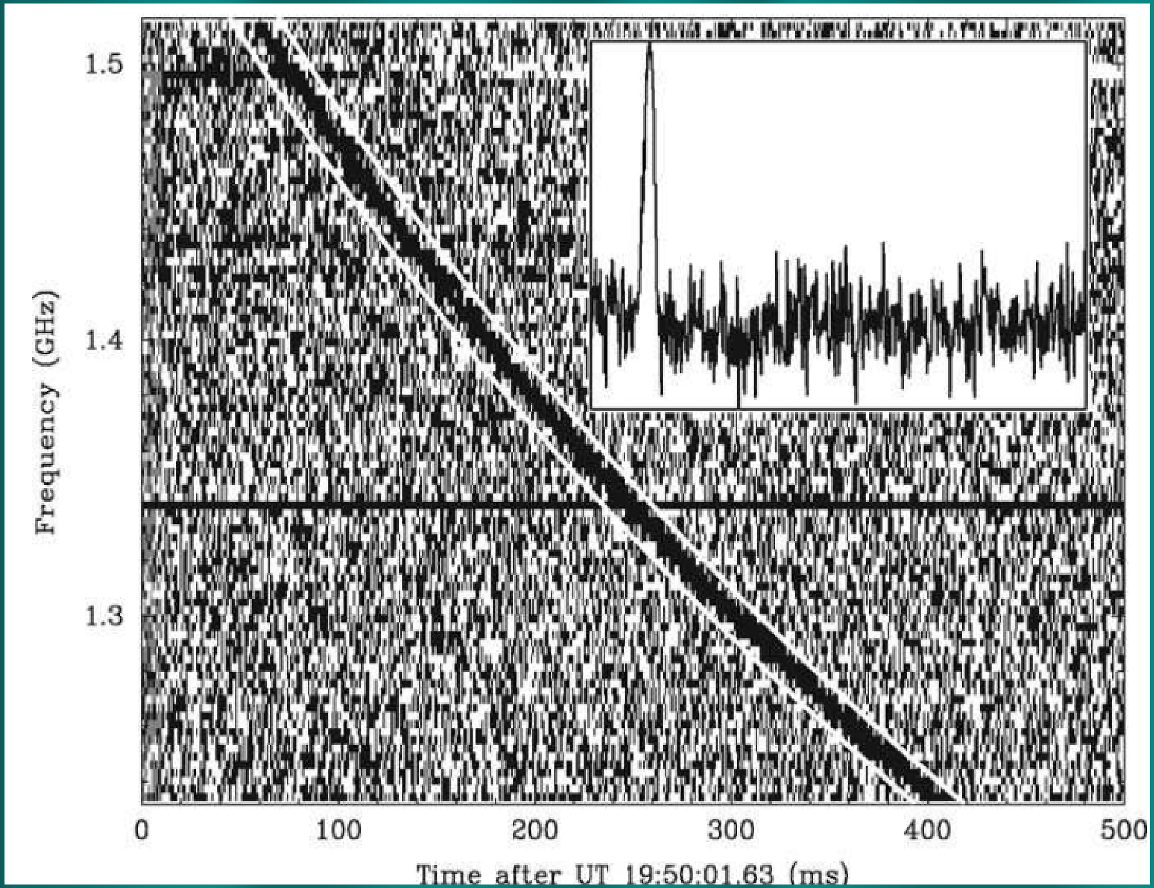


Discovered by Lorimer et al. [Science 318, 777 (2007)]
1.4 GHz, Parkes

~30-40 Jy, < 5 msec
3 degrees from SMC



mERB: millisecond extragalactic radio burst



Large DM 375 cm^{-3} pc
Extragalactic
Distance ~< 1 Gpc
(>600 Mpc from optical
 limits on the host galaxy)
10^{40} d^2_{500} erg in radio

Rate is about 90/day/Gpc^3

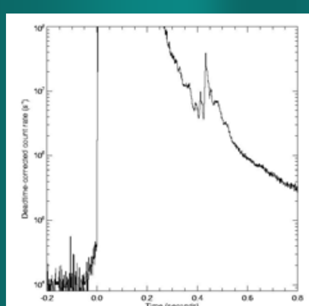
This rate is much lower
than the SN rate, and
much larger that
the rate of GRBs.

[Science 318, 777 (2007)]

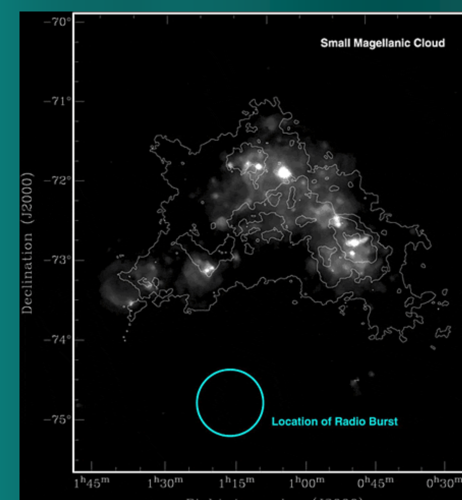
Hypothesis: hyperflare of an extragalactic magnetar

At first we note that the rate about 50-100 per day per cubic Gpc is about the expected rate of extragalactic hyperflares of magnetars.

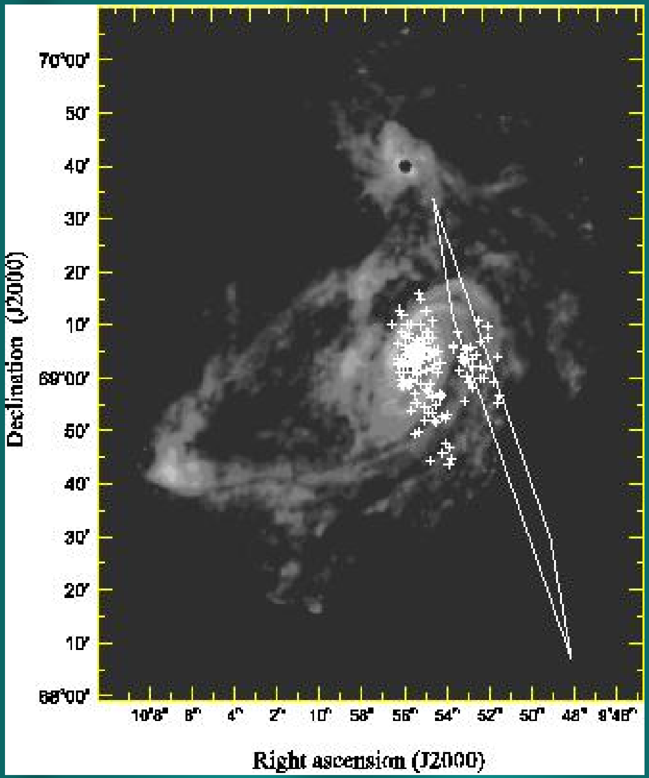
The possible mechanism of radio emission can be related to the tearing mode instability in the magnetar magnetosphere as discussed by Lyutikov (2002) and can produce the radio flux corresponding to the observed 30 Jy from the mERB using a simple scaling of the burst energy.



(Popov, Postnov arXiv: 0710.2006)



SGRs: monitoring and extraG



M81 group of galaxies: M81 itself, M82, M83

Now there are few other candidates
(Mazets et al., Frederiks et al., Golenetskii et al., Ofek et al, Crider ….),
including one in the direction of M31.

(D. Frederiks et al. astro-ph/0609544)

Rate of hyperflares

We estimated (astro-ph/0503352) the rate of hyperflares per galaxy as ~1/1000 yrs.

We propose that the best sites to search for SGRs outside the Local group are galaxies with active massive star formation, and searched for giant flares from near-by star forming galaxies (M82, M83, NGC 253, NGC 4945) and from "supernova factories" (Arp 299 and NGC 3256) in the BATSE catalogue. No statistically significant excess of sources is found.

We also searched for HFs from the Virgo cluster. Nothing was found. Renormalizing this result to our Galaxy we obtain that HFs (>5 10^{45} erg in spike) should be as rare as one in 1000 years.

Lazzati et al. (2005) provide an estimate somehow smaller than ~1/130 yrs, but this is just an upper limit (see also Palmer et al. 2005, Ghirlanda et al. 2005).

These values are 5-50 times lower than the galactic rate of SN.

So, the rate of hyperflares is expected to be ~20-200 per year per cubic Gpc. This is in good correspondence with the estimate of mERBs rate.

Radio emission

Lyutikov (2002) proposed that a standard (weak) burst of a SGR produces a radio burst with a flux at ~1 GHz ~1 Jy from 10 kpc for a burst with $L_x \sim 10^{36}$ erg/s.

A flare mechanism is assumed to be similar to type III solar bursts.

For $L_x = 10^{47}$ erg/s and distance 600 Mpc we obtain ~30 Jy in excellent correspondence with data on mERB.

Timing properties

The raising part of the burst 27 Dec 2004 was about 5 msec.
This is about what was observed for the mERB.

However, the duration of a radio burst in the model by Lyutikov can be even smaller, down to tens of microseconds ($t_A \sim R_{NS}/c$).
This does not contradict data on the mERB.

Discussion

1. No GRB was detected at the time of mERB
   This is natural as a hyperflare (in X-rays) is undetectable from ~600 Mpc.
2. Host galaxy.
   SGRs are expected to be related to starformation sites.
   So, the host galaxy can be a starforming galaxy with dust.
   Then it can be closer than 600 Mpc.
   Observations by Spitzer are welcomed.
3. No weaker sources.
   The observed mERB was 100 times above the threshold.
   This can be explained if hyperflares do not form one energy distribution with normal giant flares.
4. Birth of a magnetar.
   We note, that the rate is also coincident with an expected birthrate of SGRs.
   However, no corresponding SN was detected.
   So, this is unlikely.
5. Testing of the model by Lyutikov.
   We want to encourage observers to look for millisecond radio bursts coincident with weak bursts of galactic magnetars.

Conclusions

We proposed that the millisecond extragalactic radio burst can be related to a hyperflare of a magnetar.

The idea of the mechanism of radio emission during magnetars bursts was suggested by Lyutikov (2002).

However, the mechanism was not applied to hyper- and giant flares, and details are not well developed.

We encourage the plasma physics community to pay attention to the astrophysical problems, in particular to those related to magnetars.