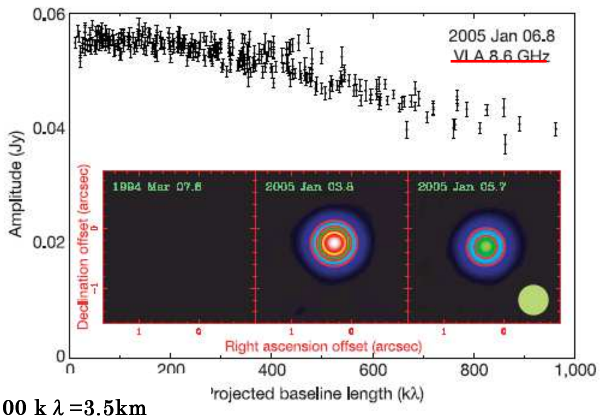
An expanding radio nebula produced by a giant flare from the magnetar SGR 1806-20

B.M. Gaensler et al.　/nature/vol434/28 April 2005/



100 kλ=3.5km

Figure 1 Radio emission from VLA J180839–202439 at 8.5 GHz. The main panel shows the visibility amplitude as a function of projected baseline length (in units of thousands of wavelengths; 100 kλ ≈ 3.5 km) at epoch 2005 Jan 06.8 (9.9 days after the giant flare), as seen by the VLA. The data have been self-calibrated in phase until the solution converged, and each baseline has then been time-averaged over the entire observation of duration 40 min. The error bars show the standard error in the mean of the amplitude on each baseline. The decrease in amplitude as a function of increasing baseline length clearly indicates that the source is resolved. The inset shows the image of the source at three epochs, smoothed to a uniform resolution of 0.5″ (indicated by the green circle at lower right). The origin of the coordinate axes is the position of SGR 1806–20 measured with the Chandra X-ray Observatory[11], which has an uncertainty of 0.3″ in each coordinate. The false-colour representation is on a linear scale, ranging from −0.3 to the peak brightness of 53 mJy beam^{-1}. The contours are drawn at levels of 20%, 40%, 60% and 80% of this peak. No source is seen in archival 8.5-GHz data from March 1994, down to a 5σ upper limit of 0.1 mJy. In the days after the giant flare, a bright but rapidly fading source is now seen at this position. The precise location of VLA J180839–202439 was determined by phase referencing to several nearby calibrators with well-determined positions. Our best measurement was on January 16.6, for which we measured a position for VLA J180839–202439 (equinox J2000) of right ascension 18 h 08 min 39.343 ± 0.002 s, declination −20° 24′ 39.80″ ± 0.04″. The source's proper motion over the time span presented in this paper is −2.8 ± 6.5 mas day^{-1} in right ascension and −2.2 ± 6.5 mas day^{-1} in declination.

ABSTRACT

・ アウトバーストによって形成され減光しつつある電波の残光の探知について報告する。この**残光は過去に唯一観測された類似の電波源の約 500 倍の明るさだった**。SGR1806-20 からのフレアの 6 日後～19 日後まで解像され、直線偏光した電波星雲が約 0.25C の速さで膨張しているのが見られた。**この星雲を形成する為には少なくとも 4×10^43 erg のエネルギーが磁場と相対論的粒子という形で巨大フレアによって放出された**と考えられる。

・ VLA での電波観測

・ ～5×10^15 W/Hz の等方的なスペクトル光度を示唆。**1998 年の giant flare の後の SGR1900+14 からの radio afterglow の 500 倍以上。**

Fig1. Radio emission from radio nebula at 8.5GHz.

・振幅が距離の関数で減少

・SGR1900+14 の radio afterglow でも同様の減光。

Fig2. Light curve

8.8 日後 decay rate が減少。フラックス密度は

$S_\nu \propto t^\delta$、　$\delta \sim -2.7$

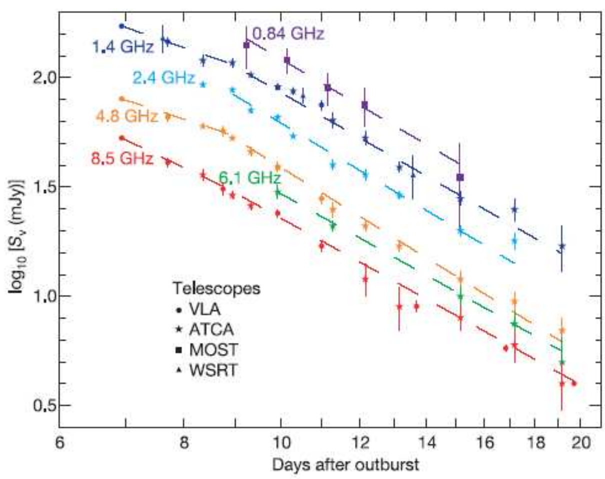
でフィットできる。

11.2 日以降のスペクトルは 0.84-8.5GHz の振動数帯で $\alpha \sim -0.75 \pm 0.02$ ($S_\nu \propto \nu^\alpha$) の連続した power law で記述できる。これも SGR1900+14 の afterglow と似ている。

放射される電子のエネルギー分布が

$dN/dE \propto E^{-p}$　$p=1-2\alpha=2.5\pm0.04$

になることを示唆。



☆シンクロトロンソース

・放射スペクトルとサイズから Bmin=0.02 gauss であることが示唆される

・放射領域における粒子と磁場の最小エネルギーは E_{min}～4×10^43 erg

・これらのパラメーターから emitting medium が n_0≦0.1 /cm^3

Table 1 The rate of decay of the radio emission from VLA J180839–202439

ν (GHz)	t_0 (days)	δ_ν ($t < t_0$)	δ_ν ($t > t_0$)
0.84	≤10.2	…	−2.7 ± 0.8
1.4	$9.0^{+0.4}_{-0.6}$	−1.6 ± 0.2	−2.61 ± 0.09
2.4	≤9.0	…	−2.74 ± 0.07
4.8	$8.8^{+0.2}_{-0.4}$	−1.5 ± 0.1	−2.84 ± 0.08
6.1	≤11.3	…	−2.6 ± 0.2
8.5	$8.8^{+0.2}_{-0.4}$	−2.2 ± 0.2	−2.54 ± 0.04

At each frequency ν, it has been assumed that the radio flux density decays as $S_\nu \propto t^{\delta_\nu}$ with a break in the power-law index, δ_ν, at time t_0. To determine values of t_0 and δ_ν, a weighted least-squares fit of a broken power law has been applied to each data set, with t_0 a free parameter. In each case, the fit shown is the only local minimum in χ^2 that meets the requirements that there are at least two data points on either side of the break, the change in temporal index on either side of the break is larger than its uncertainties, and the power-law fits on either side of the break meet at the break point. Before day 8.8, we find that δ_ν possibly decreases with ν; after day 8.8, the flux decays rapidly at all frequencies with a power-law index $\delta \approx -2.7$, independent of ν.

Table1.The rate of decay of the radio emission

- フレアから大体 10 日後にスペクトルの指数依存性が大きく変化する：硬化
- この鋭い依存性はスタンダードな GRB の Blast wave model では説明不可。

⇒ ejecta と pre-existing shell との衝突？