Pulsar Astronomy — 2000 and Beyond
ASP Conference Series, Vol. 202, 2000
M. Kramer, N. Wex, and R. Wielebinski, eds.

NTT and VLT Observations of two young pulsars

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Abstract. The two young pulsars PSR J0537-6910 and PSR B1706-44 have been recently observed with the NTT and the VLT. Although both pulsars turned out to be undetected ($V \geq 23.4$ and $V \geq 27.5$ respectively) the observations provided interesting constraints on the evolution of the optical luminosity of young pulsars.

1. Introduction

The comprhensive picture of the optical emission properties of pulsars has been greatly improved by the number of detections gathered during the last decade (see Mignani 1998 for a summary). Two main processes are identified to be reponsible of the pulsars' optical emission: (i) synchrotron radiation from the neutron star's magnetosphere and (ii) cooling radiation from the neutron star's surface. While the first process is clearly dominant in young ($\sim 10^{3-4}$ yrs) and bright objects, for the middle-aged and fainter ones ($\sim 10^5$ yrs) the two process seem to coexist, with the thermal emission becoming dominant beyond 10^6 yrs. Although this picture is basically accepted, the question of how and when the optical emission of young pulsars starts to fade away and switches from a magnetospheric to a thermal regime is still an open issue. Optical observations of pulsars in the age bracket $\simeq 1\,000 - \simeq 20\,000$ years are thus crucial to address this point. Here, I discuss the results of recent optical observations of two objects within this age interval: the Crab-like pulsar PSR J0537−6910 ($\simeq 5\,000$ yrs) and the Vela-like pulsar PSR B1706−44 ($\simeq 17\,000$ yrs).

2. PSR J0537-6910 and PSR B1706-44

• The 16ms X-ray pulsar PSR J0537−6910 is the fastest known isolated (non-recycled) pulsar and, with a rotational energy loss $\dot{E} \sim 4.8 \times 10^{38}$ erg s^{-1}, the most energetic (together with the Crab). At the center of the SNR N157B, it also represents the fifth known case of a plerion/pulsar association. Although the X-ray detection has been confirmed by all orbiting X-ray satellites, PSR J0537−6910 is still undetectable in radio (see Mignani et al. 1999a and references therein). In the optical, the field was observed in 1998 with the SUSI2 camera of the NTT. Few objects are detected close/inside the $\simeq 3''$ X-ray error circle but none of them can be convincingly associated to the pulsar, which appears undetected down to $V \sim 23.4$ (Mignani et al. 1999a), a result circum-

stanciated by the upper limits obtained by Gouiffes and Ögelman on the pulsed optical flux (these proceedings). Our measured upper limit thus corresponds to an optical luminosity $L_{opt} \leq 1.3 \times 10^{33}$ erg s^{-1} ($A_V \simeq 1.3$ and d=47 kpc).

• PSR B1706−44 (P=102 ms) was discovered during a 20cm radio survey of the southern hemisphere and detected as a γ-ray pulsar by EGRET with a single broad peak, offset in phase wrt the radio one. In soft X-rays, it has been detected by ROSAT as a weak non-pulsating source (see Mignani et al. 1999b and references therein). PSR B1706−44 appears thus strikingly similar to the Vela pulsar both in its dynamical parameters and in its multiwavelength behaviour. Deep optical observations of PSR B1706−44 were obtained in August 1998 during the Science Verification programme of the VLT-UT1 (Mignani et al. 1999b). However, no possible optical counterpart to the pulsar has been detected at the revised radio position down to $V \sim 27.5$. For the possible values of the interstellar extinction, this implies an optical luminosity L_{opt} between $\simeq 2 \times 10^{28}$ erg s^{-1} ($A_V \simeq 0.6$) and $\simeq 5 \times 10^{29}$ erg s^{-1} ($A_V \simeq 3$) for a pulsar distance d=4.4 kpc.

3. Summary

In spite of the null results of the above observations, our magnitude upper limits can be used to contraint the evolution of the optical luminosity of young pulsars. While PSR J0537−6910 is probably not brighter than the slightly younger Crab and PSR B0540−69, PSR B1706−44 seems to have (for an average A_V) the same optical luminosity of the Vela pulsar. The derived optical luminosities compare thus favourably with the general trend recognizable in Fig. 1 of Mignani (1998), confirming the presence of a turnover in the optical luminosity around 10^4 yrs. In particular, this seems to reinforce the validity of the Pacini law (Pacini 1971), which predicts a decay of the optical emission of young pulsars on a timescale of few thousands years at a rate uniquely determined by the neutron star spin parameters and magnetic field.

References

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