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Giant Pulses in Millisecond Pulsars

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Abstract. Giant pulses (GPs), occasional individual pulses with an intensity 100 times the average intensity, have been detected in four pulsars to date. Their origin is not well understood, but studies suggest a connection between the strength of magnetic field at the light cylinder B_{lc} and the existence of GPs. Here, we report on detection of significant Large Amplitude Pulses (LAPs) in two more pulsars with high values of B_{lc}, PSRs J0218+4232 and B1957+20, observed using Giant Meterwave Radio Telescope (GMRT).

1. Introduction

Giant pulses (GPs) have been reported in four pulsars (B0531+21, B1937+21, B1821−24 and B0540−69) to date (Staelin & Reifenstein 1968; Lundgren et al. 1995; Cognard et al. 1996; Romani & Johnston 2001; Johnston & Romani 2003). Three of these pulsars are millisecond pulsars (MSPs) and also show strongly pulsed hard X-ray profiles (Takahashi et al. 2001). The radio GPs occur in a narrow phase window close to the high energy non-thermal pulse indicating a common magnetospheric origin. All these pulsars have a high value of B_{lc}. We have used the GMRT to search for GPs in MSPs with non-thermal high energy emission and a range of B_{lc} and report detection of such pulses in two more pulsars, PSRs J0218+4232 and B1957+20.

We obtained about 3600 s of data on each pulsar using 20 to 22 GMRT antennae in an incoherent mode at 610 MHz with 16 MHz of bandwidth. The expected rms noise in the above configuration of GMRT for a sampling time of 258 μs is about 1 Jy. The data in two subbands (8 MHz each) were dedispersed to a common sky frequency (610 MHz). The periods with a peak greater than 3.5 × rms in both bands at the same sample were identified as Large Amplitude Pulses (LAPs). This procedure disperses any narrow interference spike, discriminating against interference. A number of marginal LAPs, i.e., pulses with a peak between 3.0 to 3.5 times rms, were also identified.

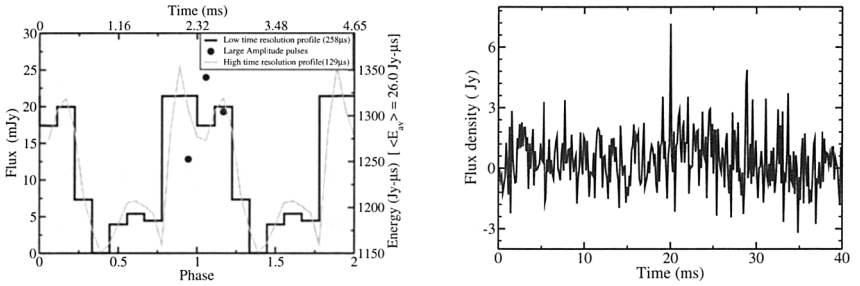

Figure 1. LAPs in PSR J0218+4232 and B1957+20. *Left panel:* baseline-subtracted radio integrated profile for PSR J0218+4232 with the LAPs marked with the filled circles at the phase of their occurrence. The energy in the LAP is labeled on the right. *Right panel:* the GP detected in PSR B1957+20 after removing the off-pulse mean.

2. Results

We searched 2.2 million periods for PSR J0218+4232 ($B_{lc} \sim 3.2 \times 10^5$ G) and found three significant LAPs. Figure 1 (left panel) shows the integrated profile for this pulsar and the detected LAPs, marked with filled circles. The largest of these had an intensity 51 times the mean intensity (intensity of LAP, $I_{lap} \sim 1341\,\mathrm{Jy}\,\mu\mathrm{s}$). Our data also contained nine marginal LAPs, seven of which occur between phase 0.89–1.2, which is the phase interval corresponding to one of the high energy peaks. We searched about 1 million periods for PSR B1957+20 ($B_{lc} \sim 3.8 \times 10^5$ G) and found one significant LAP, shown in Figure 1 (right), with an intensity 129 times the mean intensity ($I_{lap} \sim 925\,\mathrm{Jy}\,\mu\mathrm{s}$). In addition, we also detected five marginal LAPs.

PSRs B1957+20 and J0218+4232 have the fourth and sixth highest values of B_{lc}, respectively, among known radio pulsars. Hence, these new detections support a connection between the magnitude of B_{lc} and the existence of GPs and LAPs. The data for pulsars with $B_{lc} \lesssim 10^5$ G are still being analyzed.

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