Analysis of Giant Pulses from the Vela Pulsar

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Introduction

Pulsars are the remnants of a condensed star's core after it undergoes a supernova. To maintain angular at such a compact density, pulsars rotate at a very fast rate. The Vela pulsar (J0835-4510), rotates at approximately 11 Hertz. When the magnetic field lines of the Vela pulsar are pointed towards the Earth during a rotation, we may detect emitted radiation frequencies using a radio telescope. It has been observed that about every three years, a glitch occurs- meaning that there is a sudden increase in the star's rotational frequency. With data collected from the Green Bank 20-meter Telescope, we analyzed and compared data before and after the Vela glitch on July 22nd, 2021.

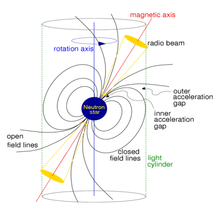


Fig. 1 Diagram of Pulsar from *Handbook of pulsar astronomy*

Fig. 2 The Green Bank 20-meter taken by Ann Schmiedekamp

Methods

- Operated the 20-meter telescope at the Green Bank Observatory in Green Bank, West Virginia through the Skynet web interface.
- Data consists of observations taken in the frequency range of 1350MHz to 1750MHz, with an integration time of 0.0001 seconds, and observation durations ranging from 100 seconds to 900 seconds during the year 2021.
- Utilized Jupyter Notebooks that consist of Python code to process the raw (.fits) files produced from the telescope. Programs from the PRESTO suite, such as "rfifind" and "prepfold", were used to clean and filter out bad data.
- Each observation's notebook provided graphical and textual data for user approval of the quality of the data.
- The output of the notebooks are text files listing each pulse detected with arrival time and strength information.
- The detected pulses are analyzed in this poster.
- In Excel, further data analysis was conducted using Excel functions, graphing on scatter plots, and analyzing the trendlines and their slopes.

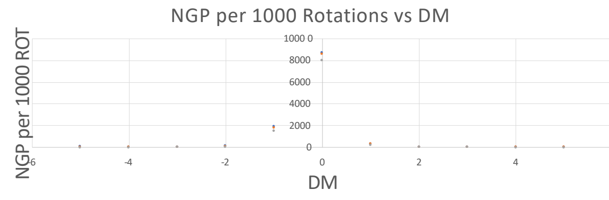


Fig. 3
In this graph, we plotted the number of giant pulses (NGP) per 1000 rotations vs the interval of dispersion measure (DM) at 3 different signal to noise (S/N) thresholds. At ΔDM=0, the recorded dispersion measure of the observation is equal to that of the pulsar. The asymmetry observed around ΔDM= -1 illustrates that RFI may have slipped past our data reduction methods. For this reason, we only used data with the ΔDM= 0 in the rest of the project.

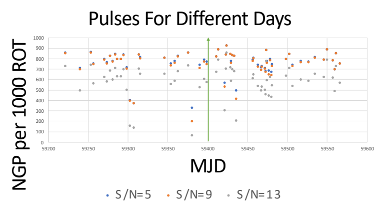


Fig. 4
Plotted in this graph is the number of giant pulses per 1000 rotations vs the date (MJD) at different thresholds. The average number of pulses per 1000 rotations was unchanged after the date of the glitch.

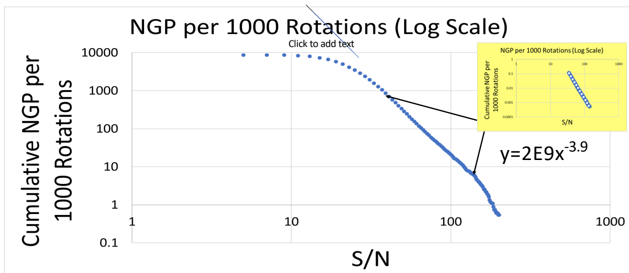
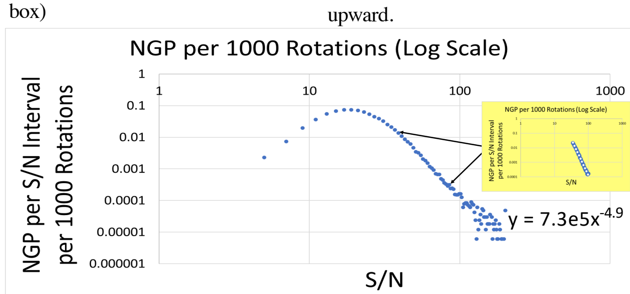


Fig. 5 (above)
Here, the log scale graph displays the count rate of pulses above the given threshold. There is an exponential drop off in the count rate between thresholds 10 through 12, which is illustrated by the power law derived with a linear trend line. (see yellow box)

Fig. 6 (below)
This log scale graph displays the count rate of giant pulses between thresholds in bins of every 2 S/N values. It shows that the number of giant pulses approximately decreases exponentially with pulse flux from an S/N value of about 30 upward.



Conclusions

- Our data reduction methods may have allowed some RFI into our data, which is illustrated by the asymmetry in Fig. 3.
- We saw no change in the average number of Giant Pulses per 1000 rotations after the pulsar glitch. We only noticed a difference of about 10 Giant Pulses while the standard deviation across the data was over 100. This may tell us something about how glitches affect the pulse mechanism in pulsars.
- We observed a power law, fall off behavior in the number of pulses with the strength of the pulses for a significant rang of S/N values.

The field of astronomy gains significant insight on this study of the Vela Pulsar through further classification of giant pulses and how glitches of pulsars can affect the production of normal pulses and giant pulses.
The Vela pulsar has been known for 50 years vs other stars which have been known for thousands of years.

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- (Software)Ransom, Scott, PRESTO, https://www.cv.nrao.edu/~sransom/presto/