

SEARCH FOR PULSARS AND SUPERNOVA REMNANTS

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Abstract

The Cassiopeia A (Cas A) supernova remnant and pulsar B0329+54 were observed in this study. With this data, both the radial velocity and the distance of the SNR from Earth were calculated. The length of the period of the pulsar B0329+54 was also observed in an attempt to locate a starquake. If a starquake were to occur, the pulsation period would shorten due to the conservation of angular momentum law. When the time came to observe the pulsar, the frequency synthesizer did not function properly and pulsars were not able to be observed. Previous data from the pulsar B0329+54 was able to be analyzed even though no new data was acquired. Data from Cas A was collected first using the 4.6 meter radio telescope (SMILEY) and from this the velocity and distance of the SNR were able to be determined.

Introduction

The original goal of this project was to observe pulsars and starquakes. Unfortunately, due to technical difficulties, this plan was unable to be executed. The frequency synthesizer set up by Dr. Moffett did not function as planned. Although original pulsar data could not be obtained, data previously collected from pulsar B0329+54 by Dr. Moffett was analyzed. Due to these discrepancy difficulties, the focus of the project switched to supernova remnants. Due to

more technical difficulties with the 26 meter radio telescope, the data collected was inaccurate. Once this was realized, new measurements were taken with the 4.6 meter radio telescope. Using the new supernova remnant data, the radial velocity of the supernova remnant and the distance to the remnant were calculated.

Pulsar observations began in an attempt to help Dr. Moffett with his observations to detect starquakes in neutron stars. Dr. Moffett has analyzed pulsar stars in the past and wants to detect starquakes in order to understand the structure of neutron stars. Starquakes occur when the interior of the neutron star shifts and the star contracts. The period decreases because of conservation of angular momentum. The frequency synthesizer Dr. Moffett used to observe pulsars was not working correctly and the focus of the project shifted to supernova remnants that could be observed without using the synthesizer.

The observations of the Cassiopeia A supernova remnant began to determine the distance from the earth to the remnant. Although previously calculations have been conducted in order to determine the distance to Cassiopeia A, recalculating the problem helped with confirming these measurements.

Methods

Work on observing pulsars began with Dr. Moffett using the East 26 meter telescope. Using the ATNF Pulsar Database, the coordinates and period of pulsar B0329+54 were found. In order to calculate the number that had to be entered into the synthesizer, the frequency had to be multiplied by 2×10^{-19} . This converted the frequency into a number that the synthesizer was able to use. Then the SpectraVue software that displays the pulsar period had to be set to the correct period for PSR B0329. The FFT Size and the smoothing had to be adjusted so that the pulsar

could be viewed optimally. Using these tools, a pulsar should have been observed. However, due to technical difficulties with the synthesizer and the telescope, a pulsar was never located. Later in the week, Dr. Moffett brought data from pulsars he had previously observed. This data was then analyzed instead of original pulsar data.

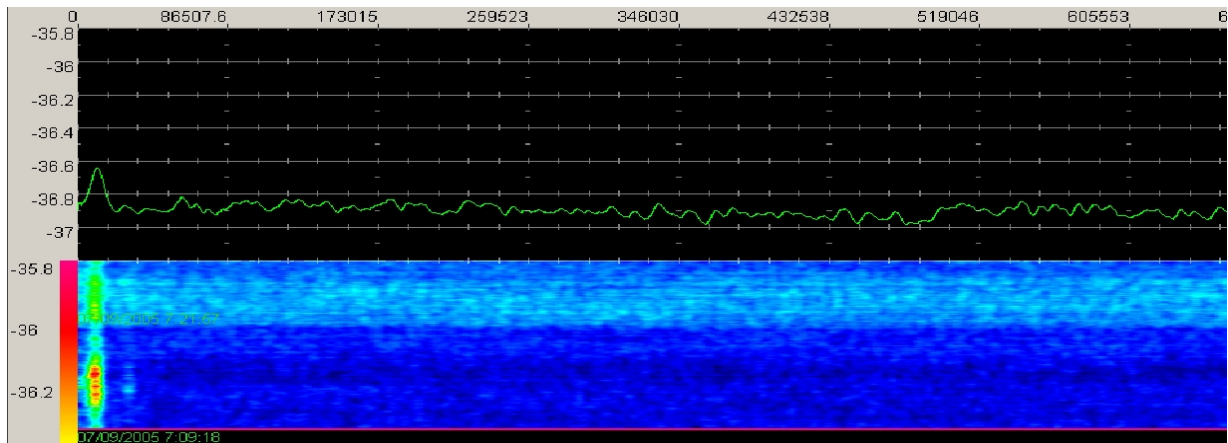


Figure 1 - Data from the B0329+54 pulsar showing one pulsation period

Using the West 26 meter telescope, the Cas A supernova remnant was observed. Scans of the frequency intensity were taken for analysis. When the data was analyzed, it was discovered that the telescope was not showing the correct frequencies. As a result, all calculations were very different from what had been previously calculated. The expected distance was 3.4 Kpc and the expected velocity was around -32 km/s. Once this discrepancy was realized, observations were conducted using SMILEY. With these correct observations, the radial velocity and distance to the Cas A SNR were calculated and closely resembled expected estimate.

Results

Because of problems with the telescope and synthesizer, new data was not obtained. Dr. Moffett's data showed what different pulsars look like graphed in SpectraVue. By looking at

different pulsars, variety in length of each pulsar's period was able to be seen. Although in this data there were no starquakes, the period of the pulsar was still observed.

The main focus shifted to SNRs because of the problems with the East 26 meter telescope and the synthesizer. The West 26 meter telescope was used to observe the Cas A SNR. After working with the data from the West 26 meter telescope and calculating values that did not come close to previous estimates, it was found that the data being used was not accurate. After taking new data from SMILEY, the correct radial velocity and distance of the Cas A SNR were measured.

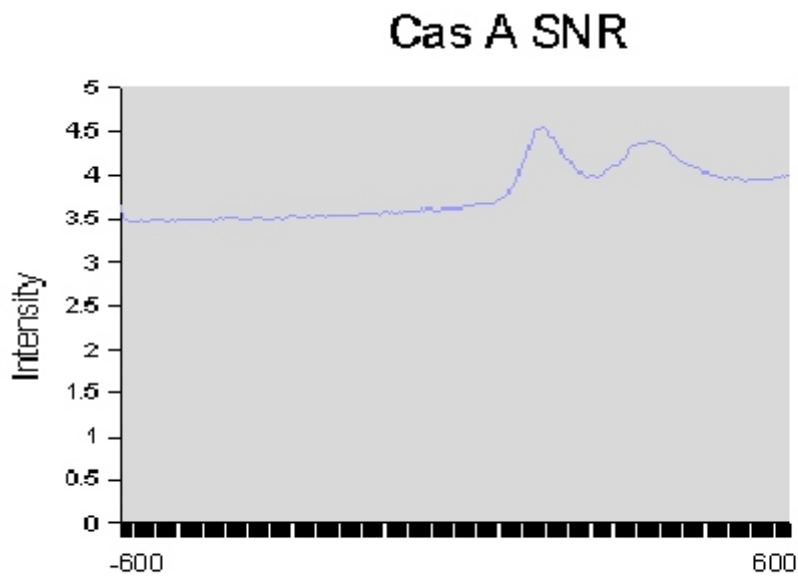


Figure 2 - Cas A data obtained by SMILEY showing intensity as a function of frequency

The radial velocity was calculated with the equation:

$$v_r = -c \left(\frac{\Delta f}{f_o} \right)$$

with v_r as the radial velocity in km/s, c as the speed of light in km/s, Δf as the change in

frequency in MHz ($.115 \pm .005$ MHz), and f_0 as the original frequency in MHz (1420.4 MHz).

The radial velocity was calculated to be -32.746 km/s. Then the distance was calculated with the equation:

$$v_r = A d \sin(2l)$$

with A as the 1st Oort constant ($14.8 \pm .8$ km/s-Kpc), d as the distance in Kpc, and l as the galactic longitude in degrees (111.7°). The distance was calculated to be $3.22 \pm .29$ Kpc. The uncertainty was calculated by using the instrumental uncertainty and the uncertainty in the 1st Oort constant.

Discussion

Dr. Moffett's pulsar data showed what a pulsar's period looked like and also explained how that period would change in the case of a starquake. In the event of a starquake, the period of the pulsar would be shortened. If the machinery for observing the pulsar was working, the data obtained would have been used to help Dr. Moffett with his research on pulsars. The chance of observing a starquake was slim, but if it had been observed, it would have greatly helped Dr. Moffett in his research.

The first set of data obtained from the West 26 meter telescope, although inaccurate, helped explain how the Oort diagram works. The telescope was off in measuring the frequency of the radio signal. Working with data that was incorrect allowed further understanding of the function of the equation used with the Oort diagram. Also, because correct data was obtained using SMILEY, the problem with the West 26 meter telescope was discovered. With the data that was obtained from SMILEY, many things, besides the distance to the supernova, could have been calculated. For example; the graph could have been used to determine the velocity of expansion of the supernova remnant, the size of the remnant, the kinetic energy of the system, and the kinetic energy of the initial supernova.

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