Automating Pulsar Bowshock Discovery

A Python-Powered Solution for Streamlined Sorting and Multi-Survey Image Analysis

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Introduction

Pulsar bowshock identification is a crucial yet time-consuming process in pulsar research. The discovery and analysis of these structures provide valuable insights into pulsar environments and local properties of the interstellar medium. However, the traditional methods of identification involve manual inspection of large datasets, which is inefficient and error-prone.

This poster presents a Python-based tool that streamlines the search for and analysis of pulsar attributes, namely bowshocks. By simplifying sorting, overlaying images from multiple surveys, and manipulating data for efficient examination, our tool significantly enhances data processing efficiency, enabling faster and more accurate pulsar analysis.

Objectives

The main objectives of our Python-powered solution for pulsar bowshock discovery are:

- To automate the process of identifying potential pulsar bowshocks in large datasets
- To streamline the user sorting process, allowing for quick and efficient data categorization
- To overlay images from multiple surveys, providing a comprehensive view of potential bowshock candidates
- To manipulate and preprocess data for more efficient examination and analysis
- To significantly reduce the time and effort required for pulsar bowshock discovery
- To improve the accuracy and consistency of bowshock identification

Acknowledgements

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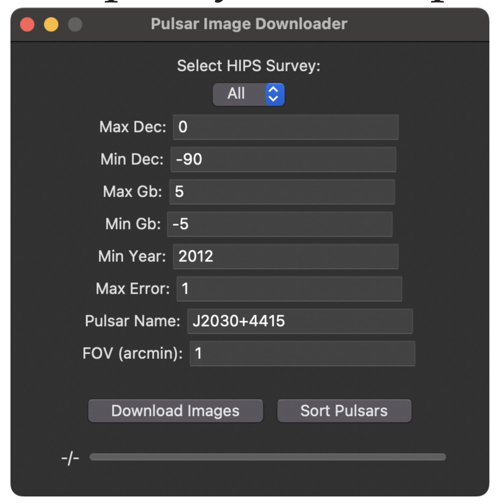
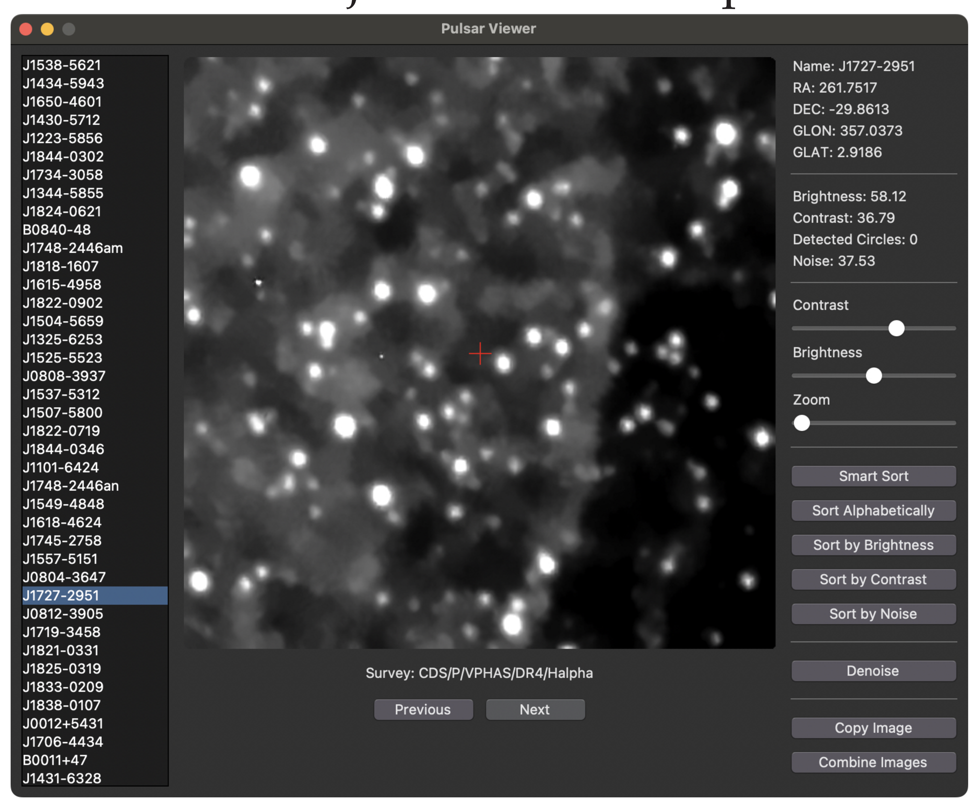
Usage

The pulsar analysis software can be downloaded at `https://github.com/benonymity/pulsar-search` (or scan the QR code above), and can be used by following these key steps:

1. Data collection: Gather images and data from multiple astronomical surveys
2. Download: Using a variety of HIPS surveys, download images of pulsars within a certain region of the sky. You can specify custom parameters



3. Sort the pulsars: After all the pulsars have been loaded, you must choose how to sort them. Smart sort takes in a variety of parameters, such as contrast, brightness, number of detected circles, noise, etc. But you can also choose just one of these parameters



4. Multi-survey overlay: To look for particular features such as bowshocks, you'll want to select images from multiple surveys or wavelengths to overlay, and specify the percentages in which to combine them
5. Analysis: From here you can use the arrow keys to navigate between pulsars and surveys, adjust image parameters, and copy the image to record or share.

Graphical Results

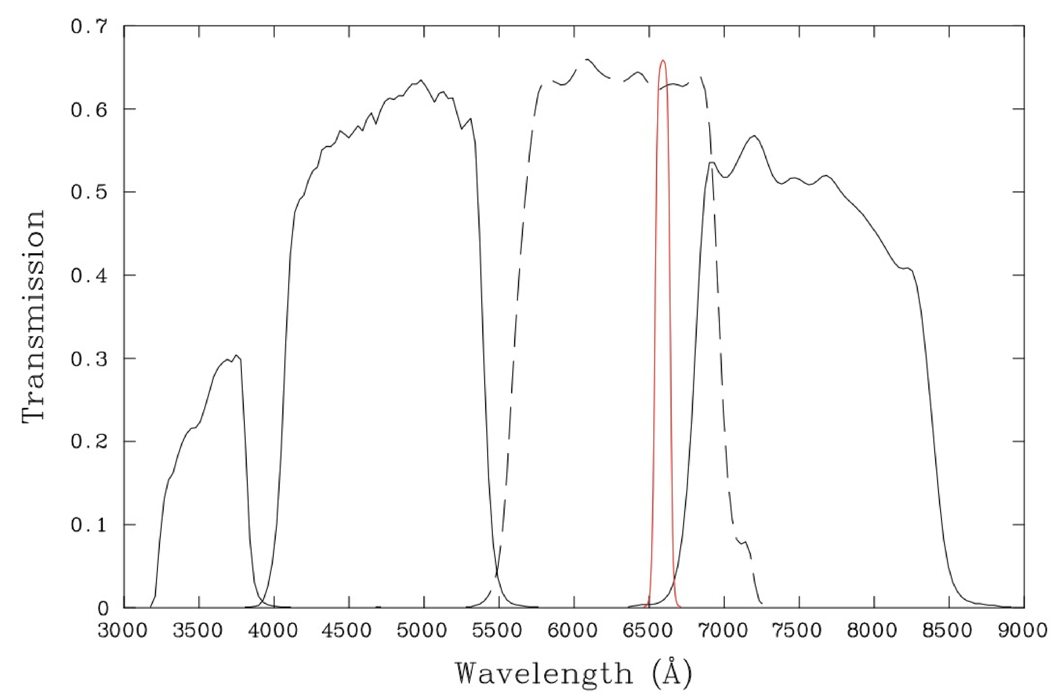


Figure 1: The wavelength distribution of the various VPHAS [1] survey bands, data from which is used to perform pixel subtraction to isolate significant features in the Hα band

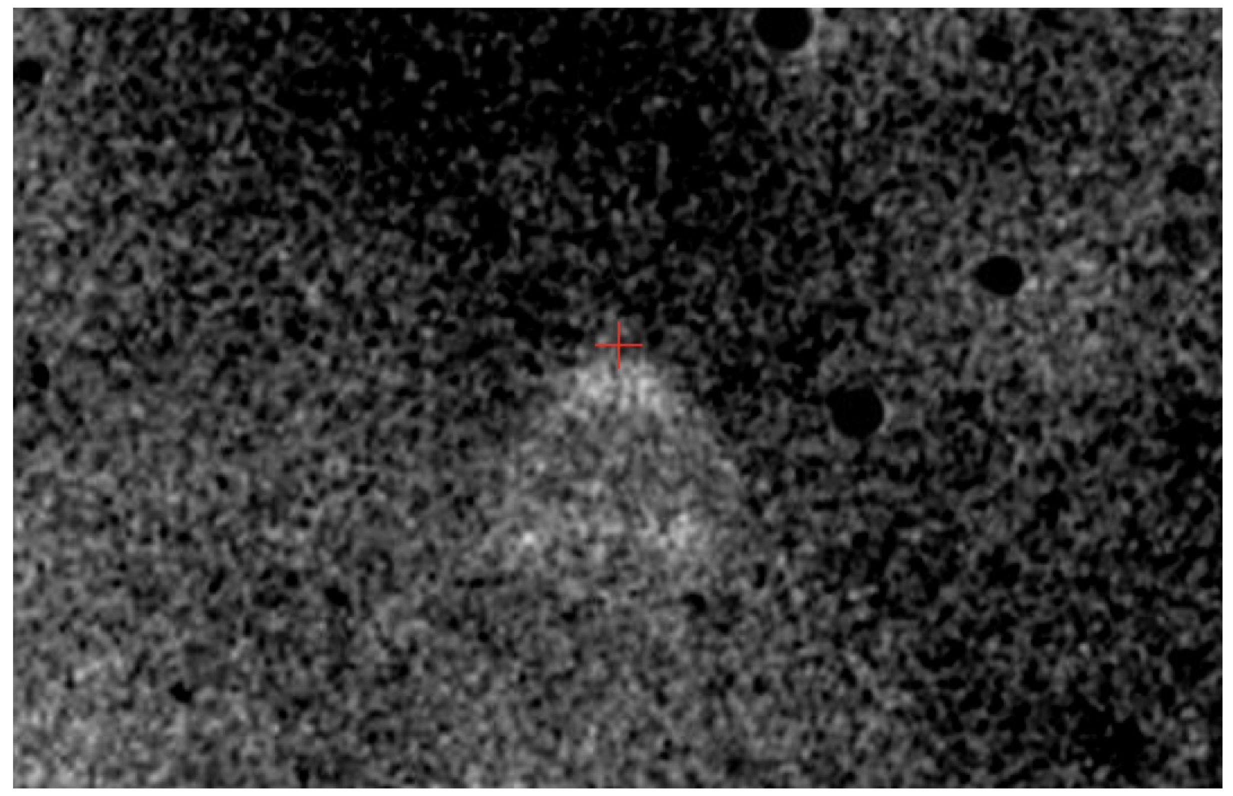


Figure 2: Processed example of the bowshock from PSR J2030+4415 [2] made prominent by visually subtracting the IPHAS i and r bands from the Hα band

Definitions

Our Python-powered solution for pulsar bowshock discovery includes the following key features:

1. Pulsar: A magnetized, rotating neutron star that emits beams of electromagnetic radiation from its poles.
2. Bowshock: A curved, shock-like structure formed when supersonic pulsar wind magnetically shocks the ambient interstellar medium.

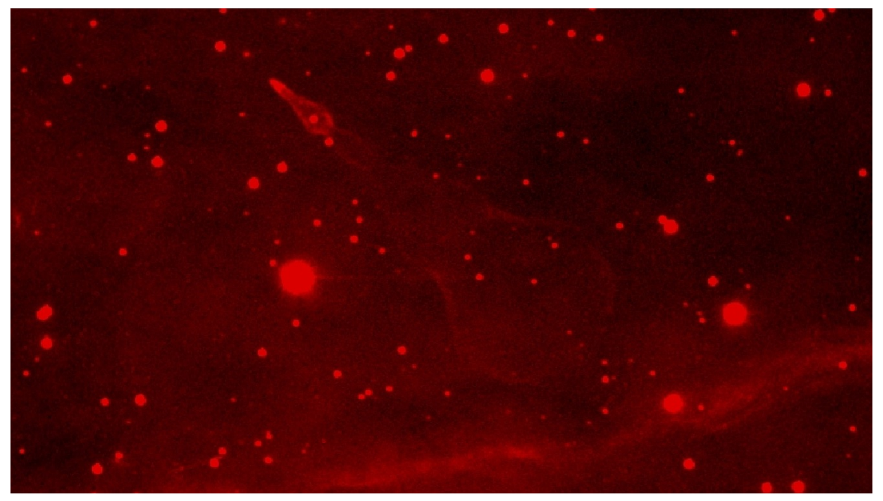


Figure 3: The Guitar Pulsar Wind Nebula [3]

Discussion

The implementation of our Python-powered solution for pulsar bowshock discovery has yielded significant improvements in the efficiency and accuracy of the identification process.

In future, we'd like to retrieve images from untapped archives, especially reprocessing old archival images of known nebulae and comparing them to more recently published images - for example the J-2030 image in IPHAS is older than its published discovery, so we could use this software to show how it's expanded since the last available image. We also plan to use this software to sift through images from previous Hillsdale campaigns at Kitt Peak National Observatory and Palomar Observatory.

Our current results and our future plans demonstrate the potential of automated tools in advancing pulsar research and highlight the importance of continued development in this area.

Ongoing Research

Our ongoing research focuses on further improving the efficiency and accuracy of our pulsar bowshock discovery tool. Future developments include:

- Implementing even better machine learning algorithms for more advanced pattern recognition
- Expanding the tool's capabilities to include additional survey datasets, especially private HiPS lists
- Developing more user-friendly software packaging for wider adoption in the pulsar research community
- Exploring the potential for applying similar automated techniques to other areas of astronomical research

References

[1] J. E. et. al Drew. The VST Photometric Hα Survey of the Southern Galactic Plane and Bulge (VPHAS+). *Monthly Notices of the Royal Astronomical Society*, 440(3):2036–3058, April 2014.

[2] Sasha Brownsberger and Roger Romani. A Survey for Hα Pulsar Bow Shocks. *The Astrophysical Journal*, 784(2):154, 2014.

[3] Timothy Dolch and et al. Recent H-alpha Results on Pulsar B2224+65's Bow-Shock Nebula, the "Guitar". *Journal of Astronomy and Space Sciences*, 33:167–172, 09 2016.