CXO analysis of PSR J1849–0001 and its PWN

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Abstract: We obtained 108-ks of new Chandra X-ray Observatory (CXO) observations of PSR J1849-0001 and its PWN located within the extent of HESS source PSR J1849-000. By analyzing the new and old archival CXO data we resolved the PWN morphology of arcsecond and arcminute scales and measured the spectra of different parts of the PWN. We consider the implications of our results for the orientation of the pulsar's spin axis and compare the PWN and pulsar properties with those of the PSRs/PWNe population.

Introduction

Pulsars are some of nature's most powerful particle accelerators. Charged particles gyrating in the strong magnetic fields of pulsars produce synchrotron radiation that we observe as a pulsar wind nebula (PWN). The magnetic field alone cannot accelerate particles as magnetic fields do no work. Therefore, it is the combination of the kinetic energy supplied by the rapid pulsar rotation and the magnetic field that leads to particle acceleration. [1]

The Chandra X-Ray Observatory (CXO) allows us to analyze the X-ray emission from the PWN in detail, due to its unrivaled sub-arcsecond angular resolution and high sensitivity.

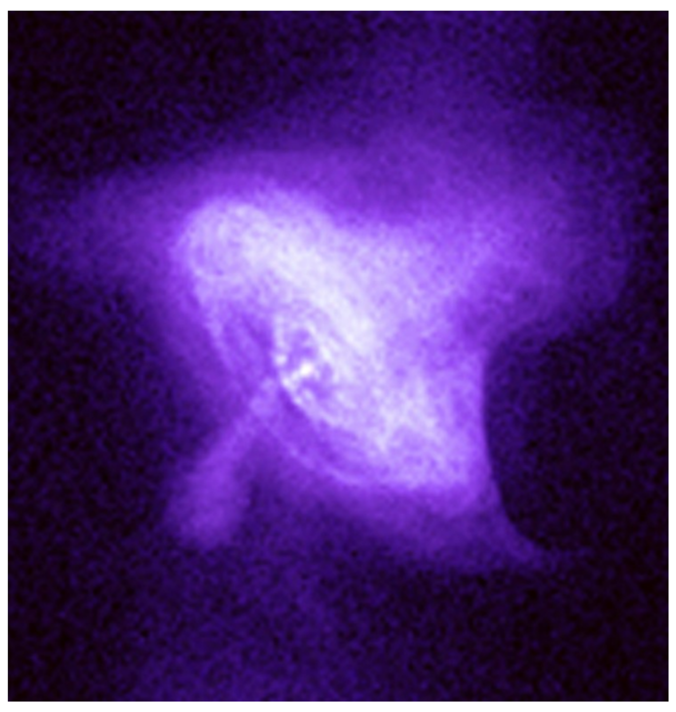

Figure 1: Crab PWN

PWN Morphology

- The large-scale PWN appears to be elongated and asymmetric with respect to the pulsar.
- There is no clear evidence of a torus.
- There is a hint of a jet structure extending to the SW of the pulsar.
- Four regions were defined for spectral analysis (pulsar, jet, compact PWN, and extended PWN).

Images

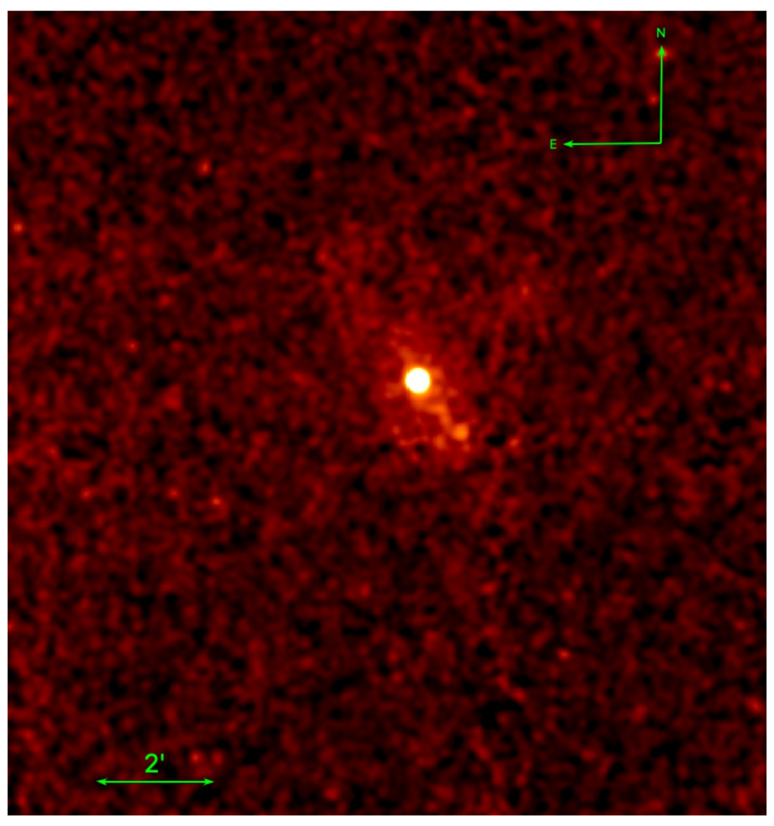

Figure 2: The image of diffuse emission around PSR J1849-0001 after subtracting the point sources.

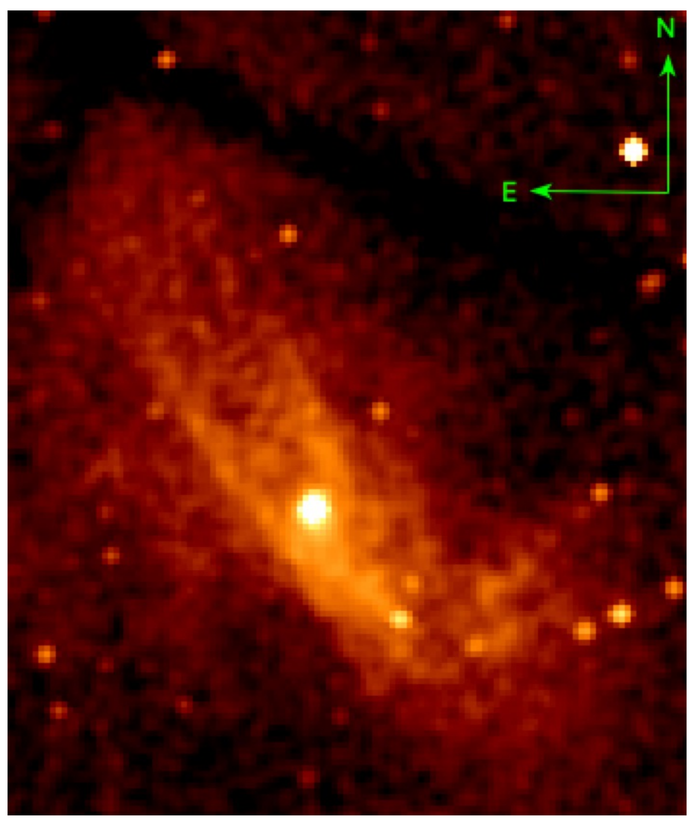

Figure 3: The image of diffuse emission within SNR MSH 11-62

The structure of J1849 and its PWN is similar to a structure found within SNR MSH 11-62. Based on this similarity, it is possible that this structure is a PWN powered by an MeV pulsar, which would explain why it has not yet been detected.

Fitting the Spectra

- The python package Sherpa was used for spectral fitting. Results are shown in the Figure 4.
- An absorbed power-law was used in the spectral fits due to the presence of synchrotron emission.
- Two additional bright point sources were found in the image and their spectra were also extracted and analyzed. Their fluxes indicate that these sources are both variable.

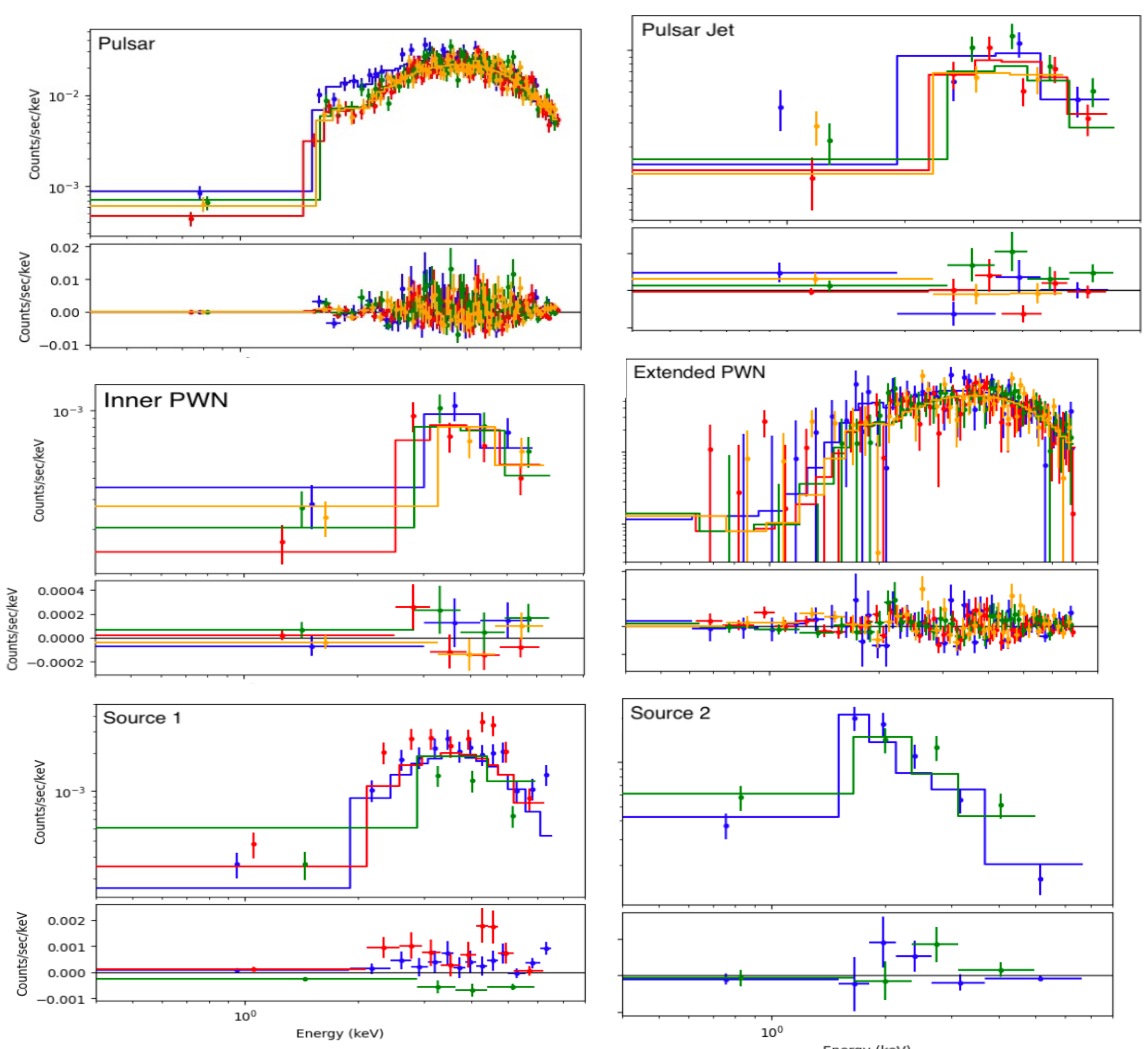

Figure 4: Spectra of PSR J1849-0001, its PWN, and the bright point sources

Modelling the Multi-wavelength SED

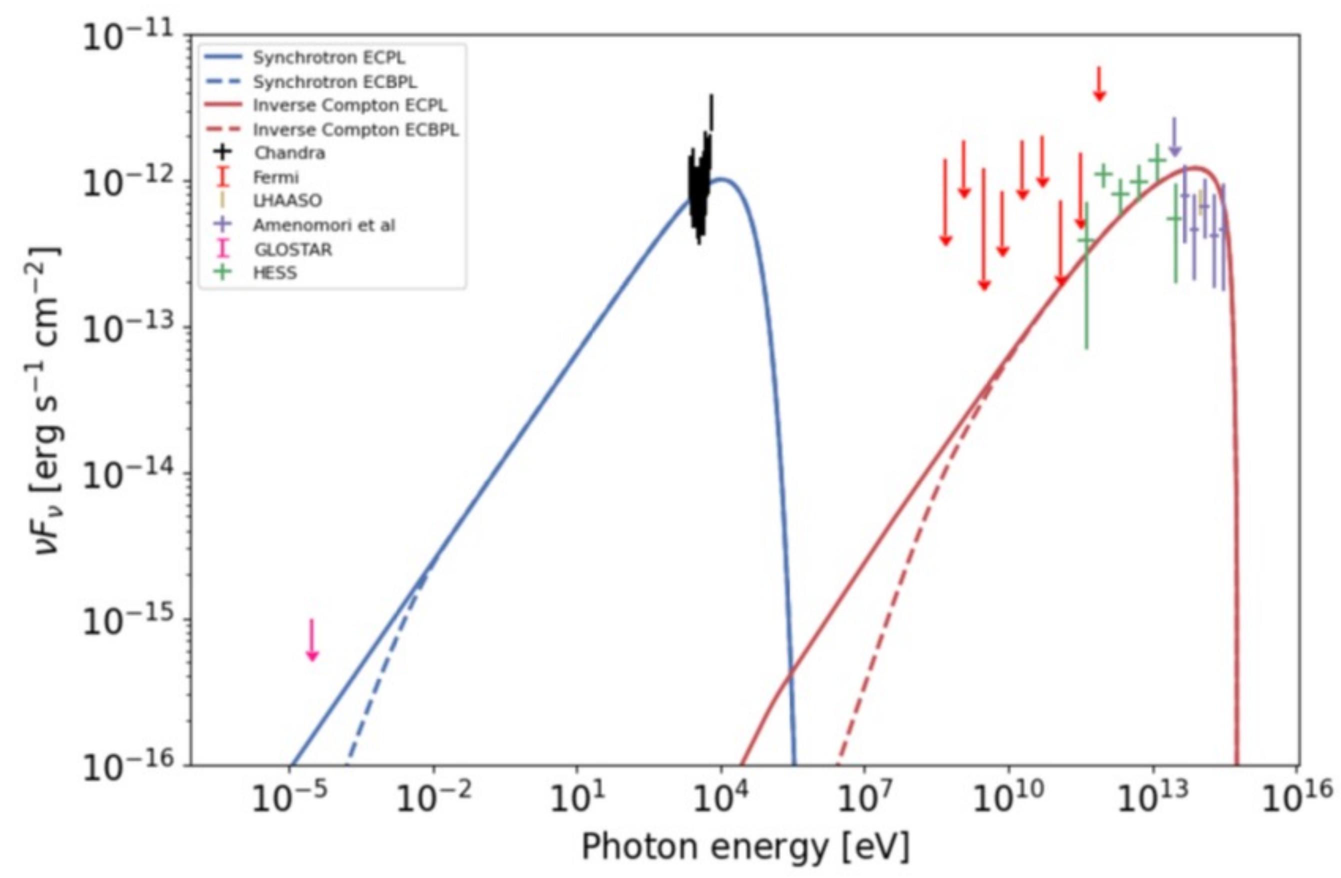

Figure 5: Multi-wavelength SED of the J1849 PWN.

- The spectral energy distribution (SED) was modeled using the python package Naima (Figure 5).
- Exponential cutoff models were used with and without a break in the spectrum.
- The magnetic field and normalization were varied to fit the models to the data.
- It was found that the magnetic field was unphysically low (~1.5 μG).
- Higher magnetic field values were obtained from a more complex multi-zone model [2].

Future Work

There is still much that we do not understand about PWN. For example,

- The particle acceleration mechanism
- The large variance in the spectra and luminosities of PWNe
- The role of the angle between the spin and magnetic dipole axis of the pulsar in the PWN morphology.

We hypothesize that the lack of a clear torus-jet morphology and a small PWN radiative efficiency (~8.5 E-2) imply a nearly aligned rotator (in agreement with the lack of radio and gamma-ray emission from the pulsar). Additionally, we are interested in performing

- complex modelling of the SED using multi-zone models
- detailed comparison to the PWN of MSH 11-62.

References

[1] Slane, P. 2017, Handbook of Supernovae, 2159. doi:10.1007/978-3-319-21846-5_95

[2] Kim, C., Park, J., Woo, J., et al. 2024, ApJj, 960, 78. doi:10.3847/1538-4357/ad0ecd