New X-ray observations towards PSR J1826-1256

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INTRODUCTION

The pulsar PSR J1826–1256, one of the brightest radio-quiet gamma-ray pulsars, is surrounded by diffuse and weak X-ray emission of non-thermal origin. It was suggested that this emission detected with *Chandra* could come from the pulsar wind nebula (PWN) powered by PSR J1826-1256, named G18.5–0.4 or "Eel" PWN (Roberts et al. 2007, BAAS, 39, 997).

PSR J1826-1256 is seen projected 5.4' away from the centroid of the TeV source HESS J1826–130, which is a newly-unidentified extended TeV source, previously hidden within the emission from the bright nearby PWN HESS J1825–137 (H.E.S.S. Collaboration 2018, A&A 612, A1).

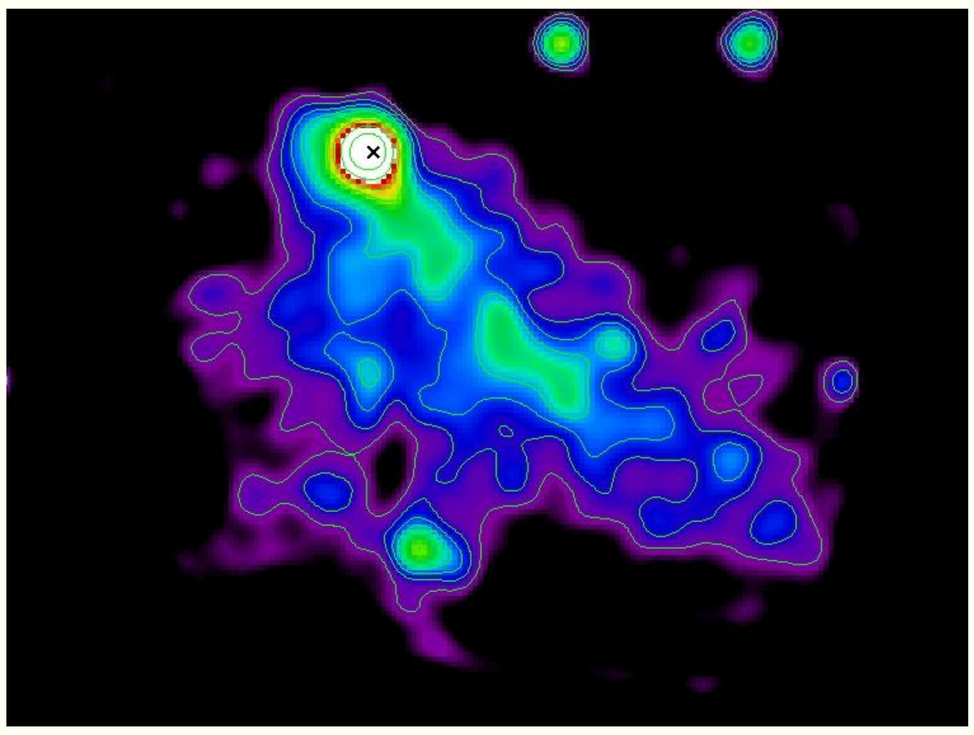
Aims: To confirm the nature of the X-ray emission around PSR J1826–1256 and investigate its connection with the very-high-energy source HESS J1826–130 in order to unveil the origin of the gamma-ray emission.

OBSERVATIONS

The X-ray image and spectra towards PSR J1826–1256 were obtained by processing unpublished archival *XMM-Newton* data. The MOS1 and MOS2 cameras were set in the full-frame mode and hence mapped the full extension of the nebula, while the pn camera was operated in the small-window mode, which covers a small region around PSR J1826–1256.

The two MOS cameras were used for the analysis of the X-ray emission and the three cameras for the spectral study of the pulsar. The data were processed using software packages SAS 16.1.0 and Heasoft 6.22.1.

NEW X-RAY IMAGE



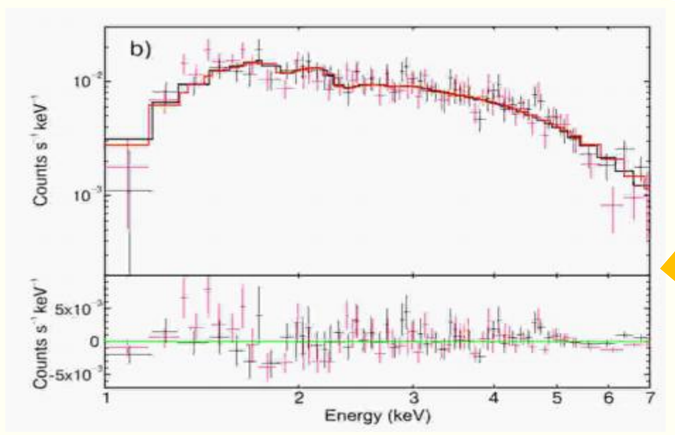
XMM-Newton X-ray emission towards PSR J1826-1256 in the energy range 1.0 to 7.0 keV. The new image reveals considerable new structures and diffuse emission not detected in the previous study performed with *Chandra*. The bulk of the emission comes from an elongated feature with an elliptical shape of about 6' x 2', which appears brighter around the pulsar and extends towards the southwest, in the direction of the TeV source centroid. The elongated feature is surrounded by faint and diffuse emission that is more prominent towards the southeast.

X-RAY SPECTROSCOPY

Global analysis

In order to obtain the overall properties of the X-ray emission, the spectrum was extracted from the region delineated by the ellipse shown in the figure.

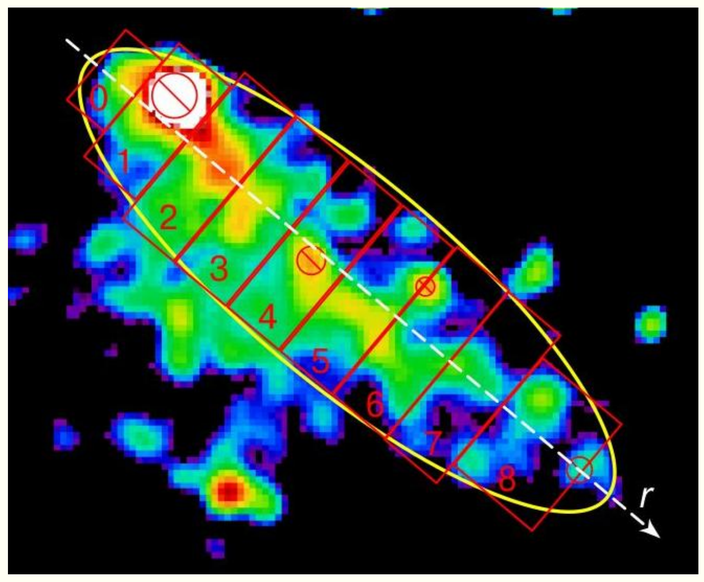
The background was chosen from a circular region free of diffuse emission and excluding the point sources over it. The spectral points were simultaneously fit in the 1.0-7.0 keV energy band with an absorbed power-law model (wabs+powerlaw). The results are shown in the figure



MOS1 (black) and MOS2 (red) spectra for the global emission in the 1-7 keV band. The solid lines represent the best fit for an absorbed power-law model.

Spectrum of PSR J1826–1256

The *XMM-Newton* spectrum of PSR J1826-1256 is well fitted with an absorbed power-law model. The fitted absorbing column density turns out to be similar to that obtained for the extended emission, as expected if they are associated sources.



Parameters of the diffuse emission from the PWN and from PSR J1826–1256

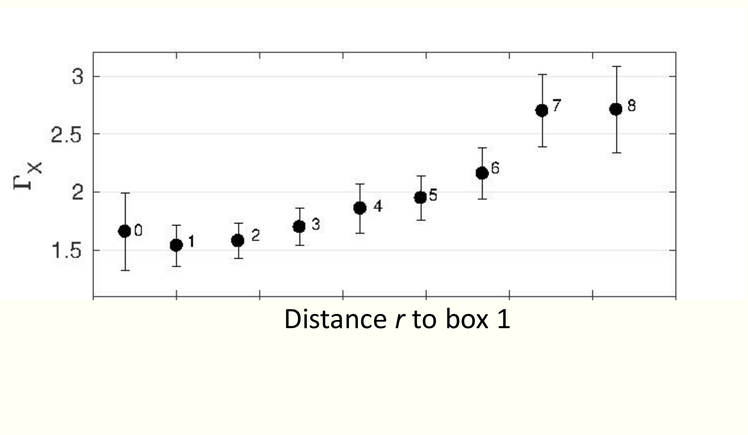
Parameter	Inside the ellipse	Pulsar
Total counts	24600	3300
N_H (10^{22} cm^{-2})	1.89 ± 0.26	1.59 ± 0.42
Γ_x	1.79 ± 0.17	1.26 ± 0.25
F(0.5-8.0 keV)(10^{-13} erg s^{-1}cm^{-2})	13.4 ± 0.4	1.14 ± 0.06

Spectral Variations

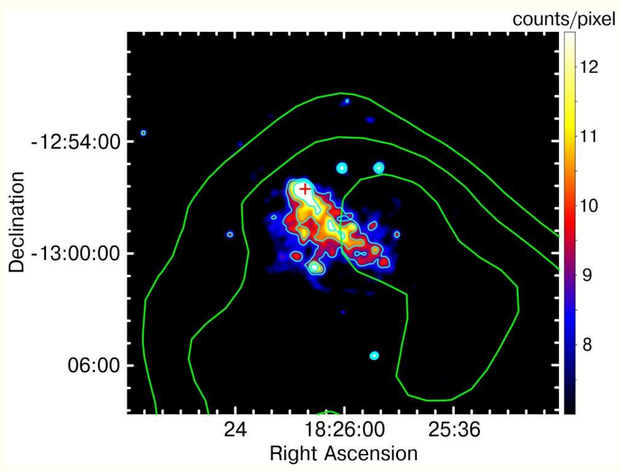
Individual spectra were extracted from nine rectangular boxes excluding the point sources indicated with the red circles in the figure. The circle inside box 1 was used to exclude the emission of PSR J1826-1256.

For each box, the two spectra are simultaneously fitted with a power-law model in the 1.0-7.0 keV energy band, keeping the column density frozen to the best-fit value obtained for the whole diffuse emission, N_H = 1.89 × 10^{22} cm^{-2}.

The spectrum is characterized by a power law with a photon index going from 1.6 around the pulsar to 2.7 in the borders of the nebula, a behavior observed in several Galactic PWNe, and consistent with synchrotron cooling of electrons.



THE CONNECTION WITH HESS J1826–130



X-ray emission towards PSR J1826–1256 in the 1.0-7.0 keV energy band (colors + cyan contours), while green contours trace the TeV emission from HESS J1826–130 .

In a leptonic scenario the TeV emission is expected to arise from inverse Compton (IC) scattering between the ambient low-energy photons and the same population of electron producing synchrotron radiation in the keV band.

Based on the X-ray results we roughly estimate the energy of the TeV photons produced by IC scattering to be lower than 30 TeV, assuming that the softening of the spectrum with the distance from the pulsar is due to cooling effects and the cosmic microwave background is the main source of background photons with a temperature of ~3 K. The calculated value is compatible with the detection of gamma rays in the 0.5-40 TeV range suggesting that HESS J1826–130 is likely produced by the PWN powered by PSR 1826–1256 via the inverse Compton mechanism.

CONCLUSIONS

The analysis of the new *XMM-Newton* data demonstrated a non-thermal origin for the X-ray emission with a photon index Γ softening with the distance to the pulsar. Besides, this study shows that the most plausible origin for HESS J1826–130 is due to the IC mechanism within the PWN powered by PSR J1826–1256.

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