A detailed X-ray study of the pulsar wind nebula around PSR B1853+01

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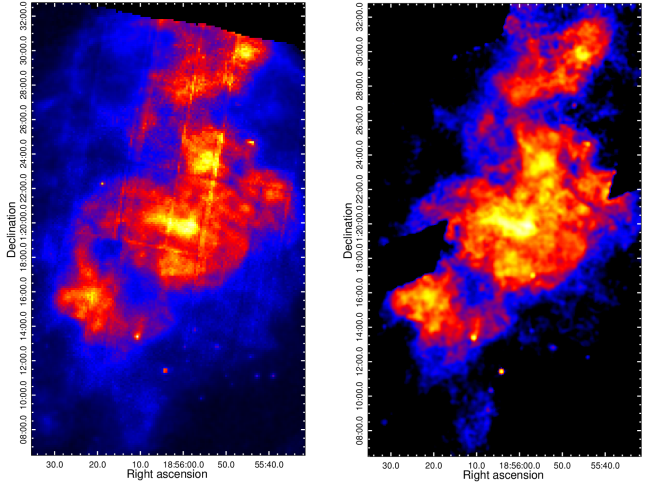
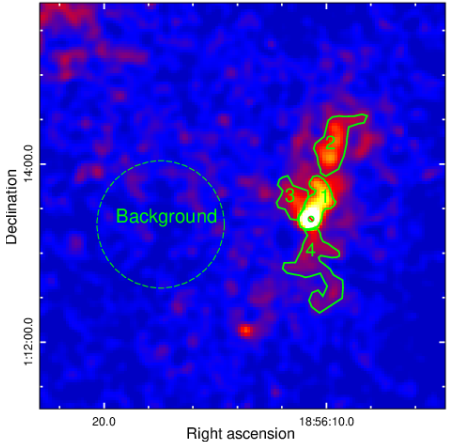
Science case: When propagating into the ambient medium, pulsar winds, mostly composed of electron-positron pairs, will be accelerated to high energies at the termination shock, emitting radiation from radio to gamma-rays. W44 is a mixed morphology supernova remnant with over-ionized plasma filled its center emitting soft X-rays of thermal origin (*Okon* et al. 2020). On the southern edge of W44 X-ray emission, is located the compact source PSR B1853+01. The analysis of archival *Chandra* and XMM-*Newton* reveals a PWN consisting of an extended tail-like structure trailing the pulsar and an intriguing antennae-like extended feature ahead of PSR B1853+01. Spatially resolved spectroscopy results reveal that this diffuse X-ray emission ahead of the pulsar is relatively hard compared to the pulsar, the compact nebula, and the regions inside the tail structure. This may be another case of a supersonic runaway PSR displaying extended structures, possibly as a results of the escape of high-energy particles into the surrounding medium (*Bandiera* 2008, *Pavan* et al. 2014, *Bucciantini* 2018).

The mixed morphology SNR W44

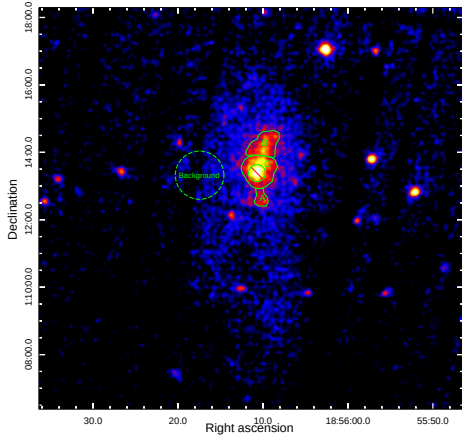


SNR W44 in X-rays where the pulsar and the PWN region is mixed with thermal X-ray emission from over-ionized plasma. Left: XMM-*Newton* (0.5 - 12.0 KeV) count image; right: *Chandra* broad band (0.5 – 7.0 KeV) flux image.

The PWN around PSR B1853+01



***Chandra* hard band (2.0-7.0 KeV) flux image of the PWN around PSR B1853+01 with spectral extraction regions overlaid. 1 - Compact Nebula (CN); 2 – PWN tail region; 3 - Lateral "jet"; 4 - Antenna-like extended emission ahead of the pulsar.**



XMM – *Newton* count image (2.0-10.0 KeV) of the PWN around PSR B1853+01. A - Antenna-like extended emission ahead of the pulsar; B – PWN tail region; C - CN.

* For XMM-Newton, due to its limited angular resolution, the lateral "jet" structure cannot be resolved.

* Above 2 KeV, the PWN emission is dominant while the contamination from the plasma is largely reduced in the vicinity of the pulsar/PWN. (*Petre* et al. 2002). Above 4 KeV the PWN is the only feature visible in the southern part of this SNR (*Harrus* et al. 1996).

References

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Pavan, L., Bordas, P., P¨uhlhofer, G., et al. 2014, A&A, 562, A122

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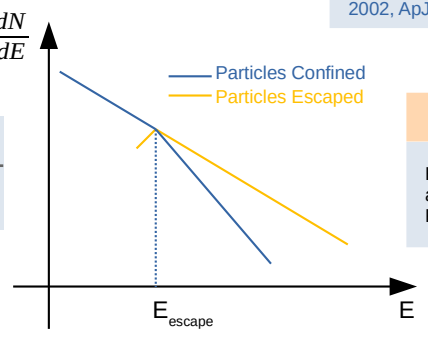
Composite Spectral Analysis

$N_H = 1.97^{-0.40}_{+0.41} \times 10^{22}\,cm^{-2}$ $\quad \chi^2_{overall} = 1100.3\,(dof = 1177)$

	Pulsar	CN	Tail	Antenna
Photon Index	$1.98^{-0.16}_{+0.17}$	$1.99^{-0.12}_{+0.13}$	$2.32^{-0.15}_{+0.16}$	$1.69^{-0.34}_{+0.35}$

Best photon index fitting results using an absorbed power law model for different regions after simultaneously fitting the whole *Chandra* and XMM-*Newton* data sets. All errors are at 3 sigma level.



Discussion

Highest energy particles are able to escape PSR 1853+01's PWN? (*Bandiera* 2008)