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Morphological Studies of the PWN Candidate HESS J1809-193

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Abstract: The source HESS J1809−193 was discovered in 2006 in data of the Galactic Plane survey, followed by several re-observations. It shows a hard gamma-ray spectrum and the emission is clearly extended. Its vicinity to PSR J1809-1917, a high spin-down luminosity pulsar powerful enough to drive the observed gamma-ray emission, makes it a plausible candidate for a TeV Pulsar Wind Nebula. On the other hand, in this region of the sky a number of faint, radio-emitting supernova remnants can be found, making a firm conclusion on the source type difficult.

We will present a morphological study of recent data of the source taken with H.E.S.S. We will compare the results with Chandra X-ray data and discuss possible radio counterparts. This may help to clarify the question of the nature of HESS J1809−193.

Introduction

Since the beginning of observations with H.E.S.S. (High Energy Stereoscopic System) in 2003 the number of known TeV gamma-ray emitting sources has increased drastically. The ongoing scan of the Galactic plane revealed several bright and extended sources for which no clear association with objects in other wavelength could be found [1, 3].

Pulsars, rapidly rotating neutron stars, are widely believed to be able to accelerate particles up to PeV energies. Those objects lose their rotational energy in winds of relativistic particles. The confinement of the wind in the interaction with the ambient interstellar material forms shocks; the shocked plasma is visible as a Pulsar Wind Nebula (PWN) (see [7] for a review). Synchrotron radiation seen in radio and X-rays prove the existence of relativistic electrons in the PWN. These electrons undergo inverse Compton (IC) scattering off ambient radiation fields, like the Cosmic Microwave Background, Galactic infrared background and optical star light, leading to the production of TeV gamma-rays.

Here we present the observation of one TeV source, HESS J1809−193, which is located close to a powerful pulsar and thus a good PWN candidate. X-ray emission from the direction of the pulsar support the theory of being a PWN. However, confusion with other sources cannot be ruled out.

TeV observations of HESS J1809−193

H.E.S.S. is a system of four Imaging Atmospheric Cherenkov telescopes (IACTs) dedicated to the observation of TeV gamma-rays. Its high sensitivity allows the detection of point sources with a flux of 1% of that of the Crab nebula within 25 h [2]. Its large field of view and an angular resolution of better than 0.1° makes it an ideal tool for observations of extended objects and for the conduction of sky surveys.

In the original Galactic plane survey conducted with H.E.S.S., TeV emission from

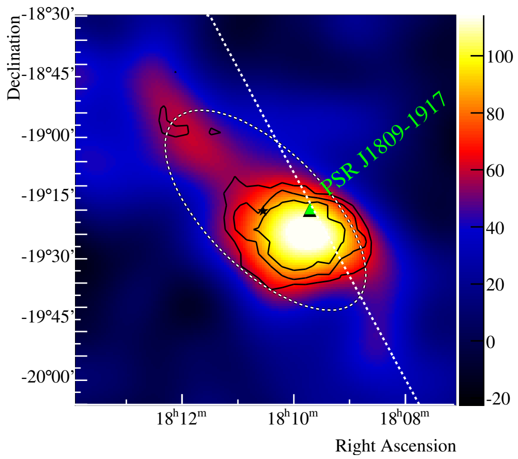

Figure 1: TeV gamma-ray excess counts from the direction of HESS J1809−193 (colour scale). The image is smoothed with a Gaussian (width = $6.6'$). Overlaid are 4, 5 and 6 σ significance contours, oversampled with a circle with radius $11.4'$. The dashed line represent the Galactic plane. The fit of a 2-dimensional asymmetric Gaussian to the excess is indicated by the white ellipse. The position of the pulsar is marked with a green triangle. [4]

HESS J1809−193 was only marginally detected. Further re-observations confirmed the existence of gamma-ray emission. Currently, data with 25 h live time are analysed [4]. Further data are available and will be presented at the conference.

The gamma-ray excess map of the source HESS J1809−193 is shown in Fig.1. It is clearly extended with an elongated shape. A fit of a 2-dimensional asymmetric Gaussian to the excess map yield a best fit position at RA = $18^{h}10^{m}31^{s} \pm 12^{s}$, Dec = $-19°18' \pm 2'$ (epoch J2000) and an extension of $32' \pm 4' \times 15' \pm 2'$. Within a circular region with radius $0.5°$ 875 excess events with a significance of $7.6\,\sigma$ were detected. The energy spectrum follows a power law with a photon index of $\Gamma = 2.2 \pm 0.1_{\rm stat} \pm 0.2_{\rm sys}$. The integrated energy flux between 1 and 10 TeV is 1.3×10^{-11} erg cm^{-2}s^{-1}.

Possible Associations

Located in the line of sight with the northern edge of HESS J1809−193 is the pulsar PSR J1809-1917. It has a spin down luminosity of $1.8 \cdot 10^{36}$ erg s^{-1} and an estimated distance of 3.5–3.7 kpc [11]. Placing HESS J1809−193 at the same distance, it has a gamma-ray luminosity of $2.1 \cdot 10^{34}$ erg s^{-1}. Assuming that the gamma-ray emission is entirely driven by the pulsar, the pulsar's apparent efficiency is 1.2%. This makes it very plausible that HESS J1809−193 is indeed a PWN.

Chandra X-ray observations revealed an X-ray PWN associated with the pulsar [10]. It has an elongated morphology, extending north of the pulsar. Additional faint and extended emission was found south of the pulsar and is also seen in ASCA data: the diffuse hard X-ray source $G11.0 + 0.0$ [5]. This source is discussed to be either a young shell-type supernova remnant (SNR) or a plerionic SNR. The existence of the PWN north of the pulsar and the diffuse source $G11.0 + 0.0$ coincident with HESS J1809−193, support the theory that the observed TeV emission is IC radiation powered by the pulsar wind.

Figure 2 compares the H.E.S.S. result with observations at other wavelengths, revealing a number of radio-detected supernova remnants in the vicinity of HESS J1809−193 [6, 8, 9]. The composite SNR $G11.2 - 0.3$ is a known source of radio [8] and X-ray emission (see e.g. [12]). The SNR candidate $10.8750 + 0.0875$, discovered in the Multi-Array Galactic Plane Imaging Survey [9], was not found in *Chandra* observations [10]. The association of the radio source $G11.03 - 0.05$ with the X-ray source $G11.0 + 0.0$ remains unclear.

X-ray quiet supernova remnants could be nevertheless TeV emitting sources if they reached a certain age; and in particular if they are associated with dense molecular clouds [13, 14]. Therefore, it is possible that one or several of these SNRs contribute to the gamma-ray luminosity of HESS J1809−193.

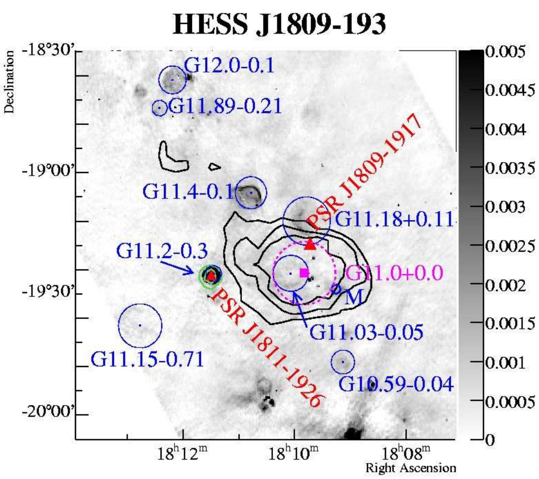

Figure 2: Possible counterparts for the TeV source HESS J1809−193 [4]. Shown in grey scale is a radio image from the Multi-Array Galactic Plane Imaging Survey [9]. Overlaid are the H.E.S.S. significance contours as in Fig. 1. Solid, blue circles mark known radio-emitting supernova remnants [6, 8]. The label *M* denotes the supernova remnant candidate $10.8750 + 0.0875$ [9]. The dashed, pink circle denotes the diffuse hard X-ray source $\mathrm{G}11.0 + 0.0$ [5].

Outlook

At the conference we will present new data taken with the H.E.S.S. telescopes. This will allow a morphological study with greater detail. We will also present *Chandra* data of the source. With the high resolution of *Chandra* it may be possible to draw firmer conclusions on the connection between X-ray and gamma-ray emission.

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References

[1] Aharonian F. et al. (H.E.S.S. collaboration). A New Population of Very High Energy Gamma-Ray Sources in the Milky Way. *Science*, 307:1938–1942, March 2005.

[2] Aharonian F. et al. (H.E.S.S. collaboration). Observations of the Crab nebula with HESS. *A&A*, 457:899–915, October 2006.

[3] Aharonian F. et al. (H.E.S.S. collaboration). The H.E.S.S. Survey of the Inner Galaxy in Very High Energy Gamma Rays. *ApJ*, 636:777–797, January 2006.

[4] Aharonian F. et al. (H.E.S.S. collaboration). Discovery of two candidate pulsar wind nebulae in very-high-energy gamma rays. *ac-*

cepted for publication in A&A, ArXiv e-prints 0705.1605, 705, May 2007.

[5] A. Bamba, M. Ueno, K. Koyama, and S. Yamauchi. Diffuse Hard X-Ray Sources Discovered with the ASCA Galactic Plane Survey. *ApJ*, 589:253–260, May 2003.

[6] C. L. Brogan, J. D. Gelfand, B. M. Gaensler, N. E. Kassim, and T. J. W. Lazio. Discovery of 35 New Supernova Remnants in the Inner Galaxy. *ApJ*, 639:L25–L29, March 2006.

[7] B. M. Gaensler and P. O. Slane. The Evolution and Structure of Pulsar Wind Nebulae. *ARA&A*, 44:17–47, September 2006.

[8] D. A. Green. Galactic supernova remnants: an updated catalogue and some statistics. *Bulletin of the Astronomical Society of India*, 32:335–370, December 2004.

[9] D. J. Helfand, R. H. Becker, R. L. White, A. Fallon, and S. Tuttle. MAGPIS: A Multi-Array Galactic Plane Imaging Survey. *AJ*, 131:2525–2537, May 2006.

[10] O. Kargaltsev and G. G. Pavlov. X-ray emission from PSR J1809-1917 and its pulsar wind nebula, possibly associated with the TeV gamma-ray source HESS J1809-193. *submitted to ApJ, ArXiv e-prints 0705.2378*, 705, May 2007.

[11] R. N. Manchester, G. B. Hobbs, A. Teoh, and M. Hobbs. The Australia Telescope National Facility Pulsar Catalogue. *AJ*, 129:1993–2006, April 2005.

[12] M. S. E. Roberts, C. R. Tam, V. M. Kaspi, M. Lyutikov, G. Vasisht, M. Pivovaroff, E. V. Gotthelf, and N. Kawai. The Pulsar Wind Nebula in G11.2-0.3. *ApJ*, 588:992–1002, May 2003.

[13] Rowell, G. for the H.E.S.S. collaboration. Discovery of very high energy gamma-ray emission in the W 28 (G6.4ˇ22120.1) region and multiwavelength comparisons. In *ICRC 2007*, 2007.

[14] R. Yamazaki, K. Kohri, A. Bamba, T. Yoshida, T. Tsuribe, and F. Takahara. TeV γ-rays from old supernova remnants. *MNRAS*, 371:1975–1982, October 2006.