Recent results on HESS J1632-478

M. Balbo, P. Saouter, R. Walter, L. Pavan, A. Tramacere, M. Pohl, J. Zurita

HESS J1632-478

Data extraction:
- X-ray
- Radio
- Infrared

Discussion & Model

Conclusion

Fig. 1. Image showing the pre-trials statistical significance in the H.E.S.S. Galactic Plane Survey region in four panels. HESS J1507−622 is not shown, since it is located −3.5° off-plane. The recently-discovered VHE γ-ray emission from Westerlund 1 is also not labeled. The significance is truncated above 15σ pre-trials to increase visibility, and the color transition (from blue to red) is set at 7.4σ pre-trials significance, which corresponds to 5σ post-trials significance. See section III-B for more information.

(Chaves, H.E.S.S., 2009 ICRC)
Fig. 1. Image showing the pre-trials statistical significance in the H.E.S.S. Galactic Plane Survey region in four panels. HESS J1507-622 is not shown, since it is located -3.5° off-plane. The recently-discovered VHE γ-ray emission from Westerlund 1 is also not labeled. The significance is truncated above 15σ pre-trials significance to increase visibility, and the color transition (from blue to red) is set at 7.4σ pre-trials significance, which corresponds to 5σ post-trials significance. See section III-B for more information. (Chaves, H.E.S.S., 2009 ICRC)
H.E.S.S. detection: (Aharonian et al. 2006)

- Elongated shape: (12±3)’ x (3.6±2.4)’ semi-axes
- Flux > 200 GeV = (28.7±5.3) x 10^{-12} ph cm^{-2} s^{-1} ~ 12% Crab Nebula
- Positional coincidence:
  - INTEGRAL & XMM-Newton observation 2-10 keV (Rodriguez et al. 2003)
  - soft X-rays ASCA source AX J1631.9-4752, ASCA Galactic Plane Survey (Sugizaki et al. 2001)

RA = 16:32:09
DEC = -47:49:12

\[ \Gamma = 2.12\pm0.20 \]
XMM-Newton detection:

- 9 observations from August to September 2008, \(~\sim\)90ks.
- In each observation, the source is not visible, but it appears in the final mosaic.
9 observations from August to September 2008, ~90ks.

In each observation the source is not visible, but it appears in the final mosaic.

AX J1632.8-4746
Massive Star

XMMU J163219.9-474731
Massive Star

IGR J16320-4751
HMXB
Absorbed power-law model

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Point</th>
<th>Extended</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$N_H$</td>
<td>$13^{+6}_{-4}$</td>
<td>$11^{+2.2}_{-2.7}$</td>
<td>$10^{22}$ cm$^{-2}$</td>
</tr>
<tr>
<td>$\Gamma$</td>
<td>$2.6^{+1.3}_{-0.8}$</td>
<td>$3.4^{+0.6}_{-0.8}$</td>
<td>$10^{-13}$ erg cm$^{-2}$ s$^{-1}$</td>
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<tr>
<td>$F_{2-10, keV}$</td>
<td>$2.3^{+0.3}_{-1.0}$</td>
<td>$4.3^{+0.8}_{-0.4}$</td>
<td>$10^{-13}$ erg cm$^{-2}$ s$^{-1}$</td>
</tr>
<tr>
<td>$\chi^2_\nu$</td>
<td>1.8</td>
<td>1.9</td>
<td></td>
</tr>
</tbody>
</table>
MGPS-2 @ 843 MHz

- Rms sensitivity ~ 1-2 mJy/beam
- Excess count ~ 16 mJy/beam
- Source size: 35” x 26” ~ beam
- Total flux density ~ 25 mJy

(Murphy et al. 2007)

Parkes Survey @ 2.4 GHz

- Rms noise ~ 12 mJy/beam
- Resolution: 10.4’
- Upper limit ~ 100 mJy

(Duncan et al. 1995)
Infrared: GLIMPSE & MIPSGAL

**MIPSGAL:** MIPS, onboard Spitzer (Carey et al. 2009)

- $\lambda$: 24 and 70 $\mu$m
- Point source sensitivity $\sim$ 2 and 75 mJy (3$\sigma$)
- Resolution $\sim$ 6$''$ and 18$''$
- No evidence for a diffuse emission corresponding to the diffuse X-ray source

24 $\mu$m

**GLIMPSE:** (Benjamin et al. 2003)

- IRAC instrument
- $\lambda$: 3.6 - 4.5 - 5.8 - 8 $\mu$m
- Point source sensitivity $\sim$ 0.2 - 0.4 mJy (5$\sigma$)
- Upper limit $\sim$ 25 mJy
Discussion

- Match in position between the radio excess and the extended X-ray source.

- The TeV centroid of the HESS source lies within the extended XMM source.

- XMM-Newton + HESS spectra:
  - two spectral bumps matching the expected synchrotron and inverse Compton emission of a PWN.
Discussion

**Match** in position between the **radio excess** and the **extended X-ray source**.

The **TeV centroid** of the HESS source lies within the extended XMM source.

**XMM-Newton** + **HESS spectra**:

Two spectral bumps matching the expected **synchrotron** and **inverse Compton** emission of a PWN.
### Electron spectrum (Spitkovsky et al. 2008)

![Graph showing electron spectrum](image)

#### Emission model

**Code (Tramacere et al. 2009)**

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<tr>
<td>$\gamma_c$</td>
<td>$1.6 \times 10^5$</td>
</tr>
<tr>
<td>$\gamma_c1$</td>
<td>$1.6 \times 10^8$</td>
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<tr>
<td>$\alpha$</td>
<td>2.4</td>
</tr>
<tr>
<td>$N$</td>
<td>$7.0 \times 10^{-8}$ e$^-$ / cm$^3$</td>
</tr>
<tr>
<td>$R$</td>
<td>$1.6 \times 10^{18}$ cm</td>
</tr>
<tr>
<td>$B$</td>
<td>3 $\mu$G</td>
</tr>
<tr>
<td>$U_{\text{rad}}^{\text{CMB}}$</td>
<td>0.25 eV/cm$^3$</td>
</tr>
<tr>
<td>$U_{\text{rad}}^{\text{IR}}$</td>
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Synchrotron

External Compton

Emission model

Code (Tramacere et al. 2009)
Assuming that the same electron population is responsible for the synchrotron and IC emission: \( f_{\text{sync}} / f_{\text{IC}} \Rightarrow B \sim 3 \mu \text{G} \)

\[
\dot{E} \sim 10^{36} d_3^{1.5} \text{ erg/s}
\]

(Possenti et al. 2002)

\[
L_{X,(2-10\text{keV})}
\]

\[
\dot{E} \sim 3 \cdot 10^{36} \text{ erg/s}
\]

(Mattana et al. 2009)
Unidentified HESS sources:

(Matthew Dalton for the HESS collaboration, Paris conference 2010: TeV Particle Astrophysics)

- HESS J0632+057
- HESS J1023-575 → WR 20a; Westerlund 2; RCW 49
- HESS J1303-631
- HESS J1427-608
- HESS J1614-518
- HESS J1616-508 → PSR J1617-5055 ?
- HESS J1626-490
- HESS J1632-478 → IGR J16320-4751 ?
- HESS J1634-472 → IGR J16358-4726 ?; G337.2+0.1 ?
- HESS J1640-465 → G338.3-0.0 ?; 3EG J1639-4702 ?
- HESS J1702-420
- HESS J1708-410
- HESS J1713-381 → CTB 37B (G348.7+0.3) ?
- HESS J1714-385 → CTB 37A
- HESS J1718-385 → PSR J1718-3825 ?
- HESS J1745-290 → SgrA*/ChanPWN?
- HESS J1745-303 → 3EG J1744-3011 ?
- HESS J1804-216 → G8.7-0.1 / W30 ?; PSR J1803-2137 ?
- HESS J1809-193 → PSR J1809-1917 ?
- HESS J1813-178 → G12.8-0.02; AX J1813-178
- HESS J1834-087 → G23.3-0.3 / W41?
Unidentified HESS sources:

(Matthew Dalton for the HESS collaboration, Paris conference 2010: TeV Particle Astrophysics)

- HESS J0632+057
- HESS J1023-575 → WR 20a; Westerlund 2; RCW 49
- HESS J1303-631

- HESS J1503-582 → miss low energy emission
- HESS J1507-622 → miss low energy emission
- HESS J1848-018 → W 43 / MC / WR 121a?
- HESS J1745-303 → 3EG 1744-3011?
- HESS J1741-302 → MC / PWN powered by PSR B1737-30

(Tibolla et al. 2009 Fermi Symposium)

- HESS J1813-178 → G12.8-0.02; AX J1813-178
- HESS J1834-087 → G23.3-0.3 / W41?
Summary & Conclusion

Broadband studies of HESS J1632-478 have identified this source as a likely PWN, with X-ray observations providing images of an extended nebula as well as the putative pulsar powering the system.

The models used to reproduce the data require a $B \sim 3 \mu G$ and yield an approximate age of 20 kyr and $\dot{E} \sim 10^{36}d_3^{1.5}$ erg/s, consistent with expectations for the late-phase evolution of a PWN.

HESS sources lacking clear low energy counterpart could represent ancient PWNs or MCs illuminated by CRs from nearby SNRs.