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High energy gamma ray emission from HESS J1809-193: Morphological and Spectral studies with HAWC

Rishi Babu for the HAWC Collaboration[a,*]

[a] *Michigan Technological University,*
1400 Townsend Dr,
Houghton, MI
USA

E-mail: rbabu@mtu.edu

HESS J1809-193 is an unidentified TeV object , first detected by the High Energy Stereoscopic System (H.E.S.S.), located in a source-rich region with multiple source classes including SNR G11.1+0.1, SNR G11.0-0.0 and PSR J1809-1917. Initially classified as a pulsar wind nebula(PWN) candidate, however, recent studies show the presence of molecular clouds in the vicinity of the TeV source, indicating the evidence of a hadronic scenario for the observed very high-energy gamma rays. Marked as a potential PeVatron candidate, morphological and spectral studies for this region have been performed to better understand the nature of the particle acceleration mechanisms in the region. With 2090 days of data and new reconstruction algorithms, the High Altitude Water Cherenkov (HAWC) observatory is able to detect emission from this source above an energy of 100 TeV. In this report, we present the analysis of HESS J1809-193 with HAWC data and the multi-wavelength modeling of the region as well as potential sources of particle accceleration.

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*Speaker

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1. Introduction

The High Altitude Water Cherenkov (HAWC) γ-ray observatory is located in the state of Peubla, Mexico at an altitude of 4100m. HAWC consists of 300 water Cherenkov detector tanks and covers a total area of 22000m^2 with four photo-multiplier tubes in each tank to detect the Cherenkov light emitted by particles travelling through water at superluminal velocities. HESS J1809-193 was discovered by H.E.S.S. collaboration in 2007 [1] and was initially classified as a PWN candidate. HAWC published its high energy catalog(eHWC) in 2020 [2], which included γ-ray sources above 56 TeV. eHWC J1809-193 was detected above 56 TeV with HAWC. The eHWC region includes multiple Supernova remnants(SNRs) and pulsars(PSRs) making it a source rich region with a potential to study hadronic PeVatron candidates. Recently the Large High Altitude Air Shower Observatory(LHAASO) reported the detection of 1LHAASO J1809-1918u [3] as one of their ultra high energy gamma-ray sources emitting above 100 TeV, consistent with the locations of HESS J1809-193 and eHWC J1809-193.

In this work, we present updated results on the HAWC J1809-193. Compared to eHWC [2], the analysis is done with 2090 days of HAWC data. We have used a systematic source search to identify a TeV source corresponding to the HESS J1809-193.

2. Data and Analysis

In this work, we analyze the region around J1809-193 using 2090 days of Pass5 HAWC data with the 3ML framework [4]. This analysis is done using the neural network energy estimator and recontructed data above 1 TeV [5]. The analysis is conducted within a rectangular region of interest(ROI) with the latitude and longitude boundaries of $9^o < l < 11.5^o$ and $-3^o < b < 3^o$ respectively.

We use a systematic pipeline inspired by Fermi's Extended source(4FGES) [6]catalog to resolve the sources in the ROI. The pipeline procedure fits a simple Gaussian model for the diffuse background emission(DBE) which includes the galactic diffuse emission(GDE) and all unresolved sources. This is followed by iteratively adding point sources to significant hotspots within the ROI until no significant emission is left and the test statistic(TS) does not improve further. These point sources are then tested for extension using a simplified 2D Symmetric Gaussian model and curvature using a cutoff-powerlaw(CPL) and a log-parabola(LGP) spectrum. Finally the model is tested with different template morphological models to determine the final spatial model for the observed emission. The systematic analysis of the region yields one single extended source with a 2D Symmetric Gaussian model with a power-law(PL) spectrum centered around HESS J1809-1917.

3. Multi-wavelength study and potential associations

Fig. 1 shows the location of HAWC J1809-193 compared to the positions of HESS J1809-193 and 1LHAASO J1809-1918u. The location of HAWC J1809-193 is coincident with the location of the PSR J1809-1917 and equidistant from SNR G11.0-0.0(possible progenitor of PSR J1809-1917) and SNR G11.2-0.3, with a distance of 0.1^o.

Morphological and spectral similarities between the three sources from each detector indicates a similar origin for the observed emission. The presence of SNRs and PSRs makes it confusing to

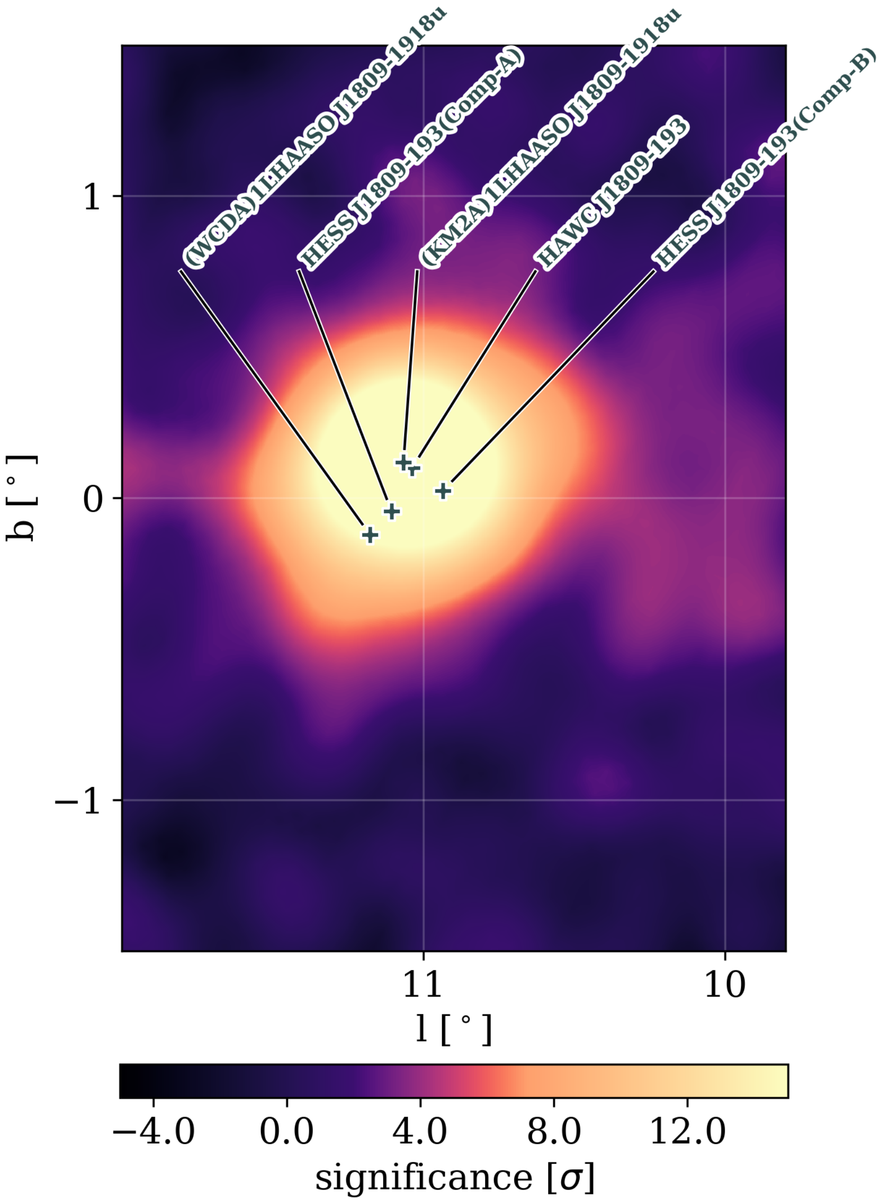

Figure 1: HAWC pre-trial significance map made by assuming a point-source hypothesis and power-law spectrum with an index of -2.7 from 1 TeV < $E_{\rm rec}$ < 316 TeV. The labels show the location of the HAWC source(this work), LHAASO source(WCDA and KM2A) and H.E.S.S. source.

associate the accelerator origin of the observed TeV emission. X-ray emission scenarios suggest a leptonic PWN origin [7] while the plausibility of a hadronic origin is still possible [8]. The HAWC analysis does not show evidence for an energy-dependent morphology due to limited statistics at higher energies. Multi-wavelength analysis with Naima [9] is done to explore the emission mechanisms of the region.

4. Conclusions

In this contribution, we report the TeV gamma-ray detection of HAWC J1809-193 using 2090 days of HAWC data. The systematic search resulted in the 2D Symmetric Gaussian model with a power-law spectrum model for HAWC J1809-193. We will explore the multi-wavelength data with radio and X-ray observations of the region to understand the potential cosmic ray acceleration mechanisms and gamma-ray production mechanisms for HAWC J1809-193.

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Full Authors List: Collaboration

Note comment afterwards: Collaborations have the possibility to provide an authors list in xml format which will be used while generating the DOI entries making the full authors list searchable in databases like Inspire HEP.

A. Albert[1], R. Alfaro[2], C. Alvarez[3], A. Andrés[4], J.C. Arteaga-Velázquez[5], D. Avila Rojas[2], H.A. Ayala Solares[6], R. Babu[7], E. Belmont-Moreno[2], K.S. Caballero-Mora[3], T. Capistrán[4], S. Yun-Cárcamo[8], A. Carramiñana[9], F. Carreón[4], U. Cotti[5], J. Cotzomi[26], S. Coutiño de León[10], E. De la Fuente[11], D. Depaoli[12], C. de León[5], R. Diaz Hernandez[9], J.C. Díaz-Vélez[11], B.L. Dingus[1], M. Durocher[1], M.A. DuVernois[10], K. Engel[8], C. Espinoza[2], K.L. Fan[8], K. Fang[10], N.I. Fraija[4], J.A. García-González[13], F. Garfias[4], H. Goksu[12], M.M. González[4], J.A. Goodman[8], S. Groetsch[7], J.P. Harding[1], S. Hernandez[2], I. Herzog[14], J. Hinton[12], D. Huang[7], F. Hueyotl-Zahuantitla[3], P. Hüntemeyer[7], A. Iriarte[4], V. Joshi[28], S. Kaufmann[15], D. Kieda[16], A. Lara[17], J. Lee[18], W.H. Lee[4], H. León Vargas[2], J. Linnemann[14], A.L. Longinotti[4], G. Luis-Raya[15], K. Malone[19], J. Martínez-Castro[20], J.A.J. Matthews[21], P. Miranda-Romagnoli[22], J. Montes[4], J.A. Morales-Soto[5], M. Mostafá[6], L. Nellen[23], M.U. Nisa[14], R. Noriega-Papaqui[22], L. Olivera-Nieto[12], N. Omodei[24], Y. Pérez Araujo[4], E.G. Pérez-Pérez[15], A. Pratts[2], C.D. Rho[25], D. Rosa-Gonzalez[9], E. Ruiz-Velasco[12], H. Salazar[26], D. Salazar-Gallegos[14], A. Sandoval[2], M. Schneider[8], G. Schwefer[12], J. Serna-Franco[2], A.J. Smith[8], Y. Son[18], R.W. Springer[16], O. Tibolla[15], K. Tollefson[14], I. Torres[9], R. Torres-Escobedo[27], R. Turner[7], F. Ureña-Mena[9], E. Varela[26], L. Villaseñor[26], X. Wang[7], I.J. Watson[18], F. Werner[12], K. Whitaker[6], E. Willox[8], H. Wu[10], H. Zhou[27]

[1]Physics Division, Los Alamos National Laboratory, Los Alamos, NM, USA, [2]Instituto de Física, Universidad Nacional Autónoma de México, Ciudad de México, México, [3]Universidad Autónoma de Chiapas, Tuxtla Gutiérrez, Chiapas, México, [4]Instituto de Astronomía, Universidad Nacional Autónoma de México, Ciudad de México, México, [5]Instituto de Física y Matemáticas, Universidad Michoacana de San Nicolás de Hidalgo, Morelia, Michoacán, México, [6]Department of Physics, Pennsylvania State University, University Park, PA, USA, [7]Department of Physics, Michigan Technological University, Houghton, MI, USA, [8]Department of Physics, University of Maryland, College Park, MD, USA, [9]Instituto Nacional de Astrofísica, Óptica y Electrónica, Tonantzintla, Puebla, México, [10]Department of Physics, University of Wisconsin-Madison, Madison, WI, USA, [11]CUCEI, CUCEA, Universidad de Guadalajara, Guadalajara, Jalisco, México, [12]Max-Planck Institute for Nuclear Physics, Heidelberg, Germany, [13]Tecnologico de Monterrey, Escuela de Ingeniería y Ciencias, Ave. Eugenio Garza Sada 2501, Monterrey, N.L., 64849, México, [14]Department of Physics and Astronomy, Michigan State University, East Lansing, MI, USA, [15]Universidad Politécnica de Pachuca, Pachuca, Hgo, México, [16]Department of Physics and Astronomy, University of Utah, Salt Lake City, UT, USA, [17]Instituto de Geofísica, Universidad Nacional Autónoma de México, Ciudad de México, México, [18]University of Seoul, Seoul, Rep. of Korea, [19]Space Science and Applications Group, Los Alamos National Laboratory, Los Alamos, NM USA [20]Centro de Investigación en Computación, Instituto Politécnico Nacional, Ciudad de México, México, [21]Department of Physics and Astronomy, University of New Mexico, Albuquerque, NM, USA, [22]Universidad Autónoma del Estado de Hidalgo, Pachuca, Hgo., México, [23]Instituto de Ciencias Nucleares, Universidad Nacional Autónoma de México, Ciudad de México, México, [24]Stanford University, Stanford, CA, USA, [25]Department of Physics, Sungkyunkwan University, Suwon, South Korea, [26]Facultad de Ciencias Físico Matemáticas, Benemérita Universidad Autónoma de Puebla, Puebla, México, [27]Tsung-Dao Lee Institute and School of Physics and Astronomy, Shanghai Jiao Tong University, Shanghai, China, [28]Erlangen Centre for Astroparticle Physics, Friedrich Alexander Universität, Erlangen, BY, Germany