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THE HESS GALACTIC CENTER SOURCE AND GALACTIC PLANE DIFFUSE EMISSION

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Abstract. The H.E.S.S. Cerenkov array has detected a strong source (HESSJ1745-290) located within an arcminute of SgrA* and SgrA East. The spectrum and light curve of this source will be discussed. Diffuse emission has been observed in the vicinity of HESSJ1745-290. It is correlated with the inner part of Central Molecular Zone. The spectrum of diffuse gamma rays shows no spatial variations. Possible explanations for the diffuse emission will be given.

1 Introduction

The H.E.S.S. (High Energy Stereoscopic System) instrument is an array of four 107 m^2 atmospheric Cerenkov telescopes installed in Namibia. It is operated by a collaboration of ~ 100 astrophysicists mostly from Germany and France. More details on the H.E.S.S. collaboration and array of telescopes are given on the H.E.S.S. collaboration homepage [2]. 17 hours of data towards the Galactic Center were taken during the installation phase in 2003 with only two telescopes. The first observation by H.E.S.S. of the Galactic Center source HESSJ1745-290, (which had already been observed by other collaborations, see Tsuchiya et al. 2004 and Kosack, et al. 2004) was published in (Aharonian et al. 2004). In 2004, 48.7 hours were taken with four telescopes. More than 70 hours of data have been also taken in 2005 and 2006. This paper will report on 2004 data only.

2 The TeV source HESSJ1745-290

2.1 Data

The 2004 data show a very strong excess in the direction of the Galactic Center (see figure 1), at the level of $\geq 30\sigma$. A point-like source observed by the H.E.S.S. instrument has $\theta^2 < 0.02$. Figure 1 shows that the Galactic Center signal is almost point-like, with an extended tail. This extended tail is due to the diffuse emission of the galactic plane (see section 3). A point-like emission corresponds to an emission region with size ¡ 15 pc at the distance of the Galactic Center.

The position of the source is $l = 359^o56'36.7'' \pm 8.2''$,$b = -0^o2'42.5'' \pm 8.5''$, at $8'' \pm 12''$(stat) $\pm 28''$(syst) from the central galactic black hole SgrA*. The source spectrum is well fitted by a power-law spectrum in the energy range (150GeV-30 TeV) with an index $\Gamma = 2.25 \pm 0.04$(stat) ± 0.1(syst) (see figure 2). There is a (non-significant) hint of a deviation from the power-law spectrum at high energy, with a cut-off energy of more than 11 TeV.

The emission of HESSJ1745-290 does not show any significant variability or periodicity at time-scales ranging from 10 minutes to 1 year. HESSJ1745 is not clearly associated to SgrA*. Its position is compatible with other objects, such as the SNR SgrA East or with an extended emission in the ISM in the vicinity of SgrA*.

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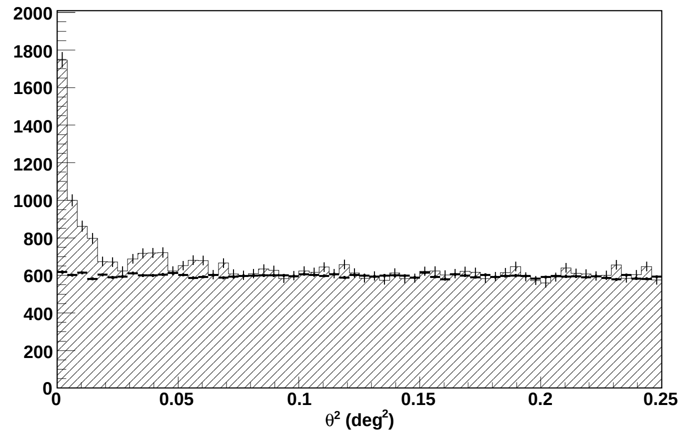

Fig. 1. Histogram of θ^2 (square of angular distance to the Galactic Center) for H.E.S.S. 2004 data. The expected background contribution is also shown (bold histogram).

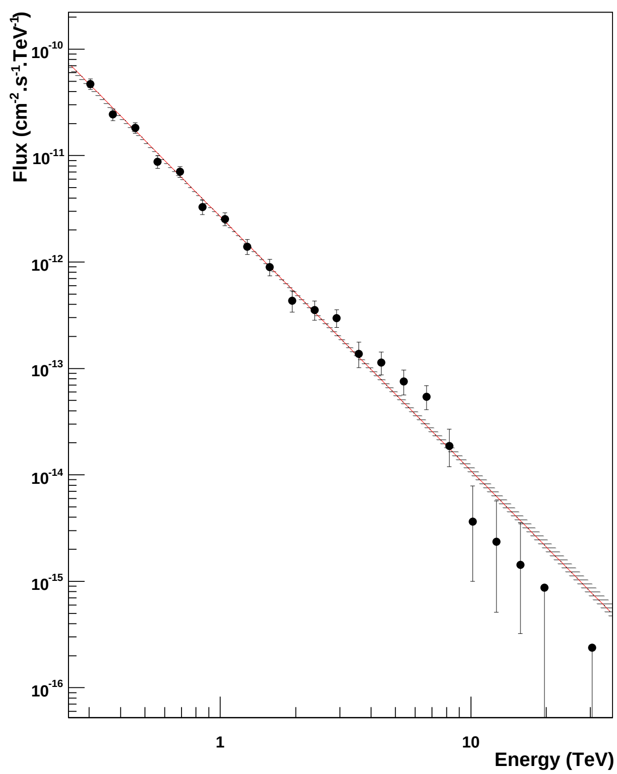

Fig. 2. Spectrum of the HESSJ1745-290 source.The solid line shows a power-law fit to the data.

2.2 *Interpretation*

The high energy emission of the Galactic Center is thus explained by very different models. In a first class of models, the emission comes from electrons or protons accelerated by the black hole. For example, a "black hole plerion" model is described in Atoyan and Dermer (2004). Various proton acceleration scenarios are described in Aharonian and Neronov (2005). In the case of protons, the high energy emission comes from proton-proton interactions in the ISM in the vicinity of SgrA*. These scenarios are appealing since they also explain the extended emission seen by H.E.S.S. (section 3). Another class of model involves the acceleration of particles by other sources. For instance: SgrA East SNR (Melia, Yusuf-Zadeh & Fatuzzo, 1998) or more recently G359.95-0.04 (Wang, Lu, Gotthelf 2006). In a model by Quataert and Loeb (2005), electrons and protons are accelerated in stellar shocks in the central stellar cluster. Last, the interpretation of TeV data as annihilation of dark matter particles is presented in (Moulin 2006).

3 Diffuse emission of the galactic plane

3.1 Data

Figure 3 a) shows the H.E.S.S. sky map of the Galactic Center region. The brightest source, at the center is HESSJ1745-290. A fainter point source, associated to the pulsar wind nebula (PWN) G0.9+0.1 (Aharonian et al. 2005) is located near $l = -1^o$.

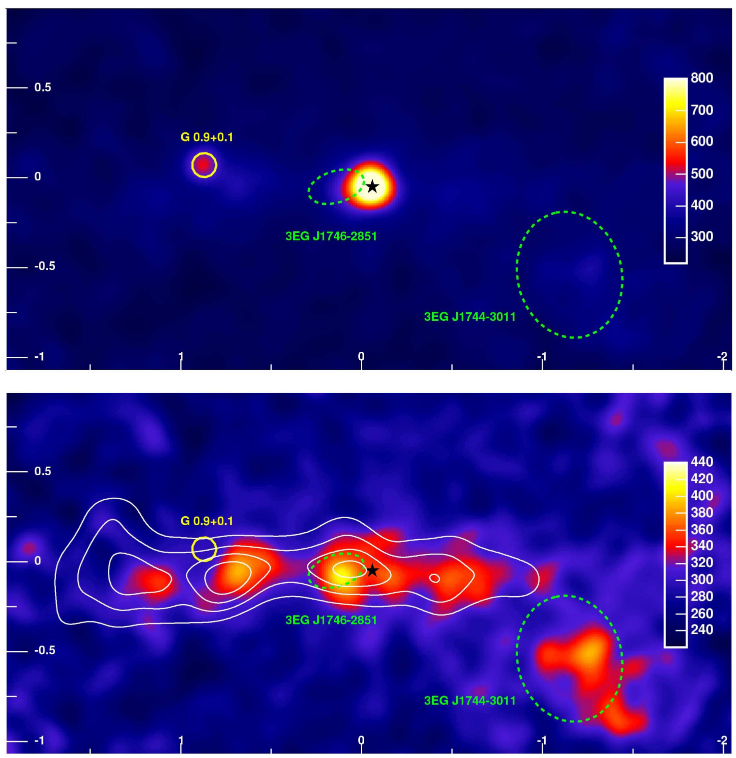

Fig. 3. a) Upper panel: HESS sky map of the Galactic Center region. The location of EGRET sources is also shown. b) Lower panel: Sky map after substraction of the 2 point sources. Diffuse emission is clearly seen. The contours are the CS maps of Tsuboi et al (Tsuboi, Toshihiro & Ukita 1999)

The subtraction of these two point sources (figure 3 b)) reveals an extended TeV emission along the galactic plane (Aharonian et al. 2006). The extended TeV emission is roughly in 3 zones: 2 zones along the galactic planes and one correlated with the position of 3EG1744-3011. Along the galactic plane, the emission coincides with the SgrB2 region and the EGRET "Galacatic Center" source 3EG1746-2851. The emission along the galactic plane has an extension of roughly 1 degree in $|l|$ and 0.2 degrees in b and correlates very well with the CS data of Tsuboi et al (1999), as shown on figure 4.

The spectrum of the diffuse emission is well described by a power-law spectum with index $\Gamma = 2.29 \pm 0.07(\text{stat}) \pm 0.2(\text{sys})$. The spectral of the SgrB2 region, the 3EG1746-2851 region and HESSJ1745-290 are equal within errors.

3.2 Interpretation

The TeV emission can be explained either by a blend of a large number of sources or by cosmic ray interactions inside the central molecular zone. In the first case, the emission should be due to inverse Compton scattering of electrons. However, due to intense magnetic fields and photon fields, the electrons should lose their energies in ∼ 100 years and the sources should appear as point-like for H.E.S.S. (just as the G0.9+0.1 PWN). In the second case, the spectrum of cosmic rays should have a spectral index equal to lowest order to the observed photon spectral index $\Gamma \simeq 2.3$. Since the galactic cosmic ray spectral index is 2.7, this scenario implies that the cosmic rays were produced by an accelerator located inside the CMZ and didn't have time to drift outside the clouds. With a typical value for the diffusion coefficient of $D \simeq 10^{30}\ cm^2/s$, the maximum drift distance of 1^o implies a drift time of a few thousand years. Plausible candidates for the accelerator are SNR SgrA East (which is roughly 10 kyr old) or black hole SgrA*.

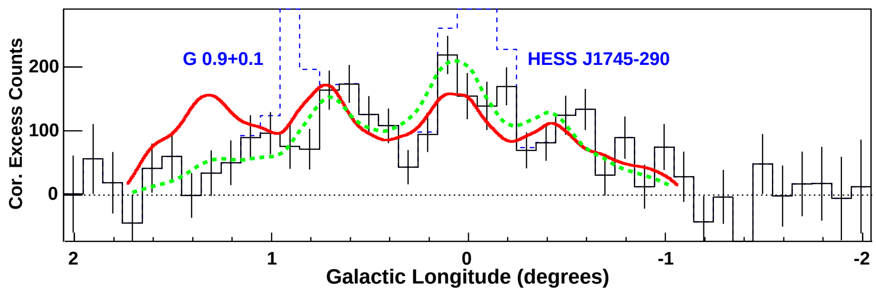

Fig. 4. Correlation of the diffuse TeV emission along the galactic plane with molecular cloud positions. The solid histogram shows the diffuse TeV emission. The red solid line is the molecular cloud density extracted from the CS data of Tsuboi, Toshihiro & Ukita (1999). It is seen to correlate with H.E.S.S. data over the central $|l| = 1^o$ region. The green dashed line is the result of a cosmic ray diffusion model from a central source with age 10^4 years.

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