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***Abstract*. The W51 region has been intensively studied at several wavelengths and is known to host high energy phenomena in which high energy particle acceleration is believed to occur. The H.E.S.S. telescope array observed this region in 2007 and 2008 and has discovered a new source of VHE γ-rays, HESS J1923+141. The possible origins of this emission are discussed.**

***Keywords*: Gamma-rays - Supernova Remnant - Molecular cloud**

I. Introduction

Up to PeV energies, the very-high-energy (VHE) cosmic ray (CR) spectrum is likely to be of Galactic origin, as these particles are confined in the Galaxy by the average magnetic field. The hypothesis of particle acceleration in the shock wave of supernova remnants (SNRs) is compatible with all known data. Since the H.E.S.S. telescope started its observations in 2003, many shell-type SNRs have been detected [1]. The VHE γ-ray spectra of several of them extend over 50 TeV, confirming that these objects indeed accelerate particles up to more than 100 TeV. The H.E.S.S. effective threshold is a few hundred GeV, depending on the source elevation. This threshold is too high to tell whether these γ-rays originate from inverse Compton scattering of VHE electrons off cosmic microwave background and infrared photons or from the decay of neutral pions produced in hadronic showers initiated by VHE protons interacting with interstellar matter. Such hadronic interactions require a significant amount of target matter to produce a detectable γ-ray flux. Dense molecular clouds in the vicinity of supernova blast waves could thus be such a target [2]. The presence of 1720 MHz OH masers is very useful to distinguish actual associations from coincidences due to spatial projection [3].

The W51 region is a very interesting target for observation with ground-based telescope such as H.E.S.S.. It is known to host several objects; among them a SNR interacting with a molecular cloud. The H.E.S.S. telescope has detected VHE γ-ray emission from this region. The discovery is reported in the next section and the possible origins of this emission are discussed in the following sections.

II. H.E.S.S. observations

The W51 radio complex was observed in 2007 during the extension of the H.E.S.S. Galactic Plane Survey (GPS) [4]. A VHE γ-ray source candidate was visible in these observations and triggered dedicated observation performed in June 2008. After quality selection and dead-time correction, a total of $\sim$17 hours of observations are available within 2 degrees from the centre of the W51 field. These data were analyzed using a combined Model-Hillas analysis [5]. This method consists of a comparison of shower images with a semi-analytical model, combined with Hillas parameters estimation. Event selection is made based on a combined estimator (Combined Cut 2) and shower image properties. The energy threshold of this analysis is 420 GeV. Independent standard H.E.S.S. analyses using the Hillas moment-analysis scheme [6] and separate calibration scheme have also been made. These analyses all give consistent results.

Figure 1 shows the resulting excess map. An excess of VHE γ-rays is detected in the W51 region with a statistical significance of 6.7σ using an oversampling radius of 0.22°. Accounting for the number of trials updated from the original H.E.S.S. GPS [7] to the current extended Survey, the excess has a post-trials statistical significance of 4.4σ. The discovery of a new source of VHE γ-rays is thus announced, referenced as HESS J1923+141. The source is clearly extended compared to the H.E.S.S. PSF, and the exact morphology is still under study. The signal integrated within 0.2° from the centroid position accounts for 220 γ rays. The integrated flux over 1 TeV is equivalent to $\sim$3% of the flux from the Crab Nebula above the same energy.

III. The multiwavelength view

W51 is an extended radio complex composed of two HII regions, W51A and W51B, embedded in a giant molecular cloud (GMC) [10]. This cloud hosts several star forming regions [11]. A third component is visible in the radio complex. The SNR W51C (also called

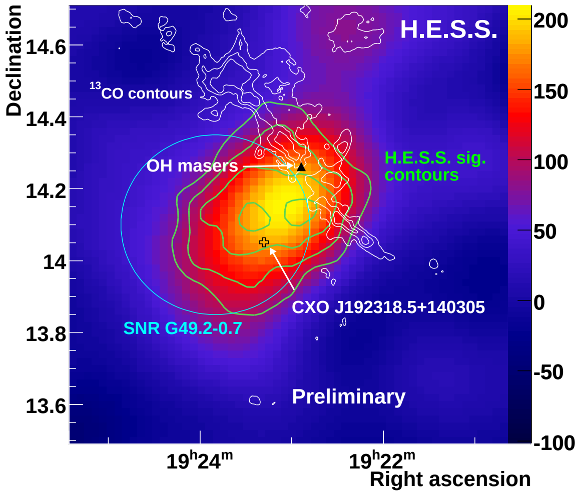

Fig. 1: H.E.S.S VHE γ-ray excess map, Gaussian smoothed with 7.6′ standard deviation. The green contours indicate the 3 σ to 6 σ significance level of the excess. The white contours show the CO emission at 25, 50, 75 and 100 K km s^{-1}, integrated between 60 km s^{-1} and 80 km s^{-1} [8]. The cyan circle indicates the position and extension of the supernova remnant W51C (also called G49.2-0.7) [9]. The black triangle and the open black cross indicate, respectively, the position of the 1720 MHz OH masers and the PWN CXO J192318.5+140305.

G49.2-0.7) appears as a partial shell with ∼30′ radius in radio continuum. The remnant is interacting with the GMC as evidenced by two 1720 MHz OH masers which have been detected toward the North of the shell [12]. Overlaid on Fig. 1 is the matter distribution revealed by the ^{13}CO line, integrated around the masers radial velocities (detected at 71.9 $\mathrm{km\,s^{-1}}$ and 68.9 $\mathrm{km\,s^{-1}}$). The total mass of this elongated cloud has been estimated to be 1.9×10^5 solar masses. Additional proofs of the interaction come from the detection of shocked atomic and molecular gases in this direction [13] [14]. The mass of shocked HI gas is thought to be equivalent to at least 1600 solar masses.

This region has been observed with several detectors in X-rays which revealed a complex region in the keV energy range. Hard X-rays have been detected towards compacts HII regions within W51A and W51B [16]. These X-rays probably come from early-type stars and young stellar objects. The SNR W51C is also detected in X-rays and has a composite structure. A thermal emission is detected from most parts of the shell. A comparison with SNR evolution models led to an age estimate of about 3×10^4 years [17]. A bright central region has also been detected. Chandra observations confirmed the non-thermal nature of the emission, CXO J192318.5+140505, thought to be a pulsar wind nebula (PWN) (indicated on Fig 1).

It is worthwhile to mention that this source may be very bright also at GeV energies. In fact, in the Fermi LAT Bright Source List [18], the brigt source OFGL J1923.0+1411 (detected at level of $\sim$ 23 σ) is spatially coincident with HESS J1923+141.

IV. Discussion on the origin of HESS J1923+141

The multiwavelength view of the W51 region shows several possible counterparts for the VHE γ-ray emission detected by H.E.S.S.. Among them, the presence of a shocked molecular cloud, revealed by OH masers, suggests a very interesting scenario. In that case, the γ-rays would be produced by π^0 decay after hadronic interactions within the cloud. Assuming that 10% of the cloud is involved in the γ-ray production, a CR density 30 times higher than the local average value is required to produce the VHE γ-ray emission above 1 TeV. Such CR enhancement is expected in the vicinity of a CR accelerator. More precise studies are necessary to confirm this estimate.

The presence of a PWN candidate provides a competitive leptonic scenario. According to recent studies [19], the pulsar spin-down luminosity is estimated through the luminosity of the X-ray nebula to be around $L_{\rm SD} = 4.5 \times 10^{36}$ $\mathrm{erg\,s^{-1}}$, assuming a distance to the PWN of 6 kpc [13]. Using the same distance for the VHE γ-ray source, the γ-ray luminosity between 1 and 10 TeV is lower than 0.1% of the pulsar spin-down luminosity and could easily be explained by IC emission from relativistic electrons accelerated within the PWN.

A third scenario is provided by the presence of star forming regions within the GMC. VHE gamma-ray emission has been already detected toward a star forming region with H.E.S.S.. It suggests that high-energy particle acceleration occurs in these objects [20]. Stellar clusters in the GMC could thus participate in the total γ-ray emission. However, the γ-ray map does not reflect the star forming region distribution within the cloud, so this scenario needs to be investigated in more detail.

At present, none of these VHE γ-ray emission scenarios can be excluded. More detailed spectral and morphological studies are in progress to understand the origin of this new VHE γ-ray source.

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