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Search for γ-ray emission from Unidentified EGRET sources Located in the Cygnus Region with the MAGIC Telescope

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Abstract: During the conference we plan to report on the observations of two flat spectrum unidentified EGRET sources (3EG J2021+3716 / 3EG J2016+3657), which have been observed by the MAGIC telescope in the direction of the Cygnus region. Recently, also the Milagro experiment has reported a γ-ray source above 12 TeV in the Cygnus region, MGRO J2019+37, which is spatially coincident with these EGRET sources. Since this region of the Cygnus spiral arm is full of interesting objects, such as pulsar wind nebulae, open clusters, binary systems, massive stars and supernova remnants, we also discuss the likely nature of this/these γ-ray sources in the context of the MAGIC (and other) observations.

Introduction

Recent detections of diffuse TeV γ-rays in the Cygnus region by Milagro [1, 2] and Tibet [3], without any compelling counterparts at other wavelengths, have made this region ($65^\circ < l < 90^\circ$, less than 2 kpc away) very interesting for the very high energy (VHE) γ-ray astronomy. The agglomeration of many SNRs, Wolf-Rayet stars and OB associations shows that this region is very active and star birth and death are repeated there. WR stars have a dense matter flow and blast waves of supernovae sweep a dense interstellar medium. Compression of matter leads to the creation of OB associations. OB stars become WR stars and result in supernovae at the end of their lives. In addition, this region is so close ($\sim$5 times closer than the Galactic Center) that sources in this region look $\sim$25 times brighter than those which are at the Galactic Center, if the intrinsic emissions are the same level. Less obstacles in the line of sight and better spatial resolution also help for detailed analysis of the regions, which would lead to an understanding of the origin of cosmic-rays and the mechanism of their propagation. Although MAGIC is not sensitive for widely ($> 1^\circ$) extended sources, it is probable that there are several point-like or narrowly ($< 0.5^\circ$) extended sources which can be detected above the diffuse emission.

The Cygnus region in γ-rays

There are 8 unidentified EGRET sources in the Cygnus region [4]. One of them is 3EG J2021+3716, which is positionally coincident with MGRO J2019+37. 3EG J2021+3716 has a flat spectrum with index -1.86. TeV upper limits have been put by the HEGRA ($\sim$ 38% Crab above 0.6 TeV, [5]) and the Whipple ($\sim 2 \times 10^{-11}\mathrm{cm}^{-2}\mathrm{s}^{-1}$ above 0.35 TeV, [6]) collaborations. The Whipple upper limit indicates that the spectra of these sources should decline at $\sim$ 100 GeV energies. Milagro detected 2 sources and diffuse γ-ray emission from a region ($-3^\circ < b < 3^\circ, 65^\circ < l < 85^\circ$) above 12 TeV. The brightest source in this region is MGRO J2019+37, spatially coincident with 3EG J2021+3716. The flux above 12 TeV is $E^2\mathrm{d}N/(\mathrm{d}E\mathrm{d}A\mathrm{d}t) = 3.5 \times 10^{-12}$ [TeV cm^{-2} s^{-1}]. Although Milagro couldn't measure the spectral index γ, in the case of $\gamma = -2.0$, the integral flux above 100 GeV would be 3.5×10^{-11} [cm^{-2} s^{-1}], 6.3% Crab. In the case of $\gamma = -2.2$ or -2.6, the integral flux above 100 GeV would be

14% Crab or 70% Crab, respectively (See also Figure 2). However, it should be noted that the flux reported by Milagro is integrated over a $3^\circ \times 3^\circ$ region which has diffuse emission. The flux of the diffuse component above 12 TeV in the region $-3^\circ < b < 3^\circ, 65^\circ < l < 85^\circ$ is 2.9×10^{-12} [cm^{-2} s^{-1} sr^{-1}]. Although the widely averaged diffuse flux reported by Milagro is ∼1 mCrab (0.1° window, above 100 GeV assuming $\gamma = -2.6$), one can see several regions on the map which have more than a third of the MGRO 2019+37 flux, which could be the targets of MAGIC. It should also be noted that since the angular resolution of Milagro is 0.35° at best, an agglomeration of point sources might be seen as a diffuse emission. The Tibet Air shower array detected a significant excess from the Cygnus region above 4 TeV [3]. It is interesting that by changing the integration radius from 5° to 0.9°, the diffuse emission fades away (because of statistics) and point-like sources can be seen ($4 \sim 5\sigma$), meaning that diffuse emission is not uniform but that small scale structures are there, which is in favor of MAGIC observations.

The power of MAGIC Observations

The position of 3EG J2021+3716 / MGRO J2019+37 was observed for 15 h during 2006. Figure 1 shows the integral flux of 3EG J2021+3716, MGRO J2019+37 and the Crab Nebula in comparison to the sensitivity of the MAGIC telescope. Provided that the EGRET sources and the Milagro source have the same nature, the MAGIC telescope should detect this source in the energy range between $100 - 10^3$ GeV. A non-detection significantly constrains the spectra of the EGRET sources, arguing for the existence of sharp cutoffs between 10-100 GeV. The WR stars, observed inside this cluster (WR141, WR142 etc, distance $\sim$ 1 kpc), were suggested as possible counterparts of the EGRET sources [7]. In fact, γ-ray spectra with such cut-offs are also characteristic for γ-ray pulsars (e.g. the Vela type pulsar J2021+3651). In this case the TeV emission reported by the Milagro experiment, might come from pulsar wind nebulae (e.g. PWN G75.2+0.1) [8] or supernova remnants [9]. Another possible explanation can be related to the presence of the nearby open cluster, Berk 87, inside the error box of the EGRET source [10, 11, 12]. In this case, it is argued that the GeV emission is due to the IC and bremsstrahlung radiation from electrons and the $\sim$ 10 TeV emission is due to the decay of π^o produced in hadronic collisions [12]. Both, electrons and hadrons can be accelerated in the turbulent medium of the open cluster. The observations with the MAGIC telescope should give at worst upper limits significantly below the present upper limits by the HEGRA and Whipple collaborations. They clearly help to resolve the problem of the γ-ray emission from the compact sources in this region.

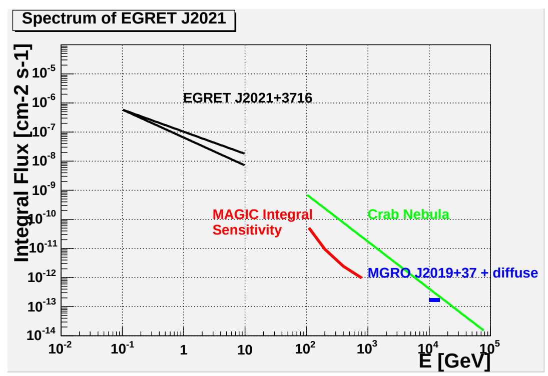

Figure 1: Integral flux of 3EG J2021+3716 / MGRO J2019+37 and MAGIC sensitivity for a point-like source ($\sim$ 2% Crab above 200 GeV), calculated based on the results of [13]. The spectrum of the Crab Nebula is also shown for reference.

References

[1] Abdo et al., 2007, ApJL, 658, L33.
[2] Abdo et al., 2007, arXiv:0705.0707.
[3] Amenomori et al., 2006, Science, 314, 439.
[4] Hartman et al., 1999, ApJS, 123, 79.
[5] Aharonian et al., 2002, A&A, 395, 803.
[6] Fegan et al., 2005, ApJ 624, 638.
[7] Romero et al., 1999, A&A 348, 868.
[8] Bednarek, W. 2003, MNRAS 345, 847.
[9] Butt et al, ApJ, 2006, 643, 238.
[10] Giovannelli, F. et al., 1996, J.Phys.G 22, 1223.
[11] Torres, D.F. et al., 2004, ApJ, 601, L75.

[12] Bednarek, W. 2007, arXiv:0704.3517.
[13] Albert, J. et al., 2007, ApJ submitted, arXiv:0705.0710.