H.E.S.S. observations of the young synchrotron-dominated SNRs G1.9+0.3 and G330.2+1.0

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Abstract

Supernova remnants (SNRs) are widely considered to be accelerators of cosmic rays (CR). They are also expected to produce very-high-energy (VHE: E > 100 GeV) gamma rays through interactions of high-energy particles with the surrounding medium and photon fields. They are, therefore, promising targets for observations with ground-based imaging atmospheric Cherenkov telescopes like the H.E.S.S. telescope array. VHE gamma-ray emission has already been discovered from a number of SNRs, establishing them as a prominent source class in the VHE domain. Of particular interest are the handful of SNRs whose x-ray spectra are dominated by non-thermal synchrotron emission, such as the VHE gamma-ray emitters RX J0850.2−4622 (Vela Jr.) and RX J1713−3946. The shell-type SNRs G1.9+0.3 and G330.2+1.0 also belong to this class and are further notable for their very young ages (~1 ky), especially G1.9+0.3, which was recently determined to be the youngest SNR in the Galaxy (~100 yr). These unique characteristics motivated investigations with H.E.S.S. to search for VHE gamma rays.

G1.9+0.3 and G330.2+1.0

SNR G1.9+0.3 and SNR G330.2+1.0 are Galactic SNRs which are observed in the radio and x-ray energy bands. Both of them are very distant, young (especially G1.9+0.3 which is the youngest SNR in the Galaxy) and small SNRs (~8, 9, 7). X-ray spectra of these SNRs are dominated by non-thermal synchrotron emission which indicates a significant electron acceleration and makes them promising objects for VHE gamma-astronomy.

The H.E.S.S. Instrument

H.E.S.S. (High Energy Stereoscopic System) is an array of four 13 m diameter imaging atmospheric Cherenkov telescopes (IACT) located in the Khomas Highland of Namibia at an altitude of 1800 m above sea level [3, 4]. The telescopes are optimized for detection of very high energy γ-rays in the range of 100 GeV to 20 TeV by imaging Cherenkov light emitted by charged particles in an Extensive Air Shower (EAS). The total field of view of H.E.S.S. is 5° in diameter. The angular resolution of the system is ≤ 0.1° and the average energy resolution is about 15% [2]. The H.E.S.S. array is capable of detecting point sources with a flux of 1% of the Crab nebula flux at the significance level of 5σ in 2 hours [2].

Data Set and Analysis Results

For the investigation of G1.9+0.3 and G330.2+1.0 data taken in the period from 2004 to 2010 were compiled. After the standard H.E.S.S. quality selection [2] it resulted in 75 and 20 hours of livetime for G1.9+0.3 and G330.2+1.0 respectively. The data were taken at the average offset angle of 1.5° for G1.9+0.3 and 1.3° for G330.2+1.0. The H.E.S.S. standard Hillas reconstruction with standard cuts and the Reflected Region Background method were used for the data analysis. No significant γ-ray signal was detected from G1.9+0.3 or G330.2+1.0. The 99% confidence level upper limits [6] on the integrated fluxes above 260 GeV (G1.9+0.3) and 380 GeV (G330.2+1.0) energy thresholds were calculated for three different assumed spectral indices 2.0, 2.5, and 3.0. The assumed spectral index does not have a major impact in the upper limits estimation.

Theoretical Interpretation

VHE γ-rays from SNRs can be produced either via inverse Compton scattering of relativistic electrons on photon fields or via proton-proton interactions. In this paper the first scenario is described.

The radio and X-ray data were fit with the model of synchrotron emission of an electron population by an energy distribution which follows a power-law with an exponential cut-off. Assuming a value for the magnetic field a gamma-ray emission created by the same population of electrons via IC scattering on nearby photon fields (optic, infrared and CMB) is predicted. The upper limit on the TeV flux leads to the estimation of a lower limit on the magnetic field (see Table). Recently, the first synchrotron-dominated SNR RX J1713.7−3946 was discovered in GeV γ-rays [1]. The observed spectrum favours the leptonic model and predicts a very low magnetic field of ~10 μG which is compatible to limits predicted for G1.9+0.3 and G330.2+1.0.

The References