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Study of the Magellanic Clouds and Other Southern Objects at TeV Energies

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Abstract

The results of observational studies of very high energy (VHE) and ultra high energy (UHE) gamma ray emission, by various astrophysical objects, made from 1988 to 1990 with the JANZOS Cerenkov facility are presented.

The active galaxy Cen A and the Galactic X-ray binary systems Vela X-1, Cen X-3, and Cir X-1 were monitored for VHE gamma ray emission above 1 TeV. No evidence was found for persistent or episodic emission from any of these objects. Upper limits on the VHE fluxes above 1 TeV of 2.1×10^{-11} , 2.7×10^{-11} , 3.6×10^{-11} and $3.5 \times 10^{-11} \text{ cm}^{-2} \text{ s}^{-1}$ respectively were obtained for these objects. These limits are consistent with previous observations made by other groups.

Various objects in the Magellanic Clouds were monitored for UHE gamma ray emission using the Cerenkov technique at large zenith angles. This technique has been found to be more sensitive at UHE energies ~ 100 TeV than the conventional air shower technique. During 1990 the equipment was modified to allow a sky coverage of $7^\circ \times 23^\circ$ at large zenith angles. This enabled most of the extent of the Large Magellanic Cloud to be surveyed at UHE energies.

An examination of the UHE database yielded no evidence for persistent emission from SN1987A and selected X-ray pulsars in the Magellanic Clouds. Upper limits on the UHE fluxes (in $\text{cm}^{-2}\text{s}^{-1}$) above the given threshold energies were obtained as follows: SMC X-1, 2.4×10^{-13} (>30 TeV); SN1987A, 2.3×10^{-13} (>65 TeV); PSR0540-693, 2.3×10^{-13} (>65 TeV); LMC Trans, 1.5×10^{-13} (>130 TeV); LMC X-4, 1.3×10^{-13} (>140 TeV). Evidence was found for two episodes of pulsed gamma ray emission above 65 TeV from SN1987A. On the nights of May 28 and June 23, 1990, a periodicity search using the Rayleigh test showed significant power at 18.356 ms. This is near a periodicity reported at optical wavelengths in September, 1990. The chance probability for the individual period was about 10^{-6} on each of the two nights. Excess events of the order of 1σ were also seen on these nights. The overall chance probability, allowing for all degrees of freedom, was found to be 0.1%. Evidence was also found for a single episode of gamma ray emission above 140 TeV from LMC X-4 on May 27, 1990. Excess events were seen with a statistical significance of 2.4σ . A periodicity test showed maximum Rayleigh power at 13.488 s on this night. The chance probability for the individual period was 8×10^{-3} and the overall chance probability was found to be 0.5%. Adopting a recent estimate of the pulsar population in the Large Magellanic Cloud, an upper bound of $3 \times 10^{34} \text{ erg s}^{-1}$ on the luminosity of an average pulsar, at energies >65 TeV, was obtained.

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