VERITAS Observations of Blazars

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The VERITAS array of four 12-m diameter imaging atmospheric-Cherenkov telescopes in southern Arizona is used to study very high energy (VHE; E>100 GeV) γ-ray emission from astrophysical objects. VERITAS is currently the most sensitive VHE γ-ray observatory in the world and one of the VERITAS collaboration's Key Science Projects (KSP) is the study of blazars. These active galactic nuclei (AGN) are the most numerous class of identified VHE sources, with $\sim$30 known to emit VHE photons. More than 70 AGN, almost all of which are blazars, have been observed with the VERITAS array since 2007, in most cases with the deepest-ever VHE exposure. These observations have resulted in the detection of VHE γ-rays from 16 AGN (15 blazars), including 8 for the first time at these energies. The VERITAS blazar KSP is summarized in this proceeding and selected results are presented.

1. Introduction

Active galactic nuclei are the most numerous class of identified VHE γ-ray sources. These objects emit non-thermal radiation across $\sim$20 orders of magnitude in energy and rank among the most powerful particle accelerators in the universe. A small fraction of AGN possess strong collimated outflows (jets) powered by accretion onto a supermassive black hole (SMBH). VHE γ-ray emission can be generated in these jets, likely in a compact region very near the SMBH event horizon. Blazars, a class of AGN with jets pointed along the line-of-sight to the observer, are of particular interest in the VHE regime. Approximately 30 blazars, primarily high-frequency-peaked BL Lacs (HBL), are identified as sources of VHE γ-rays, and some are spectacularly variable on time scales comparable to the light crossing time of their SMBH ($\sim$2 min; [1]). VHE blazar studies probe the environment very near the central SMBH and address a wide range of physical phenomena, including the accretion and jet-formation processes. These studies also have cosmological implications, as VHE blazar data can be used to strongly constrain primordial radiation fields (see the extragalactic background light (EBL) constraints from, e.g., [2, 3]).

VHE blazars have double-humped spectral energy distributions (SEDs), with one peak at UV/X-ray energies and another at GeV/TeV energies. The origin of the lower-energy peak is commonly explained as synchrotron emission from the relativistic electrons in the blazar jets. The origin of the higher-energy peak is controversial, but is widely believed to be the result of inverse-Compton scattering of seed photons off the same relativistic electrons. The origin of the seed photons in these leptonic scenarios could be the synchrotron photons themselves, or photons from an external source. Hadronic scenarios are also plausible explanations for the VHE emission, but generally are not favored.

Contemporaneous multi-wavelength (MWL) observations of VHE blazars, can measure both SED peaks and are crucial for extracting information from the observations of VHE blazars. They are used to constrain the size, magnetic field and Doppler factor of the emission region, as well as to determine the origin (leptonic or hadronic) of the VHE γ-rays. In leptonic scenarios, such MWL observations are used to measure the spectrum of high-energy electrons producing the emission, as well as to elucidate the nature of the seed photons. Additionally, an accurate measure of the cosmological EBL density requires accurate modeling of the blazar's intrinsic VHE emission that can only be performed with contemporaneous MWL observations.

2. VERITAS

VERITAS, a stereoscopic array of four 12-m atmospheric-Cherenkov telescopes located in Arizona, is used to study VHE γ-rays from a variety of astrophysical sources [4]. VERITAS began scientific observations with a partial array in September 2006 and has routinely observed with the full array since September 2007. The performance metrics of VERITAS include an energy threshold of $\sim$100 GeV, an energy resolution of $\sim$15%, an angular resolution of $\sim$0.1°, and a sensitivity yielding a 5σ detection of a 1% Crab Nebula flux object in <30 hours[1]. VERITAS has an active maintenance program (e.g. frequent mirror recoating and alignment) to ensure its continued high performance over time, and an upgrade improving both the camera (higher quantum-efficiency PMTs) and the trigger system has been proposed to the funding agencies.

[1] A VERITAS telescope was relocated during Summer 2009, increasing the array's sensitivity by a factor $\sim$1.3.