Invited Lecture 招待講演

Teraelectronvolt Gamma-ray Astronomy – a New Window on the High Energy Universe

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A new window on the high-energy Universe has been opened with the development of instruments that allow astronomical sources to TeV gamma radiation to be studied. Direct gamma-ray astronomy must be done from space, as the Earth's atmosphere acts as a protective shield and absorbs this radiation well before it reaches ground level. However, at energies greater than ~100 GeV the incident gamma rays carry enough energy that, when they are absorbed, showers of hundreds of particles are created in the atmosphere. These showers propagate in the direction of the incident photon and may be detected via a faint pulse of Cherenkov radiation that is emitted as they travel relativistically through the atmosphere. Thus, large optical reflectors equipped with fast, high-gain light detectors may be used to detect these Cherenkov flashes and identify candidate gamma-ray events. Unfortunately, there is a very large background of similar showers caused by charged Cosmic Ray particles that also collide with the atmosphere, and extracting the small gamma-ray signal proved very difficult with early detectors. The breakthrough came in the 1980's with the development of the imaging atmospheric Cherenkov technique (IACT), which used imaging cameras in conjunction with Monte Carlo simulations of air shower development to identify background rejection techniques based on the recorded image characteristics.

Since the first detection of a TeV gamma-ray source, the Crab Nebula, in 1989, the field has flourished with the development of third generation detectors, which utilize stereoscopic imaging with arrays of telescopes to improve sensitivity. There are now over 130 objects in the TeV sky catalogue. The extragalactic sky is dominated by blazars: Active Galactic Nuclei that have their jets pointed directly at the Earth. Galactic sources detected include Pulsar Wind Nebulae, Shell-type SuperNova Remnants, and binary systems. Of particular note is the detection of the Crab Pulsar at energies >200 GeV, which was not expected from theoretical models of pulsar emission. In addition to the source classes mentioned above, there are several unidentified sources that so-far lack a clearly identified counterpart at longer wavelengths. TeV telescopes are also used for indirect Dark Matter searches, and through observations of distant objects may be able to constrain the Cosmic Extra-galactic Background Light level.

In this talk I will present a brief overview of the technique and instrumentation for TeV gamma-ray astronomy, and will describe some of the scientific highlights to date.