With H.E.S.S. II, these can be explored in much higher resolution and, in particular, also at lower energies, an up till now poorly explored energy domain with a huge discovery potential.

Beyond the Milky Way, galaxies with active nuclei, starburst and radio galaxies are found as faint objects in the very-high-energy gamma-ray light. In our neighbouring companion galaxy, the Large Magellanic Cloud, H.E.S.S. was able to identify several extremely luminous sources.

**H.E.S.S. and the MPIK**

The H.E.S.S. project was initiated by the astrophysics and particle-physics groups at the MPIK. The institute has played a central role in the design and construction of H.E.S.S.: Together with the institute’s workshops, MPIK scientists and technicians were responsible – among other things – for the steel structure and the drive systems of the telescopes, the mirror facets and the main trigger system. Additionally, the MPIK is one of two centres responsible for the quality control and calibration of the data, and plays an important role in the data analysis and interpretation. The Max Planck Society has been by far the largest financier of H.E.S.S.

The H.E.S.S. observatory is being operated by a collaboration consisting of more than 170 scientists from 39 scientific institutions in 13 different countries. H.E.S.S. has been awarded in 2006 the Descartes Prize of the European Commission – the highest recognition for collaborative research – and in 2010 the prestigious Rossi Prize of the American Astronomical Society. In 2009, H.E.S.S. was ranked among the 10 world-leading astronomical observatories, based on the scientific impact derived from a citation analysis.
H.E.S.S.
Cosmic accelerators in gamma-ray light – Astronomy at the highest energies

An array of four 12-metre-mirror telescopes and a huge fifth telescope with a 28-metre-sized mirror is observing the sky above the highlands of Namibia. Undisturbed by light from large cities, the location provides an optimal view of the central part of the Milky Way. The H.E.S.S. experiment is studying sources of high-energy gamma rays and uncovers a Universe which looks completely different to that seen by the naked eye.

Gamma radiation from space

The light that is detected by H.E.S.S. from our Milky Way and distant galaxies is a trillion times more energetic than ordinary starlight. The amount of energy is so high that it cannot be produced by normal stars. Instead, it must originate in the most extreme places in the Universe, such as in the vicinity of black holes and in shock waves of supernovae – exploding stars. H.E.S.S. was the first experiment to observe spatially and temporarily resolved images of these objects.

Closely related to the observation of high-energy gamma radiation is the question of the origin of cosmic rays. Highly energetic electrically charged particles are meandering through space under the influence of cosmic magnetic fields, and a large number of these particles hit the Earth’s atmosphere. More than 100 years after their discovery by Victor Hess in the year 1912, it is not yet fully understood how these particles are accelerated to highest energies and in which astronomical objects this is accomplished. Gamma radiation is produced when these highly energetic elementary particles and atomic nuclei slam into gas clouds or interact with magnetic or radiation fields in the vicinity of the cosmic particle accelerators. This gamma-ray light thus provides an image of the cosmic accelerators.

Gamma astronomy with H.E.S.S.

Although very-high-energy gamma radiation is absorbed in the atmosphere of the Earth, it can nevertheless be detected by instruments like H.E.S.S. on the ground. The atmosphere plays the role of a detector medium: On its absorption, each gamma quantum produces a cascade of secondary particles, known as a particle shower. The shower particles emit a faint bluish light – called Cherenkov light. The light flash is too short – only about a billionth of a second – and too weak to be observable by the naked eye. Using large mirrors and rapid photo detectors, however, Cherenkov telescopes are able to record these weak and extremely short flashes. For this purpose, H.E.S.S. uses five telescopes that simultaneously observe each particle shower from different points of view. Similar to the depth perception we obtain with our two eyes, a stereoscopic observation enables the exact directional as well as energetic reconstruction of the incident gamma radiation. Each of the telescopes can be precisely rotated in every direction so that they can follow celestial objects as they move through the sky.

The four identical H.E.S.S. I telescopes started operation between 2002 and 2004. Each of these telescopes has a mass of 60 tons and is 16 m high. Per telescope, 380 facets of 60 cm diameter form a focusing mirror of 107 m² area. Every single facet can be adjusted with respect to the camera with an accuracy of a few thousandths of a millimetre by computer-controlled motors. The H.E.S.S. II telescope saw its ’first light’ in July 2012. It has an overall mass of 580 tons and the height of a 20-story building when pointing up. The mirror with an area of 614 m² is composed of 875 adjustable hexagonal facets and has a focal length of 36 m. The elevation axis is 24 m above the ground. H.E.S.S. II strongly enhances the sensitivity of the entire system and extends the observable energy range to lower energies.

Highly sensitive cameras form the central part of the telescopes. Their function is to record the particle showers that are produced in the atmosphere by gamma radiation. Each camera incorporates 960 (H.E.S.S. I) or 2048 (H.E.S.S. II) rapid photo sensors which convert the incident light with an exposure time of a few parts in a billion of a second into electrical signals. The cameras have a diameter of 1.4 m (H.E.S.S. I) or 2.3 m (H.E.S.S. II), respectively, which corresponds to a field-of-view of about 5 (H.E.S.S. I) or 3.2 (H.E.S.S. II) degrees in the sky, or several times the extent of the full moon. The H.E.S.S. II camera has four times more pixels per sky area compared to H.E.S.S. I, providing a higher resolution of the particle shower images.

The sky as seen in gamma rays

H.E.S.S. has examined the central part of our Galaxy for several thousand hours searching for sources of highly energetic gamma radiation. For the first time, it has produced a detailed map of the Milky Way in gamma-ray light (see below). Like pearls on a string, the map shows a large number of gamma sources – each being a cosmic particle accelerator – arranged along the Galactic equator. Many of these gamma-ray sources are connected with the remnants of exploded stars (supernovae and pulsar-wind nebulae). Using H.E.S.S., it was thus possible for the first time to image the shock wave of a supernova remnant (RX J1713.7-3946) in rich details in gamma-ray light. The supermassive black hole the Galactic Centre turned out to be a cosmic “pevatron” that accelerates particles to extreme energies and is presumably responsible for the Galactic cosmic radiation. Some mysterious gamma sources, so-called dark sources, however, cannot yet be assigned to a known object in the sky.

The High-Energy Stereoscopic System H.E.S.S.. The four H.E.S.S. I telescopes span a square of length 120 metres, in the centre of which the huge H.E.S.S. II telescope is placed.

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