Körber-STIFTUNG
Forum für Impulse

Gravity signals from the depths of space

The Körber European Science Prize 2017 goes to physicist Karsten Danzmann

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Hamburg, 31 May 2017. Karsten Danzmann is to receive the Körber Prize 2017, endowed with 750,000 euros. The German physicist and his team have developed the key technologies, including high-precision lasers, with which detectors in America were able to provide direct evidence of gravitational waves for the first time in 2015. Astronomers have thus literally opened a new window to the cosmos, as they were previously able to explore the universe only by means of electromagnetic waves – light, radio waves, X-rays or gamma rays. "Now gravity has practically sent us its own messengers, the gravitational waves," says Danzmann. "They mark the beginning of the era of gravitational wave astronomy, which promises new discoveries, as 99 percent of the universe is dark." With the funds of the Körber Prize, Danzmann intends, amongst other things, to further refine laser technology for earth-based detectors.

Karsten Danzmann, 62, studied physics at the University of Hannover, gaining his PhD in 1980. In 1986 he moved to Stanford University in the USA, where he was Professor of Physics until 1989. From 1993 to 2001 he was Head of the Hannover branch of the Max Planck Institute (MPI) for Quantum Optics. Since 2002 he has been the Director of the MPI for Gravitational Physics. Parallel to this, he has taught at the Leibniz University of Hannover since 1993, where he is Head of the Institute of Gravitational Physics.

In the autumn of 2015, a worldwide team of physicists achieved a sensation: The American LIGO detectors were able to provide direct evidence of gravitational waves for the first time. Albert Einstein had theoretically predicted the existence of gravitational waves as early as 1916. According to his theory of relativity, gravity results from the fact that a mass bends four-dimensional space-time. This can be envisaged as a tightly stretched rubber mat. If a heavy ball is placed on it, it buckles downwards – space-time bends. If a smaller ball then passes nearby, its path is deflected by the dent of the heavy ball. This path deviation is the effect of gravity in space-time.

If a very heavy ball is thrown forcefully at the mat, the entire surface of the mat trembles. These vibrations correspond to Einstein's gravitational waves, which spread as cosmic quakes through space-time at the speed of light. Gravitational waves are by nature so weak that Einstein believed they could never be detected. Typical triggers are cosmic catastrophes such as supernova explosions or the fusion of two black holes orbiting each other.

Gravitational waves can be detected directly using Michelson interferometers. These are equipped with two very long measuring arms extending at right angles to each other. The basic principle is simple: If a gravitational wave passes through the detector, one of the arms is compressed and the other is stretched. These changes in length are measured using lasers. The measuring technique is complicated, as it must be extremely precise: The four-kilometre-long measuring arms of the LIGO detectors vary by only a few thousandths of the diameter of a hydrogen atom core.

The enormous measurement precision of the LIGO lasers is the main achievement of the Danzmann team. In Hannover, the researchers operate the GEO600 detector, whose arms are 600 metres long. In work lasting decades, the physicists have trimmed the lasers and measuring instruments in the detector to the highest precision. For example, the optical systems are suspended as pendulums in order to absorb vibrations. Both the laser beam and the measured signals are recycled in the system for amplification. This has further increased the measuring sensitivity tenfold. These technologies, which were initially developed for basic research, are now widely used for practical purposes in many fields, for example in geodesy satellites and in data communication.

With the help of Danzmann's optimizations, the American detectors succeeded in registering a gravitational wave for the first time on 14 September 2015. The wave comes from two black holes with 29 and 36 solar masses that fused 1.3 billion light years away from Earth. A second signal in December 2015 eliminated any remaining doubts that the first signal could have been an artefact.

Starting in 2034, the European Space Agency (ESA) will even be stationing a Michelson interferometer in space. Three satellites will be spanned by measuring arms with a length of 2.5 million kilometres. This LISA detector, the basic concept of which also originates from the Danzmann team, is particularly sensitive to gravitational waves from ultramassive black holes in the centres of galaxies.

The Körber European Science Prize 2017 will be presented to Karsten Danzmann on 7 September in the Great Festival Hall of Hamburg Town Hall.

Every year since 1985, the **Körber European Science Prize** has honoured a major breakthrough in the physical or life sciences in Europe. The prize is awarded to excellent and innovative research approaches with high application potential. With prize money of 750,000 euros it is one of the world's most highly endowed prizes. To date, six prize winners have also been awarded the Nobel Prize after receiving the Körber Prize.