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AN INTERNATIONAL INFRASTRUCTURE FOR GRAVITATIONAL WAVES

There is one phenomenon predicted by Albert Einstein in his theory of General Relativity that has not yet been directly detected: gravitational waves. Ripples in space-time that propagate at the speed of light, created by the acceleration of masses. Astrophysical sources such as explosions of stars, the collapse of galaxies and black holes cause vibrations in what is metaphorically described as the “fabric” of space-time, on which stars, planets and galaxies rest. These waves are infinitesimal and to detect them scientists have had to build large detectors: laser interferometers, like VIRGO, which is located in the countryside at Cascina, near Pisa in Italy. VIRGO is the result of a Franco-Italian partnership between the INFN and the CNRS (Centre National de la Recherche Scientifique), operated by the EGO (European Gravitational Observatory) consortium. The huge research infrastructure has been in use since 2003 and since 2007 has been part of an international collaboration involving the US LIGO observatories and the German Geo600 project. The aim is to make the activities and results of each of the research centres more effective and expeditious. By obtaining data from different detectors, scientists can identify and reject any spurious signals. And if a gravitational wave is detected, it will be possible to locate its source based on the different times of its arrival at the various devices.
A coordinated scheme to enhance the sensitivity of the interferometers is now in the final stages. This will enable gravitational waves to be detected on a regular basis in the coming years, thus paving the way for a new kind of astronomy: gravitational astronomy. VIRGO embodies cutting-edge technology capable of achieving hitherto unimaginable levels of precision. It consists of a detector with two perpendicular arms each three kilometres long, through which two laser beams travel in a vacuum environment inside large pipes. The initial laser beam is split into two rays by a beam splitter mirror. These are then reflected back and forth several hundred times by special mirrors so as to increase their path, before being recomposed. The resulting interference pattern is created by overlapping the beams. If a gravitational wave passes through the interferometer, the length of the arms changes and

» FOCUS ON

the interference pattern is altered.
VIRGO is capable of measuring changes in the length of the arms that are a billion times smaller than the diameter of an atom. VIRGO's mirrors meet extremely high quality standards. Their surfaces are so smooth that any flaws are less than one billionth of a metre in size and less than one millionth of the incident light is dispersed. A system of superattenuators has been built to prevent any vibrations due to seismic noise: huge shock absorbers that support the mirrors by means of pendulum structures. And to avoid any background noise caused by the refraction of air, the laser beam travels inside ultra-high vacuum pipes, where the pressure is one thousandth of a billionth of an atmosphere. These devices have been implemented in close collaboration with scientists from the INFN and CNRS and industries, including many small Italian companies that have accepted the challenge and chosen to invest in the scientific and technological venture of building this important research infrastructure. ■