Description for the general public of the project titled „Gravitational-wave astronomy: participation of the Polgraw group in Advanced Virgo and Advanced LIGO projects''

Until recently the vast majority of knowledge about astrophysical objects, and about the Universe as the whole, was acquired by astronomers by means of observations of electromagnetic radiation of different kinds. We thus have radio-astronomy, which studies radio waves, optical astronomy dealing with visible light, X-ray astronomy, etc. The recent historical first direct detections of gravitational waves, being probably the best proof for the significance of this proposal, opened a new window onto the Universe, the window related with gravitational physics which allows to observe Universe from a completely new perspective. These detections mark the beginning of a new era of gravitational-wave astronomy.

Gravity is one of the fundamental interactions in nature, very well known from our everyday life, but it probably has the most mysterious nature among all known interactions. The real nature of gravity was described by Einstein in his general relativity theory. One of the most important consequences of this theory is the existence of gravitational waves and black holes. Gravitational waves can directly probe regions of Universe with extremely strong gravity - vicinity of black-hole horizons and of neutron stars. Gravitational waves are emitted during violent astrophysical phenomena, in which the spacetime curvature is dynamically changing, they are created by fast, large-scale movement of massive bodies, and after the emission they interact very weakly with the surroundings, providing a view otherwise obscured for traditional electromagnetic observations. They are important in studying the densest, most extreme matter in the Universe - the largely unknown interiors of neutron stars.

Gravitational waves, which were recently directly registered, all came from collisions of black holes forming binary systems. These collisions, named GW150914, GW151226, and GW170104, were observed by laser-interferometric detectors built within the LIGO and Virgo projects. Detections of gravitational waves emitted during the black-hole mergers were possible not only by using extremely sensitive instruments, but also required a complicated data analysis made by LIGO-Virgo collaboration.

The Polgraw[1] group comprises Polish scientists which apply the present proposal. The group is a part of international Virgo Collaboration, which constructed the gravitational-wave detector Virgo and now is managing and upgrading it. Since 2008 Polish scientists have access to unique data collected by the Virgo detector and also to data collected by two American detectors constructed within the LIGO project. Due to participation in the Virgo Collaboration the members of the Polgraw group have opportunity to collaborate with the world-wide best institutions involved in constructing and upgrading gravitational-wave detectors, analysis and astrophysical interpretation of data. Within the present proposal the Polgraw group scientists will participate in searches in LIGO/Virgo data for gravitational waves emitted by single rotating neutron stars, both these which emit almost monochromatic signals in time scales of millions of years, and those which are newly born in collisions occurring in close compact binary systems and undergo rapid changes. Studies will be conducted on in what way close binaries made of compact objects are formed and on physical mechanisms generating gravitational waves by single neutron stars. Also studies on enhancement of the sensitivity of the Virgo detector will be performed.

[1] Polgraw group website: https://polgraw.camk.edu.pl .