CosmoBubbles - Gravitational waves and primordial black holes from cosmological phase transitions

In 2015, nearly a century after their existence was predicted by Einstein's theory of general relativity, the LIGO detectors observed gravitational waves directly for the first time. The significance of these observations can be compared to the pioneering observations of astronomical objects made by Galileo Galilei in the 17th century at visible wavelengths of light. Both observations opened a new window to the Universe, and, in the same way observations made across the electromagnetic spectrum have revolutionised our view of the Universe, it is expected that observational advances in gravitational wave astronomy will result in great scientific breakthroughs. Gravitational wave astronomy has potential for solving some of the biggest questions in astrophysics, cosmology and fundamental physics. This, however, requires theoretical studies that allow us to understand the observations and their implications.
This project includes such studies quantifying connections between the following three topics: GWs, primordial black holes (PBHs) and cosmological phase transitions. First, considering formation of GWs in cosmological phase transition, we develop new approaches for the calculation of the resulting GW spectrum, which allow for efficient studies of the parametric dependences of the spectrum. Second, considering formation of PBHs in cosmological phase transitions, we quantify the phase transition and collapse dynamics with numerical simulations to determine whether PBHs can form and, if yes, what are their properties and whether this process can be probed through GWs. These studies may lead to important developments in our understanding of what is dark matter, and the results of this project are necessary for deploying the full potential of the current and future GW observatories.

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Total EU Contribution: Euro 172.750,08

Call ID: HORIZON-MSCA-2021-PF-01

Project Duration in months: 24

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