

Cepheids are one of the most important stars in astrophysics - cosmic beacons, standard candles that allow us to measure distances in the Universe. They contributed significantly to the discovery of the accelerated expansion of the Universe - a discovery that was honoured with the 2011 Nobel Prize in Physics. These variable stars change their luminosity with a period closely related to their absolute brightness. It is this relationship, period-luminosity, that is used to measure distances using Cepheids. The variability of Cepheids is due to radial pulsations - the star rhythmically expands and contracts while maintaining its spherical shape, and changes in size are accompanied by changes in temperature and brightness. But do we fully understand the variability of these extremely important stars? Recent years have shown that the Cepheids still hold many secrets, and that their variability is not as regular as once thought.

Thanks to sky surveys monitoring the brightness of millions of stars, such as the Optical Gravitational Lensing Experiment (OGLE), and observations by space missions such as Kepler and TESS, additional low-amplitude variability has been discovered in Cepheids that cannot be explained by radial pulsations. Excitation of extremely interesting non-radial pulsations, i.e. such periodic variability that does not preserve the spherical shape of the star, has been discovered. In the future, these pulsations will perhaps allow us to look inside the Cepheid, thanks to the methods of asteroseismology applied to stars in which multiple variability is excited. Periodic pulsation modulation has also been detected in a significant number of Cepheids - the amplitude and period of the pulsations change periodically with a period longer than the pulsation period. Moreover, the mean brightness of the star can change periodically. Does this affect the precise determination of distances to Cepheids?

Finding these additional low amplitude variations is not easy. It requires systematic and precise observations of the brightness of Cepheids. Space telescopes, although they have yielded many ground-breaking observations, perform poorly for Cepheids – they observe too few of them. These stars in our Galaxy are scattered almost all over the sky and quite bright. In distant galaxies, they are fainter and densely packed in a small area. Ground-based projects such as OGLE, which monitors the brightness of thousands of Cepheids in the Magellanic Clouds, are of great importance in the study of Cepheids. New observations, starting in 2021, are extremely frequent - for many Cepheids we have already collected fantastic data that allow us to look for additional low-amplitude variability. In these data we are able to find variations with amplitudes thousands of times smaller than the amplitude of the radial pulsations! Until now, we have not had such good data for so many Cepheids. This search and analysis of additional variability is precisely the aim of the project. The more additional periodicities we find and the better we study them, the deeper will be our knowledge and understanding of Cepheid pulsations. In the future, we will use these additional variabilities to study the interior of Cepheids and thus test the physics of the stellar interior.