Neutron stars are remnants of supernova explosions, representing the final stage in the life of a massive star. These objects possess extreme properties: their immense mass is concentrated in a sphere with a radius of about 10 km, resulting in a density comparable to that of an atomic nucleus. Additionally, a complete rotation of a neutron star typically takes much less than one second. For some neutron stars, known as pulsars, we observe the emission of electromagnetic radiation from their poles. This radiation can be observed both from Earth and from space using telescopes operating at various wavelengths: from radio waves, through microwaves and visible light, to X-rays and gamma rays. Regular observations show that the emission of radiation causes the star's rotation to slow down.

To great surprise, observational data revealed the effect of a sudden increase in the rotation speed of a pulsar, which seemingly contradicts the conservation of angular momentum. However, this effect can be understood by assuming that the neutron star consists of two components: a crust and superfluid neutrons. The first component has a crystal structure, composed of regularly arranged atomic nuclei, responsible for emitting radiation that causes the star to slow down. Quantum theory tells us that the second component, the rotating superfluid, contains quantum vortices.

The interaction between the vortices and the nuclei causes the angular momentum to not freely transfer between the crust and the superfluid neutrons. In this configuration, the crust slows down due to energy loss, while the superfluid component has a fixed angular momentum. At a certain critical difference in the rotational speed of the two components, a reorganization of the vortices occurs, transferring angular momentum from the superfluid to the crust. This effect is observed in terrestrial astronomical observatories as a sudden increase in the rotation speed of the entire star. Determining the interaction between the nuclei and the vortices is extremely difficult, as it is either subject to large uncertainties or requires significant computational resources to accurately determine.

**The aim of this project is to determine the force between a nucleus and a vortex** using a method that employs precise three-dimensional simulations performed on supercomputers. The plan is to determine this parameter for different depths of the neutron star, temperatures, and nuclear models. Accurate knowledge of this parameter will allow for more precise modeling of the process and may indirectly help in understanding the internal structure and dynamics of a neutron star.