Abstract for the general public

The aim of the proposed research is to use gravitational waves to understand and solve the mysterious nature of dark matter. Galaxies are known to exist in the dark matter halos. To investigate them, the phenomenon of gravitational wave lensing will be employed. When a galaxy happens to lie along the line of sight between our gravitational wave source and the detector, it will result in gravitational wave lensing. During which, the spacetime curvature of the galaxies bend the path of gravitational waves coming from the background source and amplify them. In certain situations they produce multiple copies of the same signal that are detected at different times. This resulting wave or waves that we detect with our instruments like Virgo, will carry important information about the dark matter halos in which those galaxies reside.

The existing models of dark matter are successful in explaining the observations of large structures like massive galaxies or galaxy clusters in our universe. But, these models seem to contradict our prediction for small mass galaxies. Such galaxies are available close to our own Milky Way galaxies and are known as the satellites of the Milky Way and they are good laboratories for dark matter studies. A model of dark matter known as Fuzzy or wave-like dark matter is successful in solving issues with our current models. In this project we will use gravitational waves from isolated neutron stars and binary black holes behind these galaxies to study and infer their properties.

To study them we use a technique proposed by Polish astronomer prof. Bohdan Paczyński called microlensing for electromagnetic waves. We extend this to gravitational waves from neutron stars in this study. The neutron stars are expected to be in large numbers and if some of them pass through our candidate satellites galaxies it will show some signature about dark matter in the resulting lensed signal.

This project will develop software and algorithms to search for signals in the existing gravitational wave data using the technique developed by Polish researchers called F-Statistic. Additionally, we also model lensed transient compact binary merger signals and infer their properties. Hence this project will help solve the mysteries related to dark matter using different kinds of lensed signals, besides advancing the field of gravitational wave astronomy.