Bose-Einstein condensates are famous for being the coldest known matter in the universe, though the amount of matter is small, dilute and fits inside a cubic millimetre in high vacuum in a few high technology laboratories. Remarkably, one of the models for dark matter, so called „fuzzy" or wave dark matter which has received a lot of attention recently, also postulates that this substance that accounts for most of the matter of the universe is nothing but a condensate with a wavelength on the size of a galaxy. While sounding improbable, these ideas not only shed light on dark matter from an entirely different perspective than the more familiar cold dark matter model, but also hold great promise to solve vexing issues such as the much discussed „cuspy halo" problem. This is the issue that while observations of galaxy properties indicate a mostly flat dark matter density distribution inside, leading dark matter models predict a much sharper inner density peak, the „cusp". In fuzzy dark matter the incorrect peak is prevented because the main condensate does not support such „short" wavelengths that do not measure up to the size of a galaxy.

In this project, we want to take advantage of the many parallels between the now very developed description of ultracold atoms and the fuzzy dark matter model to obtain a more nuanced and accurate representation of the postulated fuzzy dark matter. In particular, dark matter simulations to date have not included higher energy, lower wavelength modes far outside of the main condensate, because including them is computationally prohibitive. We will port some more nuanced computational approaches developed in ultracold atoms to include the effect of these higher energy waves into dark matter simulations. By including these shorter wavelength phenomena we hope to get a more accurate picture of the fuzzy dark matter predictions. We hope that the new results will also allow us to investigate how such waves of fuzzy dark matter would affect „small" tracer particles such as globular clusters or dwarf galaxies. If the effect is observable, it might allow for real astronomical observations to distinguish between the predictions of fuzzy dark matter and the more standard dark matter model to determine which of them is closer to reality.