Dynamical and radiative impacts of jet-star interactions

To fully understand the multi-messenger emissions from AGN jets, it is essential to connect their dynamics with the underlying physical processes. Recent numerical studies indicate that jet-star interactions significantly contribute to mass-loading the jet with protons. These interactions, coupled with local shock accelerations, can propel electrons and protons to high energies, facilitating the production of non-thermal emissions and cosmic rays, including neutrinos. If perturbations are injected into the jet, this can temporarily increase the non-thermal emission during shock-shock interactions and allow the production of neutrino flares during shock-star interactions.

Using numerical simulations of jets and the post-processing radiative transfer code RIPTIDE, I will demonstrate how protons influence both the dynamics of jets and non-thermal emissions. Specifically, protons affect jet dynamics through mass-loading: at large scales, they dissipate kinetic energy, while at small scales, they engage in local jet-star interactions. Additionally, protons impact non-thermal emissions by shaping the multi-wavelength emission from accelerated electrons at large scales and inducing the local, temporal production of very energetic neutrinos through the photo-pion process at small scales.

Our results will be compared to multimessenger observations. At large scales, VLBI-Gaia observations show the presence of positive radio-optical shifts that depend on the AGN type and characteristics. At small scales, we will compare our results with simultaneous multi-wavelength activity in blazar jets, and the neutrino flux will be compared with the sensitivities of neutrino detection facilities (IceCube, KM3NeT).