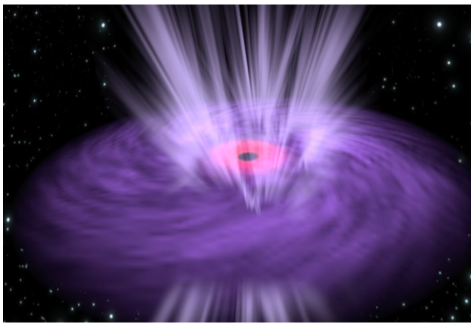
Cosmic compact objects are the most extreme objects in the Universe, accumulating enormous amount of mass in a small space. They are formed as e result of supernovae explosions of the largest stars. The explosion is so powerful that the core of the star collapses inward, creating a black hole or neutron star. Neutron stars are made of atomic nuclei so crushed that this kind of matter cannot be obtained in Earth laboratories. On the other hand, black holes are regions of space-time where the compressed elementary particles are no longer able to create any gravitationally stable formation defined by the known laws of matter. Therefore, black holes are constantly collapsing stars, interacting with their surroundings only through the enormous force of gravity. Dead stars roam the cosmos. If on their way, they encounter areas of gas, they naturally initiate the phenomenon of accretion - i.e. the gravitational fall of gas onto a compact object (Photo: Accretion diagram on a compact object. Credit: ESA).

Accretion of gas onto compact object, either onto black hole or neutron star, is one of the most powerful way of energy production in the Universe, which is than converted into electromagnetic flux. Therefore, astrophysicists, aiming to understand the nature of compact objects of various masses, they constantly monitor the radiation of matter, which disappears on our eyes, feeding black holes or neutron stars. This has been happening since the accretion process successfully explained the mystery of high luminosity of distant quasars observed at the beginning of the last century.



Together with the development of new observation technologies allowing to put telescopes on satellites, astronomers have learned to view the Universe at high energies, blocked by the Earth's atmosphere. Since the 1960s, we have been constantly monitoring cosmic space in the X-ray range invisible to the human eye. Over many years of research, it turned out that accreting compact objects, regardless of their mass, are strong sources of X-rays. The accreting gas heats up to the temperature of millions of degrees – the one being observed in Solar corona. At such temperatures, X-rays are produced with characteristic features that can be defined as X-ray fingerprints of accreting compact objects. In this project, we aim to study these most important fingerprints in the context of: developing new numerical codes for computing advanced models of radiation, analysing X-ray observations, and finally making predictions of signal that will be observed by future X-ray missions as ATHENA (European Space Agency, ESA mission) and ARCUS (NASA mission).

The primary goal of our project is to develop a new code that would simultaneously model all X-ray fingerprints taking into account the matter structure. As a result, we would obtain the emission spectra depending on viewing angle, taking into account all important processes occurring in the illuminated gas. In addition, the same code will model the absorption of radiation by the warm gas on the line of sight toward observer. From the very beginning, the numerical work will be accompanied by the work with observations and simulations of signal for future X-ray missions. At the end of the project, our advanced models will be ready to use at the time when accreting sources will be observed by most advanced X-ray telescopes.

Up to now, existing models of X-ray fingerprints from accreting objects are computed under a constant gas density. Several important physical processes occurring in the matter are treated by separate numerical codes, with no possibility to compare their qualitative meaning. The novelty of our project will be the new public numerical code allowing to model simultaneously all X-ray fingerprints taking into account the gas structure. The novelty of our work with observations will be to collect all data of accreting objects of different masses in order to establish a common model of gas distribution and dynamics in the vicinity of black holes. We will create a new line of actions to model X-ray signal seen by future detectors. Such complete methodology is necessary to prepare new specialists which may work in the Science Ground Segment Operating Centres of new X-ray telescopes after their launch on the orbit. For this purpose, we will combine the work of theorists, observers and mission development scientists.

We plan to use most advanced computational algorithms, data reduction tools and signal simulators to work in the project. The X-ray fingerprints studied by us will allow to answer fundamental question: is there a uniform model of accretion geometry responsible for all fingerprints and what is it? All results will be posted on our website, and the newly developed codes and scripts will become public. Ultimately, our team will be completely prepared to work with future X-ray detectors, which primarily goal is to observed accreting compact objects.