

The goal of the project is to solve some problems of astrophysics of accretion onto black holes and associated ejections. Specifically, we will study these processes occurring in stellar binaries (i.e., systems in which two stars orbit around their centre of mass). Such binaries can form when at least one star was initially very massive, with the mass of at least 25 solar masses. After the more massive star exhausted its nuclear fuel, it exploded and became a black hole, while its companion remained a normal star. The observed masses of black holes in stellar systems are within about 5 to 20 solar masses. If the companion star is a large enough, the black hole gravity can cause a mass flow from the star onto the black hole to occur. We call such a process called accretion. During accretion, a fraction of the kinetic energy of the falling matter is converted into random motion of particles, i.e., the particles are heated, which leads to observable radiation.

The process of accretion is still not fully understood, in spite of many years of studies. The accreted matter in a system of two stars has high angular momentum. Thus, accretion does not proceed spherically but in via a thin disc. Such accretion discs are often observed in stellar binaries containing black holes, and their emission peaks in soft X-rays.

We also observe hard X-ray radiation from some states of the binaries. This emission comes from some hot plasma rather than the thin disc. The geometry of the hard X-ray sources has been a subject of an intense debate. Some evidence points to the disc extending down to the innermost stable orbit around the black hole. The source of hard X-rays can then be located above the disk and the black hole. Other evidence shows that the accretion disc is truncated at a relatively large inner radius and replaced by a hot flow with relativistic electrons. We propose to develop computer codes allowing us to analyze the available data in more detail than before and to conclusively decide what is the actual geometry of the hard X-ray sources.

It turns out that not all of the falling mass enters the black hole in the accretion process; a part forms bipolar outflows called jets, moving with velocities close to the speed of light. We propose to search for physical connections between the accretion and outflows. In particular, transfer of magnetic fields through the accretion flow to the vicinity of the black hole seems to be crucial, but not well understood, for the formation of outflows. The magnetic field can also be as strong as to hinder the accretion, causing it to occur intermittently. Also, time lags of the jet emission (typically in radio bands) with respect to the emission from accretion (typically in X-rays) are sometimes observed and can give us hints regarding the structure of the sources.

Furthermore, we see three kinds of jets, two associated with two main states of the accreting binaries and one occurring during state transitions. Also, one of the three types occurs very rarely. The underlying physical causes of that phenomenology are not understood. We propose to study these issues in detail, and hopefully find the true answers.