DESCRIPTION FOR THE GENERAL PUBLIC

Among the most spectacular celestial objects are extended, double radio sources which surround some galaxies and quasars. The first such radio sources were discovered shortly after the birth of radio astronomy around the middle of 20th century, and as such, stimulated the growth of the field. From the start, those revealed surprising spatial scale and form, but also the energy content. Their sizes often span the range of many hundreds of thousands of light years; the mechanism of their emission is the synchrotron process, via relativistic electrons gyrating in magnetic field; and indicated by radio luminosities their energy content is equivalent to annihilation of milions of stars. As was apparent from interferometric radio observations, the original source of their energy are processes associated with ordinary matter falling into black holes in centers of galaxies. The radio images (maps) reveal that the distant, extended lobes are connected to the active galactic nuclei via narrow, well-collimated streams of matter, providing the means to deliver the energy – generated near the black hole – to the distant lobes. In some cases, the rate of the energy transmitted via those streams over the distance of hundreds of thousands of light years approaches the rate of release of the gravitational energy provided by the matter falling into the black hole. The generation of such remarkably energetic streams is possible to explain theoretically only if one invokes rapidly rotating black holes, immersed in strong magnetic fields, which can exist in the vicinity of those black holes, but only if the material falling onto the black hole forms a geometrically thick disk of ionized matter, necessary to support such magnetic field.

Here is the first puzzle, which we wish to solve in the context of the proposed research program. Specifically, such geometrically thick disks are theoretically predicted to exist in the objects where the rate or material falling onto the black hole is either quite modest, or alternatively, very large. However, the observations imply that such streams are also present in objects where the material falls onto the black hole at some intermediate rate, which in turn on theoretical grounds, are believed to posess discs that are likely to be geometrically thin. We observe such sources as radio galaxies posessing strong optical emission lines. We intend to study the following possible reasons for such disagreement: (1) erroneous assumptions about the structure of such streams, leading to an overestimate of their power; (2) not including the effects of time variability (modulation) of the mechanism generating those streams; (3) our incomplete understanding of all physical process that should be included when considering material flowing onto a black hole, and specifically, significant swelling of an otherwise thin disk resulting from a pressure that might be provided by magnetic fields; and (4) a possibility of thin, cold disks becoming hot thick disks at higher rates of flow of matter onto the black hole than expected from the currently accepted theories.

The formation of powerful streams of matter is associated with another, comparably curious and fascinating puzzle. Observations of quasars – which are believed to be characterized by a very large rate of fall of material onto the black hole – reveal that those extended, double radio sources take place in one of (roughly) 30 quasars. In the remaining sources, the streams of matter are too weak to form such large radio lobes, or they are not present at all. The question why some quasars posess such streams, powerful enough to form those large radio lobes, and others do not – still lacks a clear explanation. This question also pertains the sources with intermediate rates of material falling onto the black hole, represented by radio galaxies with broad optical emission lines. One answer that is frequently invoked has the effects of the physical properties of the matter falling onto the black hole affecting the efficiency of production of the streams. However, in that case, one would expect differences in radiative properties of active nuclei in those sources, and the second part of the proposed investigation will address this specific question. Demonstrating that such differences are insignificant would provide arguments supporting the hypothesis that the efficiency of formation of such streams is governed by the rate of rotation of the back hole and the level of its magnetization, rather than the properties of matter falling onto the black hole.