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Editorial

Global Understanding of Accretion and Ejection around Black Holes

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Accretion and ejection around compact objects, mainly around black holes, both in low mass, and supermassive, is rich and has been studied exhaustively. However, the subject is expanding and growing rapidly after the launch of different space-based satellites and ground-based telescopes in multiwavelength bands, leaving a range of questions on accretion and ejection mechanisms. The proper understanding of the underlying physical mechanisms responsible for observational evidence is still lacking for several reasons. For instance, different phenomena are studied as a separate system, the hydrodynamics of one component ignores the other, spectral properties ignore timing properties or vice versa, and there is not enough instrumental resolution to decipher small scale physics.

With the advent of high-resolution satellite observations, it is possible to look at the problems globally as a complete package in a more consistent way. Recently, many new low mass black hole candidates have been discovered; however, very little is known about those systems, e.g., mass, spin parameter, orbital period. The study in the spectrotemporal domain also needs proper understanding of spectral state change, quasi periodic oscillation (QPO) frequency evolution, hardness intensity diagram, and line emissions. Therefore, it is a good time to take a break, recapitulate what has been carried out, what is ongoing, and what can be carried out in the future with upcoming missions, both from a theoretical and observational perspective, bringing together experts across the electromagnetic spectrum to gain new insights into the physical process of accretion.

This special issue covers both theoretical and observational aspects of accretion and ejection around both low mass and supermassive black holes. The papers published in this Special Issue provide novel, interesting phenomenological and theoretical contributions to this mainline topic. There is a range of questions related to the underlying physical processes which are responsible for the observed variabilities. This Issue puts some light on those basic questions and provide a roadmap for the resolution. For example, the physical picture of luminous active galactic nuclei (AGN) with powerful jets has been several decades-old problems in high-energy astrophysics. One of the fundamental problems is that to produce such powerful jets strong magnetic fields are to be transported from the accretion disk to the black hole horizon. This gives rise to greater disk thickness, which in turn decreases the radiative efficiency of the disk. Ref. [1] pointed out that recent numerical simulations have been partially successful to address the issue and much work is needed to single out the physical processes. They provided a road map for a resolution that counterrotating black holes with thin disks should be further explored in new simulations.

In addition, for a class of AGNs where the radiation is dominated by the accretion disk and its corona are known as Seyfert galaxies. This class of AGNs shows variability in different timescales in their observed lightcurve and emitted spectra, however, the physical origin of which is highly illusive, most importantly when the question comes on the origin of the inner hot corona and its geometrical and thermodynamical properties. Ref. [2] studied a well-known source Mrk 335 using several models including both physical and phenomenological and inferred the origin of variability from the basic accretion flow parameters. Authors suggested that the cooling and viscosity are important to make the corona variable, similar to low mass black hole candidates (LMBHCs, ref. [3]), which

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actually depends on the variation of the mass accretion rate (ref. [4,5]). The matter which is falling onto a black hole can be isothermal or adiabatic depending on the radiation mechanisms taken into account. Ref. [6] studied the Bondi accretion onto a supermassive black hole for the variable adiabatic index of the flow using Paczyński–Wiita potential. Earlier, a detailed study of accretion processes with varying the polytropic index was also done by ref. ([7,8] and others).

The other class of AGNs of which the radiation is mainly dominated by the jets is called blazars and radio-loud AGN. In their high activity state jet is the dominating contributor to the observed features, however, the disk can also contribute when the jet activity is low or moderate ref. [9]. Therefore, distinguishing the central engine responsible for the variabilities in these objects is one of the front line topics. Refs. [10–12] studied these issues and related variability properties in this special issue. Apart from continuum modeling, line emission is crucial to understand the gaseous outflows from these systems. This indeed helps us to understand the role of the Eddington luminosity, mass accretion rates, and the geometry of the flow in originating variable line profiles (see ref. [13] in this context and references therein), the wind/outflow velocities, and also from which region these lines are originating. Ref. [14] addressed some of these issues for quasars.

If we look at the black holes of small scales, they too show variability in their spectro-temporal domain, including QPOs, jet/outflows, the signature of magnetic field etc. Refs. [15,16] studied low LMBHCs, XTE J1908+094 and V404 Cygni, and determined their mass accretion rates, corona radii etc. Ref. [16] estimated the equipartition magnetic field strength of V404 Cygni source during the outburst phase and estimated the value of 900 Gauss. The authors did not find any QPO frequency in their power density spectra. They suggested that the absence of QPOs is due to the non-satisfaction of resonance condition (see ref. [17]).

It is to be noted that the mass of the central compact objects is hardly known, therefore, estimating its value is important to estimate different length scales of the flows correctly. Refs. [2,15] estimated the masses of the AGN and LMBHC from their spectral fitting, which agree with the dynamical mass measurement of the sources.

In addition to the fluid dynamics, one can also find the geodesic orbit of particles in black string spacetime geometry. Ref. [18] studied the same and found that the presence of the compact extra dimension leads to an increase in the number of the isofrequency pairing of geodesic orbits.

To summarize, the papers compiled in this Special Issue presented interesting results and gave useful insights onto the accretion-ejection processes around black holes. Furthermore, the articles on this Issue also put light on what can be carried out using future observations.

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