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On the role of magnetic reconnection in jet/accretion disk systems

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Abstract. The most accepted model for jet production is based on the magneto-centrifugal acceleration out off an accretion disk that surrounds the central source (Blandford & Payne, 1982). This scenario, however, does not explain, e.g., the quasi-periodic ejection phenomena often observed in different astrophysical jet classes. de Gouveia Dal Pino & Lazarian (2005) (hereafter GDPL) have proposed that the large scale superluminal ejections observed in microquasars during radio flare events could be produced by violent magnetic reconnection (MR) episodes. Here, we extend this model to other accretion disk systems, namely: active galactic nuclei (AGNs) and young stellar objects (YSOs), and also discuss its hole on jet heating and particle acceleration.

Keywords. accretion disks, acceleration of particles, magnetic fields.

MR IN MICROQUASARS AND AGNS: A violent MR process between the magnetic field lines of the accretion disk and those that are anchored into the black hole may occur when a large scale magnetic field is established by turbulent dynamo in the inner disk region with a ratio between the gas+radiation and the magnetic pressures $\beta \leqslant 1$. During this process, substantial angular momentum is removed from the disk by the wind generated by the magnetic flux, which increases the disk mass accretion rate to a value near the Eddington limit. After the reconnection, the partial destruction of the magnetic flux in the inner disk will make it to return to a less magnetized condition with most of the energy being dissipated locally within the disk instead of in the outflow. The magnetic power released by MR (see Figure 1) is able to heat the coronal/disk gas and accelerate the plasma to relativistic velocities through a diffusive first-order Fermi-like process within the reconnection site that will produce intermittent relativistic ejections or plasmons (GDPL). The resulting power-law electron distribution is compatible with the synchrotron radio spectrum observed during the outbursts of these sources. We are presently testing this acceleration mechanism with fully 3D numerical simulations. The diagram of the magnetic energy rate released by violent reconnection as a function of the black hole (BH) mass spanning 10^9 orders of magnitude (Figure 1) shows that the magnetic reconnection power is more than sufficient to explain the observed radio luminosities of the outbursts, from microquasars to low luminous AGNs (LINERs and Seyfert galaxies). This result is consistent with recently found empirical relation that correlates the observed radio emission from microquasars and radio quiet AGNs to that of magnetically active stars (Laor & Behar 2008; Soker & Vrtilek 2009), suggesting that it is mainly due to magnetic activity in the coronae and therefore, is nearly independent of

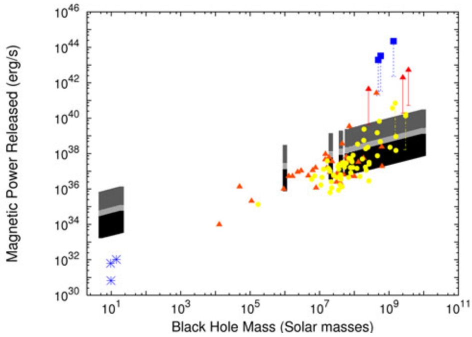

Figure 1. Magnetic power due to violent reconnection versus the BH mass for both microquasars and AGNs. The stars represent the observed radio luminosities for three microquasars. The circles, triangles and squares are observed radio luminosities of jets at parsec scales from LINERS, Seyfert galaxies, and luminous AGNs, respectively. The thick bars correspond to the calculated magnetic reconnection power and encompass a fiducial parameter space (see de Gouveia Dal Pino, Piovezan & Kadowaki, 2009, for details).

the intrinsic physics of the central source and the accretion disk. The correlation found in Figure 1 does not hold for radio-loud AGNs, possibly because their surroundings are much denser and then "mask" the emission due to coronal magnetic activity. In this case, particle re-acceleration behind shocks further out in the jet launching region will be probably the main responsible for the radio emission. The violent MR could also be responsible for the transition from the so called hard steep power-law state (SPLS) to the soft SPLS in microquasars (Remillard & McClintock, 2006).

MR IN YSOS: The observed flares in x-rays are often attributed to magnetic activity at the stellar corona. However, some COUP (Chandra Orion Ultra-deep Project) sources have revealed strong flares that were related to peculiar gigantic magnetic loops linking the magnetosphere of the central star with the inner region of the accretion disk. It has been argued that this x-ray emission could be due to magnetic reconnection in these gigantic loops (Favata et. al, 2005). We have extended the MR scenario described above to these sources and found that a similar magnetic configuration can be reached that could possibly produce the observed x-ray flares in most of the sources and provide the heating at the jet launching base if violent magnetic reconnection events occur with episodic, very short duration accretion rates $\sim 100 - 1000$ times larger than the typical mean accretion rates expected for more evolved (T Tauri) YSOs.

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