INSIGHTS AND CONCLUSIONS
Chapter 4

Insights and Conclusions

4.1 Broad, constituent specifications of black hole signature

From our study the emerging black hole environment specifications could be classified as follows -

1. Appearance of a narrow 511 KeV gamma-ray line,

2. FWHM of the line (\(\sim 3.2\) KeV or 5 KeV),

3. Size of the annihilation site, based on its variability, from days to months,

4. Nature of the annihilation site - neutral, ionized, partially ionized medium (depending on the value of FWHM and \(n_e / n_H\)).
4.2 **Insights**

**Magnetic field line reconnection and amplification**

We would also like to dwell on the evolution of magnetic fields in a convective disk.

Within the inner portion of the disk, reconnection may not limit field growth and approximate equipartition would tend to occur. Field amplification would then lead to flux eruption from the disk.

The closed field topology above the disk, together with plasma heating resulting from reconnection, would perhaps lead to the formation of an ensemble of very hot confined plasma structures whose emission time scales may be dictated by the heating process. [Fig. 4.1].

The cooling of these plasma structures would then tend to be strongly influenced by the soft X-ray luminosity of the underlying accretion disk. The plasma confinement thus obtained by the erupted magnetic field would then tend to allow substantially higher coronal temperatures to be attained.

Secondly, the spatially-inhomogeneous nature of the resulting accretion disk corona could be an essential aspect for the temporal fluctuations in its emission.
Formation of Structured Confined Coronae

Schematic drawing of inner accretion disk geometry

Adapted from: Galeev, Rosner and Vaiana

"Formation of Structured Confined Coronae on Accretion Disks"

Figure 4.1

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Magnetic field evolution within accretion disk. Field amplification resulting from joint action of differential rotation and convection within the disk.

Schematic of the flow pattern for a typical convective cell. [Galeev, Rosner, Vaiana]

Figure 4.2
Magnetic field amplification may result from the joint action of differential rotation and convection within the disk. Convection is essential, as without it, only linear field growth is obtained. Field amplification is thus limited by non-linear effects that would come into play when Lorentz forces begin to be effective at suppressing convection. The field energy density then would tend to become comparable to thermal plasma energy density. [Fig.4.2].

Reconnection may not act to limit field strengths before approximate equipartition is attained. Once this stage is reached, density contrasts between magnetized and relatively unmagnetized plasma may lead to buoyancy effects and the eruption of flux from the disk. The emerging fields could be sheared by disk fluid motions and the consequent free energy could be rapidly thermalized by tearing mode instabilities.

The confinement of the heated plasma by the magnetic field would then lead to enhancements both in temperature and density within the erupted flux loops.

The detailed energy balance analysis within these confined plasma structures would perhaps yield the following results -
1. Compton-cooling by soft photons from the disk, thus providing an important loss mechanism for the hot coronal loops;

2. Energy release process being stochastic, tending to generate emission from individual loop structures;

3. Plasma confinement providing high temperatures $10^9$ K. Thus, for a low disk luminosity ($\sim 0.02 \times$ Eddington limit), Compton-cooling may be insignificant. The loop temperature attained would then tend to be $\sim 3 \times 10^9$ K. The energy released in the reconnection process, that would have a typical time scale of 1 sec., would then be of the order of a few times $10^{35}$ ergs s$^{-1}$.

To sum up, a source such as Cyg X-1, would therefore, require a corona consisting of an ensemble of roughly 100 such loop structures.
4.3 Conclusions

1. Our study thus brings out commonality in the observations of plausible black hole candidates.

2. In particular, the study shows that black hole candidates like Cyg X-1, 1E1740.7-2942 and Nova Muscae tend to exhibit similar physical environment.

3. It brings out the plausible nature of electron-positron annihilation sites.

4. It provides an insight into pair production processes.

5. It attempts to visualise the anomalous mechanism causing the black hole system to go into the "hard" state of temporal 511 KeV gamma-ray line emission.

6. It also attempts to evolve a model that tries to simplify our comprehension of the entire black hole physical environment ultimately leading to the signature (narrow, 511 KeV line) of the black hole.