COMMON GAMMA-RAY SPECTRAL PROPERTIES OF GROJ0422+32 AND CYGNUS X-1

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Abstract. We report similar soft gamma-ray (30 keV to 1.7 MeV) spectral properties found in black holes GROJ0422+32 during its first known outburst in 1992 (Ling & Wheaton 2003) and Cygnus X-1 during its “low” to “high” x-ray state transitions in 1994 and 1996 (Ling et al. 1997, McConnell et al. 2000, 2002). The high-intensity gamma-ray spectrum of GROJ0422+32 consists of two components, a Comptonized shape below 300 keV plus a power-law tail above 300 keV with an index of 3-5. The low-intensity spectrum, however, has only a power-law shape spanning the entire energy range with an index of ~2. The two spectra intercept at ~600 keV. These same spectral properties were also seen in the γ_2 and γ_0 spectra, respectively, of Cygnus X-1, suggesting that similar processes were at work in both systems.

We suggest a scenario for interpreting these common spectral features seen in both sources by including a separate non-thermal (perhaps a jet-like) source region in the ADAF model of Esin et al (1998) along with the source geometry envisioned by Poutanen & Coppi (1998) and others. In this scenario, during the high-intensity gamma-ray state of GROJ0422+32 (or γ_2-state of Cygnus X-1), the system consists of a hot inner corona, a cooler outer thin disk, and a region that produced the variable power-law gamma-ray emission. Under this condition, the transition radius of the disk is ~100 Schwarzschild radii from the black hole. Electrons in the hot corona up-scattered the low-energy photons produced both inside the corona as well as from the outer disk to form the Comptonized component that dominates the spectrum in the 35-300 keV range. They also down-scattered the high energy photons (>10 MeV) produced in the “jet” region resulted in forming a softer power-law component observed in the 300 keV to 1 MeV range compared to that observed in the low-intensity spectrum. When GROJ0422+32 was in the low-intensity gamma-ray state (or γ_0 -state for Cygnus X-1) due probably to a significantly increase of the accretion rate, a large soft flux was produced in the disk that effectively quench and cool the inner corona, and moved the transition radius inward to a distance very close to the horizon Under this condition, the Comptonized component in the 35-300 keV range diminishes, and the source spectrum is dominated by the unperturbed power-law emission produced in the “jet”-like non-thermal source region with a characteristic index of ~2.