

Spectral and Timing Properties of Accretion Around Black Holes: Analytical Modelling and Numerical Simulations

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The spectral and timing properties of black-hole accretion systems are closely related to the physical structure and dynamics of the accreting matter. The two-component advective flow (TCAF) model, consisting of a Keplerian disc and a sub-Keplerian flow, provides a framework for studying these connections. In this model, the centrifugal pressure-supported boundary layer (CENBOL) plays an important role in Comptonization and outflow formation.

Monte Carlo simulations have been used to study thermal Comptonization and the resulting high-energy spectra in the presence of accretion flows and outflows. These studies were further extended through coupled Monte Carlo–TVD simulations to investigate the effects of Compton cooling on the dynamics, spectral properties and outflows of the accretion flow.

The variation and origin of quasi-periodic oscillations (QPOs), along with time lags, photon bending and time-dependent images, have also been explored through numerical modelling. Together, these studies provide insight into how the physical conditions and time-dependent behaviour of accretion flows influence their observable spectral, timing and imaging properties.