

Accretion flow variability in SAX J1808.4-3658 with X-ray spectral-timing

Shayak Barh, Aman Kaushik, Sayantan Bhattacharya, Sudip Bhattacharyya

Department of Astronomy and Astrophysics, Tata Institute of Fundamental Research, Mumbai 400005, India

ABSTRACT

We present a systematic X-ray spectral-timing analysis of the accreting millisecond X-ray pulsar SAX J1808.4-3658 with the Neutron Star Interior Composition Explorer (NICER). SAX J1808.4-3658 was observed with NICER during its outbursts from July to November in 2019 and from August to October in 2022, providing approximately 500 ks of good exposure. The hardness-intensity diagrams show that the source remains in the soft state throughout both outbursts. We identify two aperiodic variability components in the power spectra in both outbursts, one at low frequencies (0.008-2 Hz) and the other at high frequencies (10-100 Hz). We investigate the energy dependence of these variability components using lag-energy and covariance spectra. The time lags from the lag-energy spectra show that emission in the soft band leads the hard component. We find that the time lag amplitude decreases as a function of frequency, with the low-frequency component showing significantly larger lags than the high-frequency component. The fractional covariance spectrum of the low-frequency component shows a dominant peak near 0.5 keV and a turnover around 2 keV. The soft contribution to the high-frequency component is significantly weaker, and the turnover around 2 keV is absent. Instead, the high-frequency component exhibits an approximately linear increase in fractional variability with energy from 0.5 to 10 keV. To determine the association of the variability features with the spectral components, we fit the absolute rms normalized covariance spectra. Our results suggest that the fluctuations in the accretion disk originating at larger disk radii mainly contribute to the low-frequency variability, while the high-frequency feature is more strongly associated with the compact, centrally located Comptonizing region.