A thesis of

Accretion Scenario of Black Hole X-ray Binaries During Outburst

submitted by

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in partial fulfillment for the award of the degree of

Doctor of Philosophy

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August 2023

Abstract

In an X-ray binary (XRB) system, a compact object with strong gravity accretes mass from the donor, often a young or evolved star. As the transferred matter falls onto the compact object, potential energy is released, resulting in the emission of X-ray radiation. Some of these systems display episodes of active (outburst) and quiescent phases consecutively. This thesis investigates the accretion scenario of different black hole X-ray binaries (BH-XRBs) during their outbursts.

Chapter 1 introduces a general overview of accretion processes. We comprehensively discuss various accretion scenarios focusing on transient black hole XRBs. We explore the spectral and temporal variability and state classification of these systems. Also, we review outflows/jet and accretion disc wind associated with the system.

The purpose of Chapter 2 is to brief various space X-ray instruments used in this study and the data reduction techniques associated with each of them. We discuss the methods of analyzing X-ray data: spectral and timing analysis. A quick overview of different models used for fitting the X-ray spectra of black hole XRBs and related physical phenomena are also provided in this chapter. Also, we briefly discuss the modelling of the power density spectra.

In Chapter 3, we aim to unveil the accretion scenario of the galactic XRB source MAXI J1820+070 in its 2018 double outburst. The study is performed using observations obtained from the telescopes *Swift/XRT, NICER, NuSTAR* and *AstroSat*. We carried out spectral modelling independently for *XRT* and *NICER* observations and studied the evolution of various physical parameters and the hardness-intensity diagram of the outburst. Then we extended the study by modelling the simultaneous wideband *XRT-NuSTAR, NICER-NuSTAR* and *AstroSat* observations using phenomenological and reflection models. The evolution of model parameters from both studies is thoroughly analysed. The timing analysis of the source is carried out using the *NICER* observations of the outburst. We look for time variability in the data, and finally, its connection with the spectral characteristics is studied in this chapter.

Chapter 4 discusses the spectro-temporal analysis of the galactic XRB source 4U 1543−47 in its 2021 outburst using data from three instruments, *NICER, NuSTAR* and *AstroSat*. Wideband phenomenological and reflection modelling is carried out for simultaneous *NICER-NuSTAR* and *AstroSat* observations. The spectra of the source show the

presence of a strong and dynamic absorption feature at $\sim 8-11$ keV, which has never been observed in any XRB before. A comprehensive spectral study of the outburst is performed using *NICER* observations, and the hardness-intensity diagram of the outburst is generated. Also, we performed timing studies using the *NICER, NuSTAR* and *AstroSat* observations during the first 100 days of the outburst.

Next, in Chapter 5, we have thoroughly investigated the origin of the absorption features observed at $\sim 8-11$ keV in the spectra of the 2021 outburst of 4U 1543−47. This study is based on the *NuSTAR* observations of the outburst. Different possibilities behind the origin of this absorption feature and their role in regulating the accretion scenario are studied. *NuSTAR* data also show a neutral absorption feature at ~ 7.1 keV. The correlated behaviour of the neutral and ionized absorption components is also closely examined.

In Chapter 6, we summarize the findings from the study and discuss the future perspectives.