ABSTRACT

The project has focused on constraining the geometry of the accretion flow in the hard state of black hole X-ray binaries using both standard spectral and combined spectral-timing techniques. I performed spectral modelling of X-ray spectra to constrain the parameters of the reflection of hard X-ray photons from the cold accretion disc. I also used spectral-timing analysis techniques to describe the spatial structure of the accretion flow, by studying the *rms* (root-mean-square) variability spectra – namely, the energy spectra of the different variability components. The variability power of these components peaks at different time scales, therefore they are likely related to different distances from the accreting object. I used both these approaches to investigate the geometry (e.g. the position of the inner edge of the cold accretion disc) and spectral stratification of the inner accretion flow (e.g. the inhomogeneities of the Comptonization zone).

In my work on GX 339-4, I tested different models of reflection and I found that the inferred physical quantities (e.g. disc truncation, iron abundance) strongly depend on the reflection model used and assumptions made. Analysing another source - MAXI J1820+070 - also using reflection fitting, we found that there are two statistically similar results: one corresponding to an untruncated disc, but having non-realistic inclination, and another where the disc is truncated and the inclination is in agreement with that of the binary system and of the jet. This shows the need for using different techniques to break model degeneracies. In addition, the spectral analysis of MAXI J1820+070 revealed the possible presence of a spectrally stratified Comptonization region, which emission is reflected by two different zones of the cold disc in the hard state. Therefore, I used spectral-timing techniques to test a scenario of a spectrally stratified inner Comptonization zone, surrounded by a truncated cold accretion disc in MAXI J1820+070. This study showed that different variability components (likely originating at different distances from the black hole) have very different energy spectra. I found that these spectra can be modelled self-consistently, as combined emission from an outer Comptonization region fueled by the photons from the cold disc, and an inner Comptonization region fueled by the photons from the outer Comptonization region.

The main result of my project is that the hot flow responsible for the primary X-ray

emission in the hard state of BH X-ray binaries is consistent with being a spectrally stratified medium rather than a point-like compact source. Physically, this is likely due to a dependence of the optical depth and/or temperature of seed photons on the radial distance from the BH. The hot flow fills the inner regions of a cold accretion disc truncated at tens of gravitational radii away from the BH in the hard state.