Short Term Scientific Mission whithin COST Action MP1304 - report

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STSM Purpose

The purpose of my Short Term Scientific Mission to the Anton Pannekoek Institute for Astronomy (API) in Amsterdam with Dr. Philip Uttley (from the 10^{th} to the 24^{th} of November 2015) was to apply advanced cross spectral analysis techniques to simultaneous high time resolution X-ray and IR observations of the black hole transient GX 339-4. Mutiwavelength approaches to variability studies of black hole transients are permitting us to investigate the connection between the accretion disc, the hot inflow and the relativistic jet (Casella et al. 2010, Gandhi et al. 2010). Moreover X-ray spectral timing analysis is proving to be a very powerful tool to study the causal connection between the different components(Uttley et al 2014). So, looking at the correlation and the lags between the emission from different X-ray energies channels and the IR band can be a way to put new strong constrains on the physics and the geometry of the system.

Description of the work and main results

During my stay at the API I used and modified a python written software package which is being developed by the PhD student Abigail Stevens to perform spectral timing analysis of only X-ray event data: the routine calculates the energy dependent CCF, the X-ray and lag energy spectrum from the cross-spectrum. Most of my activity consisted learning to use the code and working with Abigail to help modify it so that it could be used to analyse IR observations. To test the code, a data set with $\approx$ 1 ks long, simultaneous high time resolution (62.5 ms) X-ray and IR observations of the black hole transient GX 339-4 was

used. The X-ray data was collected by PCA (2-60 keV) on the RXTE satellite, while IR data taken by the ISAAC (K_s band) instrument mounted on UT-1/Antu at ESO's Paranal Observatory. The power spectrum in both bands presented a QPO at 5 Hz. The CCF as a function of the energy showed that the QPO is stronger at higher energies, where the hot inflow dominates the emission. The X-ray lag energy spectrum was computed in the frequency range of the QPO using the IR as a reference band. The resulting spectrum was found to be approximately constant in the range between 2 and 20 keV, with no particular difference in shape from spectrum computed using X-rays as reference band. Moreover from the study of the coherence and of the phase lag, the two QPOs presented a high level of coherence (≈ 0.6) and a phase lag of π radians, so almost out of phase. Such result was interpreted with a scenario in which the hot inflow precesses together with jet, illuminating different parts of the disc as it does so. More and longer observations will help in the future to confirm this scenario and have a more detailed view of the geometry and the physics of the system.

Foreseen publications

The work done on the analysed data set represents a first step of a wider project that includes a systematic spectral-timing study of simultaneous multi-wavelength fast observations of the black hole transients and that will lead in the next year to at least one publication.

Future collaboration with host institution

I am going to continue a collaboration with the Anton Pannekoek Institute for Astronomy in Amsterdam with Dr. Philip Uttley and Abigail Stevens in order to broaden my knowledge on spectral-timing analysis techniques using simultaneous multiwavelength observations and to continue to give contributions to the code. In particular, I will also be able to act as a developer and experienced 'test user' for the full spectral-timing code, to enable improvements before a wider public release of the code.