Non-thermal particles in spectra and light-curves of Sco X-1

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Abstract

Fast and strongly variable optical emission of accreting neutron star binaries was thought to be originating from the reprocessing of the X-ray emission coming from the central regions in the outer parts of the accretion disc. This picture is supported by the temporal properties, where the optical light-curve is delayed with respect to the X-ray light-curve (Ilovaisky et al. 1980, Munoz-Darias et al. 2007). However, recent observations (Durant et al. 2011) show that this scenario is not always realized, and the optical/X-ray cross-correlation function shows a complex structure with the so-called precognition dip (anti-correlation), commonly seen in black hole binary systems (Kanbach et al. 2001). We show that the anti-correlation can be explained in the scenario where optical emission is partially produced by the synchrotron self-Compton mechanism in hybrid plasma (Veledina et al. 2011). This scenario is supported by the detected non-thermal MeV emission in Sco~X-1 (Revnivtsev 2014).

Observed and modelled spectra

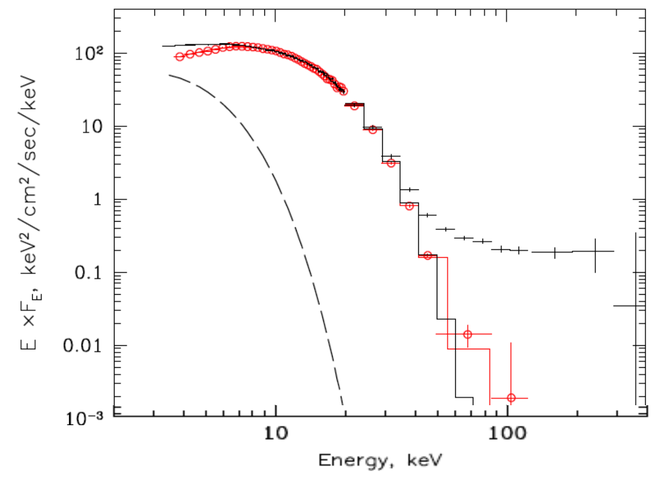


Figure 1. High-energy spectra of Sco X-1. The non-thermal tail is associated with the optically thick accretion disc component (dashed line). Pure spreading layer spectra (red crosses) are seen when neither disc no high-energy tail are present. From Revnivtsev et al. 2014.

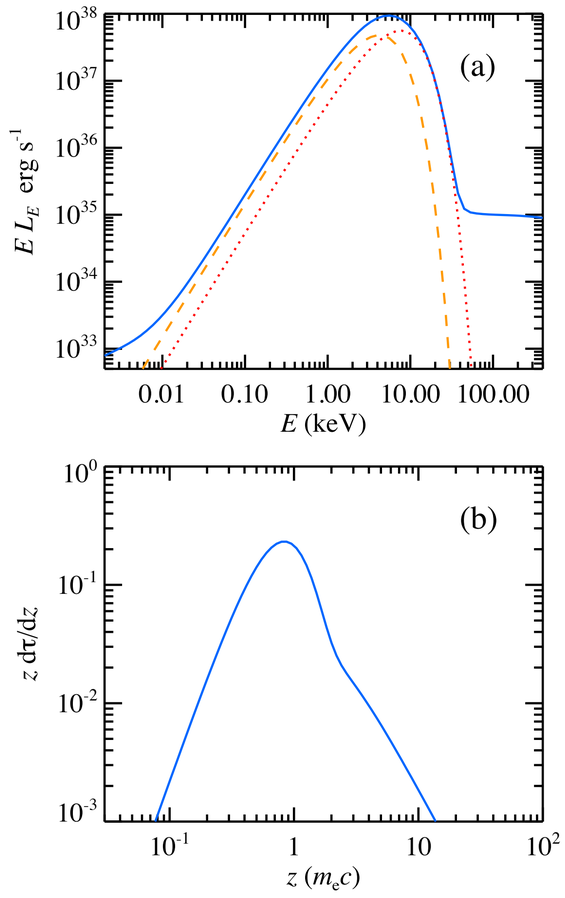
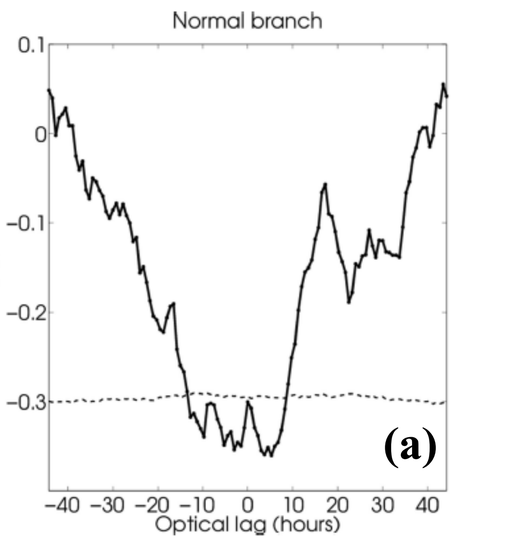
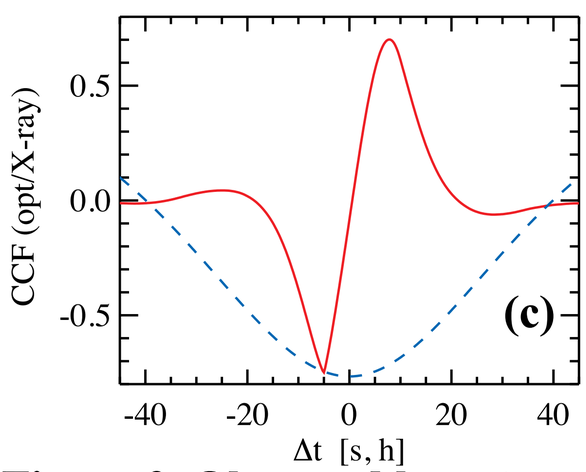


Figure 2. Emergent spectra (a) and electron distribution function in units of Thomson optical depth (b) of the hot medium close to the NS surface, calculated self-consistently. Both MeV (Compton up-scattered) and optical (synchrotron) emission are due to presence of non-thermal electrons seen as power-law tail above electron momenta z=3.

Timing properties





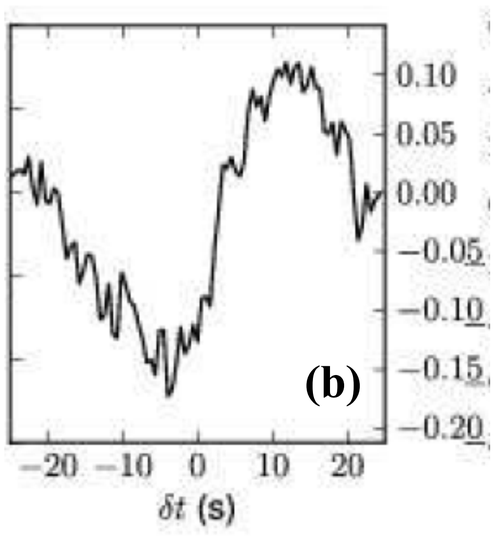


Figure 3. Observed long-term (a) and short-term (b) optical/X-ray cross-correlation functions and their theoretical modelling (c). Negative correlation is produced by synchrotron self-Compton mechanism (Veledina et al. 2011). Positive correlation seen at fast time-scales is due to additional presence of reprocessed component. Data from Scaringi et al. 2015 and Durant et al. 2011.