Sco X-1: the first LMXB observed with *Kepler*

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Scorpius X-1 (hereafter Sco X-1) is the brightest nonsolar persistent X-ray (1-10 keV) source in the sky (see Giacconi et al. 1962, PhysRevLet, 9, 439, for its discovery). It is the historical prototype of a class of binaries called low-mass X-ray binaries (LMXBs) and is a Z-source. LMXBs are interacting binary systems with a neutron star (NS) primary accreting material, via an accretion disk, from a low-mass secondary star. Plots of "hard" color against a "soft" color from some LMXBs usually form a Z shape (thus the Z-source name) that is traced on timescales of hours to days, with the three Z branches (from the top to the bottom of the Z) called the horizontal, normal, and flaring branches. The Fourier X-ray timing properties of Z sources display strong (up to 10%) quasi-periodic oscillations (QPOs) overlayed onto broad-band noise components (see e.g. Hasinger & van der Klis 1989, A&A, 225, 79). Up until now, the broad-band timing properties of LMXBs have only been studied at X-ray wavelengths, and long term X-ray/optical correlations for these systems have been extremely hard to quantify. The K2 observations during Campaign 2 will provide a unique opportunity to study the optical variability of the prototypical LMXB Sco X-1. As the accretion disks in LMXBs can reach close to the NS surface, they instrinsically display accretion-induced flickering variability on timescales ranging from seconds to hours. Monitoring Sco X-1 in long cadence (LC) mode would not allow us to study this timescale range approriatley, and we thus request short cadence (SC) data for this source.

In order to fully exploit this unprecedented opportunity to monitor Sco X-1 with SC data for 3 months, we are actively planning simultaneous multi-wavelength observations for this source during the Campaign 2 period. The X-ray daily monitoring will be obtained by the MAXI instrument on-board the International Space Station (ISS). This instrument already provides 3-color X-ray lightcurves for Sco X-1 as well as X-ray spectra, and additionally has the potential to provide photon event data. The MAXI data will be used in conjunction with the *Kepler* lightcurve to correlate the optical/X-ray variability as the source transitions between the Z-branches, and study changes in the variability power, search for optical high-frequency QPOs, and monitor X-ray/optical time-lags. Fig. 1 shows the up-to-date, 1-day, X-ray color-color and color-flux diagram for Sco X-1 obtained by MAXI, and demonstrates the clear power of this instrument to isolate different branches for this source.

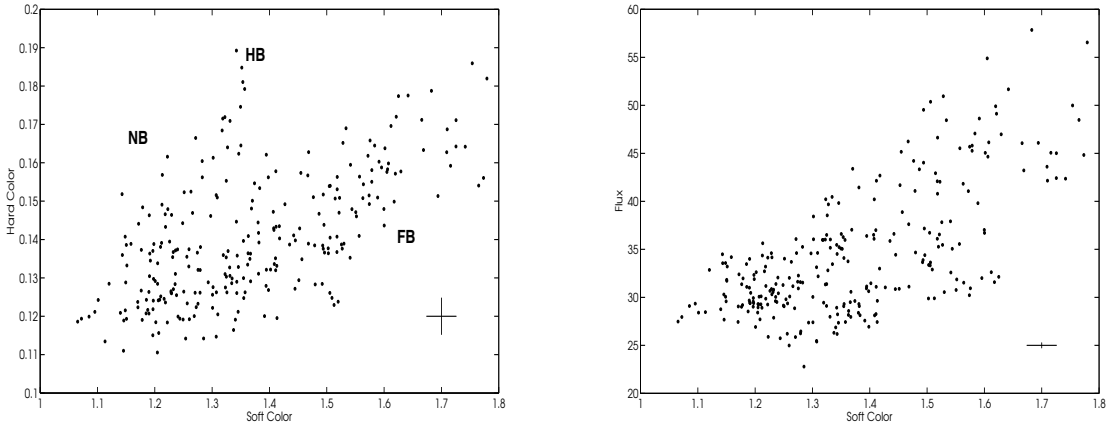

Figure 1: Left: X-ray color-color diagram for Sco X-1 obtained with MAXI during 3 months of observations with Horizonal, Normal and Flaring branches labelled. Right X-ray color-flux diagram for Sco X-1 obtained by MAXI during the same period. Typical errorbars displayed in the bottom-right of each panel. (Soft color = 4-10 / 2-4 keV, Hard Color = 10-20 /4-10 keV, Flux = 2-20 keV)

During Campaign 2, we will also monitor Sco X-1 with the high-resolution HERMES spectrograph mounted on the 1.2m Mercator telescope (La Palma, Spain) through already awarded telescope time. We plan to monitor Sco X-1 with HERMES on a daily basis during the first period of Campaign 2, and will additionally monitor the source more frequently in case it undergoes X-ray flares (which will be notified by the MAXI instrument lightcurves updated every 4 hours). We are also actively seeking to obtain radio follow-up observations with the Australia Telescope Compact Array (ATCA) and/or KAT-7 radio telescope array.

The simultaneous combination of optical/X-ray spectroscopy, X-ray timing, radio imaging together with the optical lightcurve obtained by *Kepler* will allow us to explore Z-source transition behavior in unprecedented detail. The *Kepler* observation of Sco X-1 will also provide an important long-lasting legacy lightcurve for the whole community studying accreting stellar-mass compact objects, since such a detailed lightcurve has never been possible to obtain before.