OPTICAL VARIABILITY OF THE ULTRALUMINOUS X-RAY SOURCE NGC1313 X-2

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Introduction

NGC 1313 X-2 is located in the barred spiral galaxy NGC 1313 at a distance of 3.7–4.27 Mpc. Its observed X-ray luminosity varies between a few x10^{39} erg/s and 3x10^{40} erg/s in the 0.3–10 keV band (Feng & Kaaret 2006; Mucciarelli et al. 2007). NGC 1313 X-2 has been studied extensively in the X-ray and optical bands. In fact, this is one of the few ULXs with a well established optical counterpart, that was identified through a chain of efforts (Zampieri et al. 2004; Mucciarelli et al. 2005, 2007; Pakull et al. 2006; Ramsey et al. 2006; Liu et al. 2007).

Recently, Liu et al. (2009) found a possible periodicity of 6.12 ± 0.16 days in the B band light curve of the optical counterpart of NGC 1313 X-2, that was interpreted as the orbital period of the binary system. Three cycles were detected in he B band, while no modulation was found in V. Previous studies carried out on the available HST and VLT observations led to negative results (Grise` et al. 2008). More recently, lack of significant photometric variability on a new sequence of VLT observations has been reported by Grise` et al. (2009).

Here we present a reanalysis of the joint VLT+FORS1 and HST+WFPC2 photometric observations of NGC 1313 X-2 obtained during 2007-2008.

References

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NGC1313 X-2 :VLT+FORS1 and HST+WFPC2 data

NGC 1313 X-2 was observed with VLT+FORS1 between October 2007 and March 2008 (11 epochs; Grise` et al. 2009), and with HST+WFPC2 between May and June 2008 (20 epochs; Liu et al. 2009). We re-analyzed the whole dataset in a homegeneous way, looking for the ~ 6 day periodicity reported by Liu et al. (2009).
After performing standard image reduction in the IRAF environment, the star magnitudes were measured using a PSF fitting technique. In order to minimize the effects of possible absolute calibration uncertainties, we decided to perform differential photometry with respect to a nearby field star (on the same chip), brighter than the target and with a low root mean square variability (0.02).
Figure 1 shows the B band light curve of NGC 1313 X-2 obtained in this way. There is clearly short term variability, likely due to X-ray irradiation. As can be seen from Figure 1, the VLT data have much smaller root mean square variability (~ 0.04 mag) than the HST ones (~ 0.1 mag), possibly because the source was in a state of lower activity between October 2007 and March 2008.
Overimposed on the short term stochastic variability, the HST+WFPC2 data show also an approximately sinusoidal modulation with a period of 6 days.
Fitting to all the VLT+HST dataset (31 observations), the period, amplitude and phase of the sinusoid turn out to be: P=6.0 ± 0.1 days, A= 0.09 ± 0.01 mag, Φ = 57°± 11°.
These values are in agreement with those reported by Liu et al. (2009). Although the VLT data alone do not show evidence of periodicity, they appear to be consistent with the sinusoidal modulationof the HST observations. This is confirmed by the agreement of the phase obtained from the best fitting sinusoid of the HST data alone versus that from the whole VLT+HST dataset (see Figure 2).
We reanalyzed also the V band HST+WFPC2 images and found no significant periodic variability.

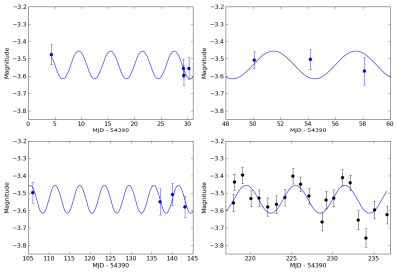

Figure 1: Joint VLT+HST light curve of NGC 1313 X-2 in the B band. The blue circles are the VLT+FORS1 data, while the black ones represent the HST+WFPC2 observations. The magnitudes are the difference with those of a reference field star. The data cover a period of almost 9 months. The blue line is the best fitting sinusoid with a period P = 6.0 ± 0.1 days.

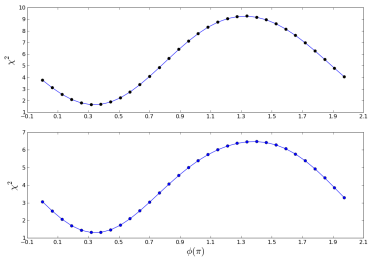

Figure 2: Reduced chi-square versus phase obtained from the best fit with a sinuosoid of the HST data alone (top) and the joint VLT+HST dataset (bottom).

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If the B band modulation is caused mostly by X-ray irradiation, its amplitude is expected to be smaller in the V band.
In fact, we found that a sinusoidal modulation with an amplitude up to ~0.06 mag is consistent, within the errors, with the data
The statistical significance of the B band modulation was tested performing a Lomb-Scargle periodogram analysis of all the observations. We found that the modulation is significant only at the ~3 sigma level.
Binning the light curve in 6 bin intervals and performing an epoch folding period search, the 6 days modulation is recovered with a significance slightly larger than 3 sigma (see Figure 3). Although the binned light curve suggets that the periodicity may be there, the low statistical significance of the B band modulation, along with the lack of detection in the V band, make its identification uncertain.
Further measurements are needed to confirm it.

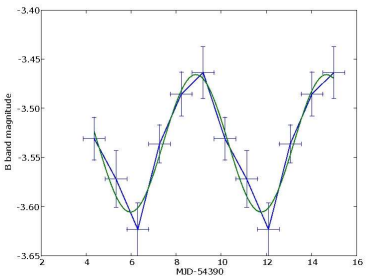

Figure 3: Binned light curve (6 bins) of the joint VLT+HST dataset of NGC 1313 X-2, folded over the best estimate of the period. The best fitting sinusoid is also shown.