Updated orbital ephemeris of the ADC source X 1822-371: a stable orbital expansion over 40 years

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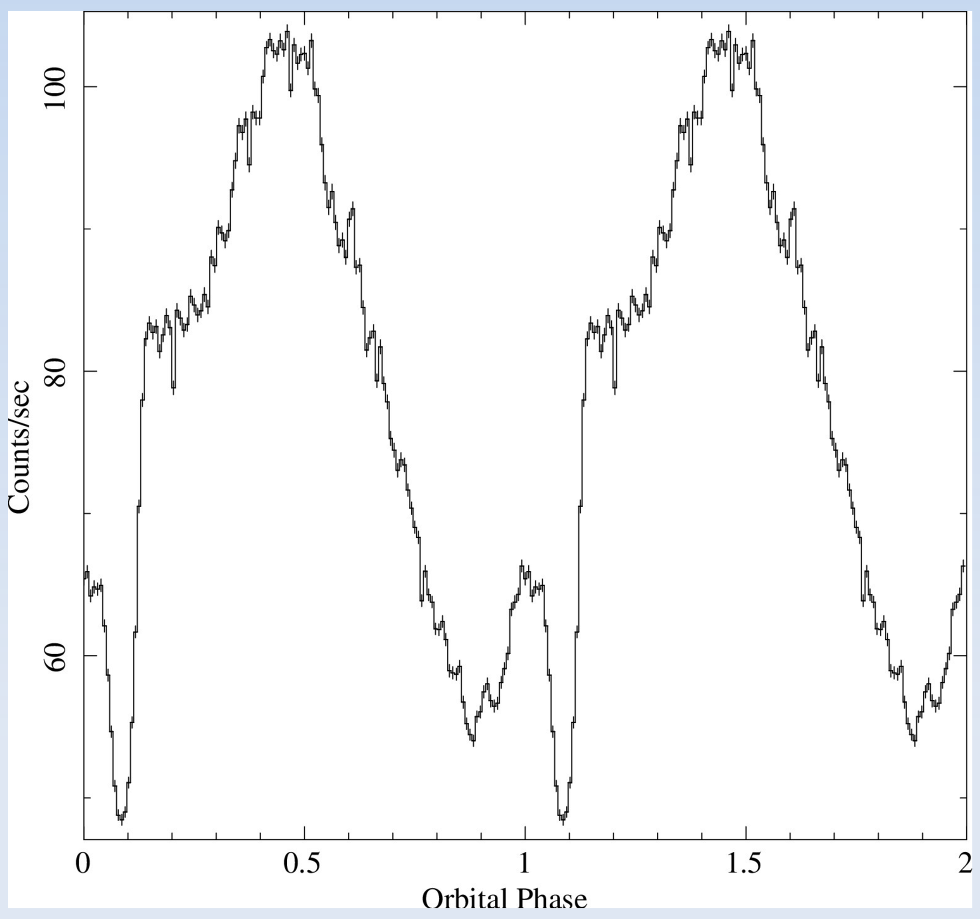
Abstract

The source X 1822-371 is an eclipsing compact binary system with a period close to 5.57 h and an orbital period derivative $\dot{P}_{orb}$ of $1.51(7)\times10^{-10}$ s s^{-1}. The very high value of $\dot{P}_{orb}$ is compatible with a super-Eddington mass transfer rate from the companion star, as suggested by X-ray and optical data. The XMM-Newton observation taken in 2017 allowed us to update the orbital ephemeris and verify whether the orbital period derivative has been stable over the past 40 yr.

Analysis method



We added two new values obtained from the Rossi-XTE (RXTE) and XMM-Newton observations performed in 2011 and 2017, respectively, to the X-ray eclipse arrival times from 1977 to 2008. We estimated the number of orbital cycles and the delays of our eclipse arrival times spanning 40 yr, using as reference time the eclipse arrival time obtained from the RXTE observation taken in 1996, for a total of 32 points.

Fig. XMM-Newton/Epn folded orbital light curve obtained by adopting a period of 0.2321107 days. The period is divided into 128 bins.

Results and Conclusions

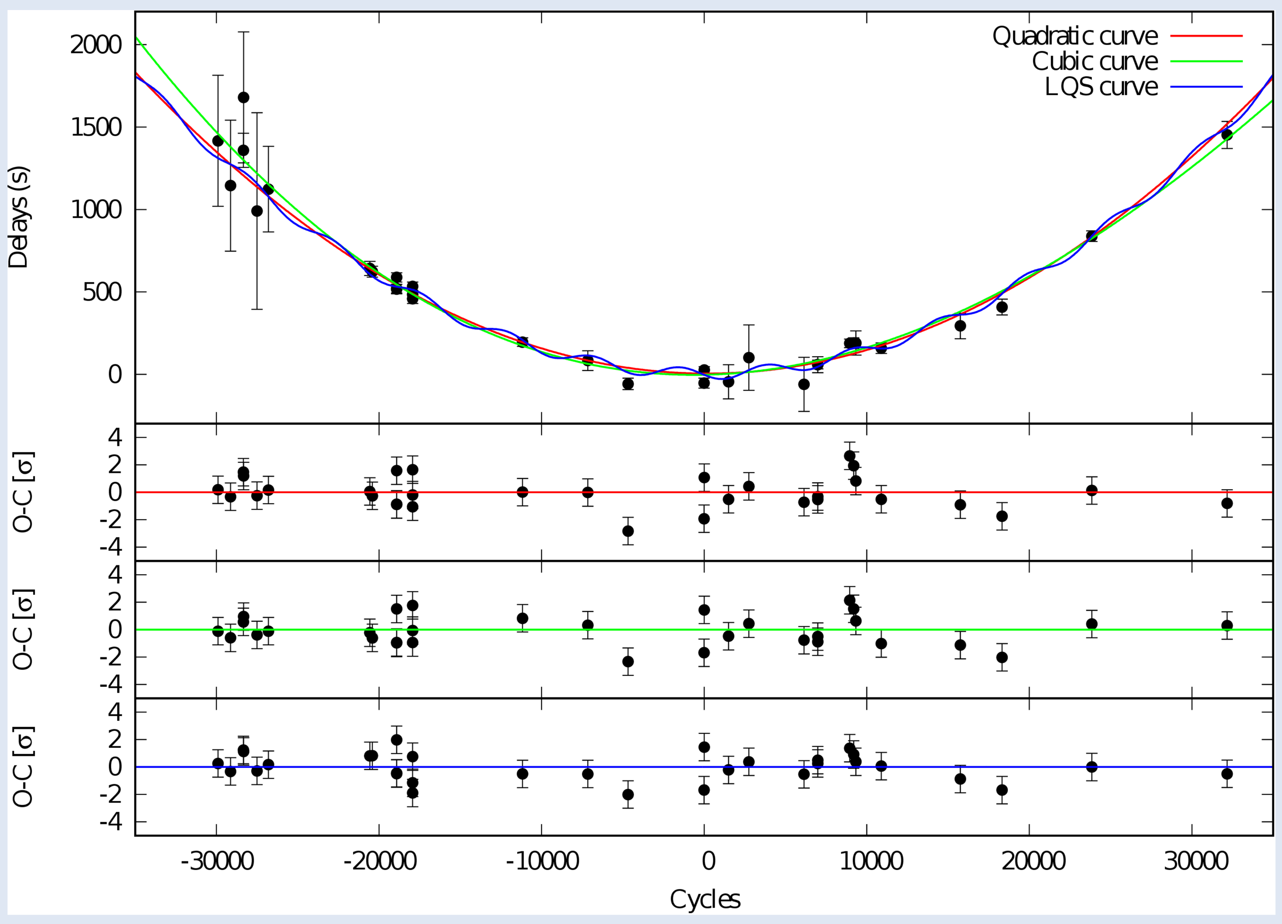


Fig. Delays vs. cycles for the quadratic (red), cubic (green), and LQS (blue) model. Residuals are in units of σ obtained by adopting the quadratic, cubic, and LQS model, respectively.

We fitted the delays as function of cycles adopting a quadratic model, obtaining P_{orb}=5.57062957(20) h and a $\dot{P}_{orb}$ value of $1.475(54)\times10^{-10}$ s s^{-1}. The addition of a cubic term to the model does not significantly improve the fit quality.

We also verified whether a gravitational quadrupole coupling produced by tidal dissipation could be detectable in our data. To this aim, we substituted the quadratic term with a sinusoidal one in our model and then we added a quadratic term also (LQS model). However, the improvement of the fit was at a confidence of about 2σ with respect to the quadratic model.

Finally, we searched for the NS spin frequency in the XMM-Newton/Epn data, determining a spin-period value of P_{spin}=0.5915669(4) s and its first derivative $\dot{P}_{spin}$=$-2.595(11)\times10^{-12}$ s s^{-1}.

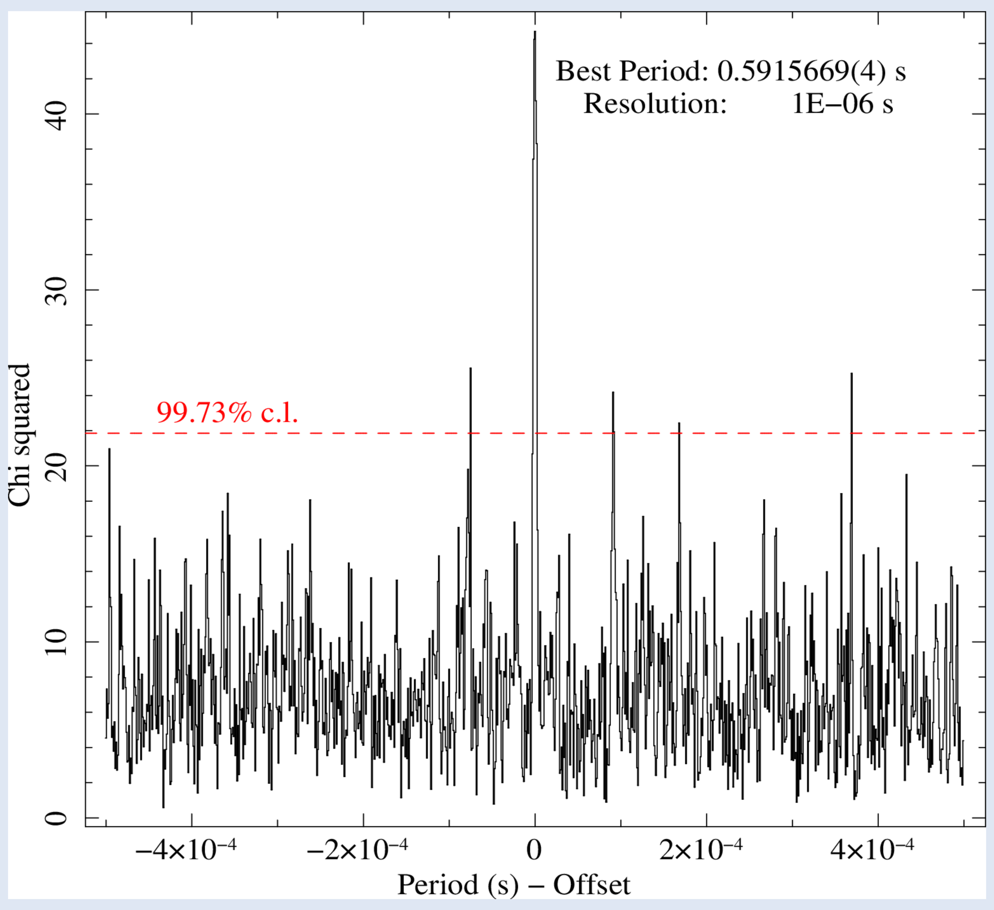


Fig. Folding search for periodicity in the 5-12 keV XMM-Newton/Epn light curve.

Our results confirm the scenario of a super-Eddington mass transfer rate; we also exclude a gravitational coupling between the orbit and the change in the oblateness of the companion star triggered by the nuclear luminosity of the companion star.

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