On the photometric study of the cataclysmic variable IGR J17014-4306

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Introduction

IGR J17014-4306 (=Nova Scorpii AD 1437) is a deep eclipsing cataclysmic variable system with a nova outburst ∼580 years ago reported by Korean Royal astronomers (Shara et al. 2017). The binary system is classified as an intermediate polar (IP), (Masetti et al. 2013, Bernardini et al. 2017) due to its pulsating X-ray emission. With an orbital period of P ∼12.8 hours, IGR J17014-4306 is the longest orbital period eclipsing IP known to date, lying in the uppermost limit of the cataclysmic variables period distribution (Warner 2003). VVV Survey observations of IGR J17014-4306 were taken during 2010 to 2013, therefore, allowing us to study its variability in the near-IR.

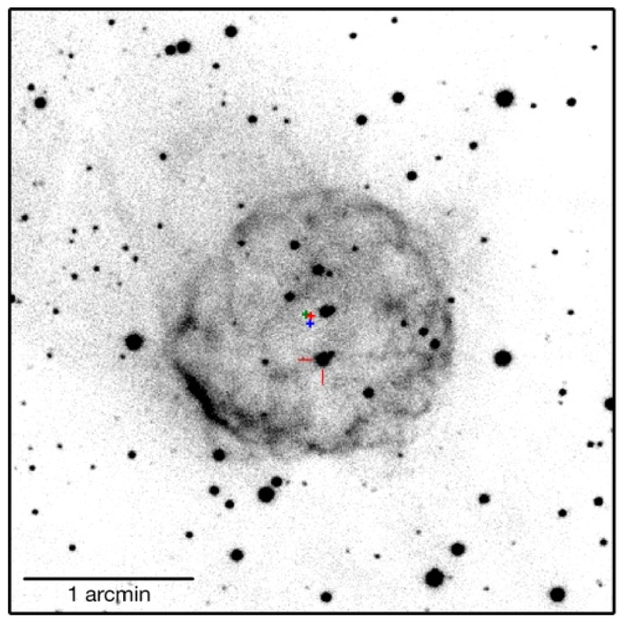

Fig. 1: On the left, the picture shows a Hα image of the classical nova from AD 1437 (Shara et al. (2017)). The top and the bottom panels compare optical (top, from DSS2) and near-IR picture (bottom, from VVV Survey) in the region of the nebulae. The current position of IGR J17014-4306 is indicated red tick marks, while the blue ticks marks show the location of the nova explosion in the early 15^{th} century (Shara et al. 2017).

Near-IR data analysis

To confirm the orbital period of IGR J17014-4306, we performed a period analysis with the Lomb-Scargle periodogram method, from VanderPlas & Ivezić (2015). It was implemented in Python language, which performs a parametric fit based on Fourier-like Power Spectrum Density (PSD) to detect the sinusoidal periodic component in an unevenly-sampled data-set. We applied an optimisation period range from 0.1 to 1.0 days on VVV Ks-band variability campaign where resulted in a significant power peak at P_{mod} = 0.26702 ± 0.0001 days (P_{mod} = 6.4 hours.), fully consistent within <1 s with half of the orbital period according to Bernardini et al. (2017). Also, a periodicity search based on the maximisation of Euclidean Mutual Information with the P4J package implemented in Python, confirmed the modulation period as P_{mod} = 6.4 hrs.

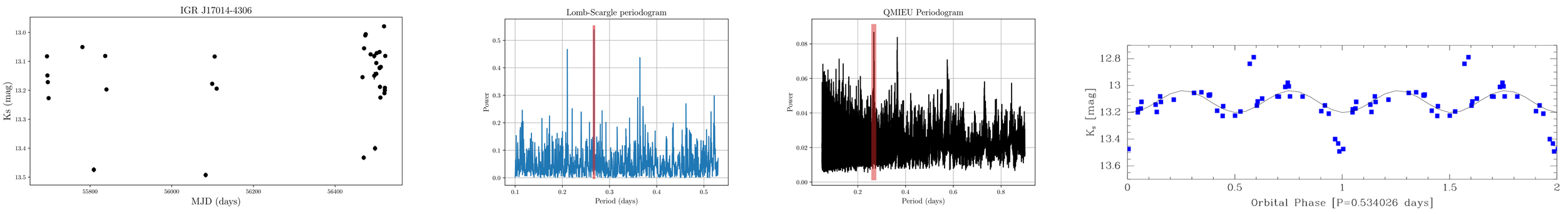

Fig. 2: The leftmost panel shows the VVV Ks-band light curve of IGR J17014-4306 with 40 epochs taken during 2010 and 2013. The periodograms performed with the Lomb-Scargle method and the P4J package are shown in middle panels, respectively. Both show a significant peak about 0.26702 days, with a difference of about 3.05×10^{-6} days between them. The resultant period calculated with the Lomb-Scargle method was used to fit the phased light curve as seen on the rightmost panel.

Discussion and further perspectives

Our analysis shows ellipsoidal variations in the Ks-band light curve of IGR J17014-4396, therefore, making it a prime target for tomographic studies of the donor, distorted secondary star. The calculated period for the ellipsoidal variation as P_{mod} = 0.26702 ± 0.00001 days (=P_{orb}/2) confirmes IGR J17014-4306 as the eclipsing IP with the longest orbital period known to date. There are only two IPs with orbital period longer than IGR J17041-4306: GK Persei (P_{orb} = 47.9 hours) and 1RXS J173021.5-055933 (P_{orb} = 15.42 hours), however, both are not eclipsing binaries (Potter et al. 2018).

From the stellar variability data obtained by VVV Survey, we demonstrate that both Fourier-like power spectrum based Lomb-Scargle periodogram method and the Euclidean Mutual Information P4J package, both implemented with Python language, were effective to determine the periodic sinusoidal component from unevenly-sampled data-set. As next steps, we may be able to apply those methods with the same objective throughout the area observed by VVV Survey and posterior the observed area by VVVX Survey.

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