Various variability phenomena observed in the binary star DQ Tau

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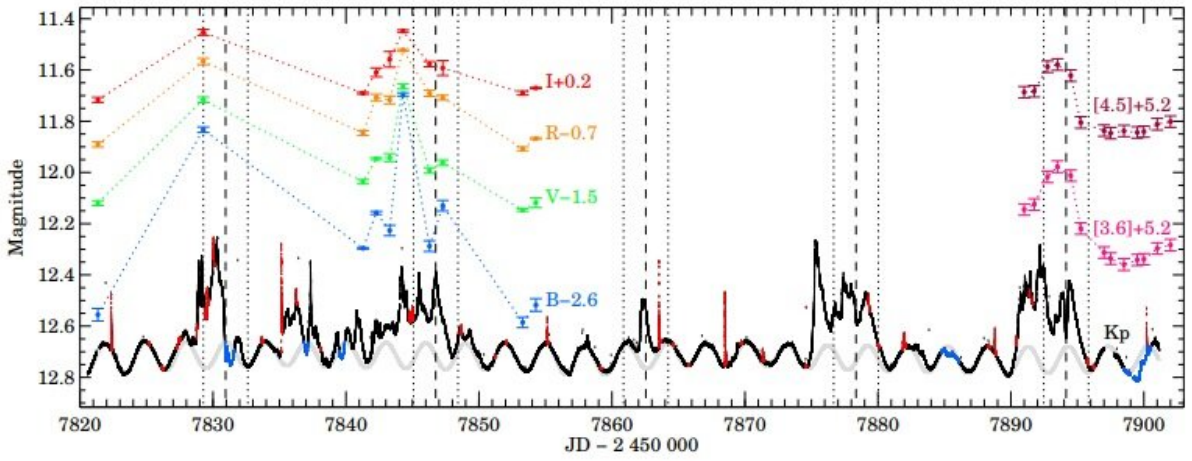

Light curves of DQ Tau at different wavelengths. Credit: Kóspál et al., 2020.

Hungarian astronomers have observed a pre-main sequence (PMS) binary star known as DQ Tau using a set of space telescopes and ground-based facilities, finding numerous variability phenomena in this system, including energetic stellar flares. The findings are detailed in a paper published February 11 on arXiv.org.

Studies indicate that PMS stars seem to be strongly linked with their circumstellar environment, which causes variability observed at a wide range of wavelengths and timescales. For instance, such behavior may be caused by stellar flares, variable accretion, as well as rotational modulation due to hot or cold stellar spots.

Located some 640 light years away, DQ Tau is a low-mass PMS spectroscopic binary consisting of two almost identical stars with masses of around 0.6 solar masses each. The system has a period of approximately 15.8 days and its components are separated by about 0.13 AU from each other.

Previous observations have shown that DQ Tau has a circumbinary protoplanetary disk from which gas and dust are accreting onto both stars. The binary exhibits quasi-periodic optical variability due to pulsed accretion, as well as millimeter flares and elevated X-ray activity due to a combination of magnetic and dynamic effects.

A team of astronomers led by Ágnes Kóspál of Konkoly Observatory in Budapest, Hungary, have analyzed light curves of DQ Tau in order to get more insight into the system's observed variability. The data for the analysis was provided mainly by NASA's repurposed Kepler mission, known as K2, NASA's Spitzer Space Telescope, and ground-based observatories. K2 has so far provided high-precision photometry for many young stars, aiding scientists in the search for young stellar variability.

"We analyzed DQ Tau's light curves obtained by Kepler K2, the Spitzer Space Telescope and ground-based facilities," the astronomers wrote in the paper.

In general, the monitoring campaign of DQ Tau revealed such variability phenomena as rotational modulation by stellar spots and energetic stellar

flares. The observations also recorded brightening events around periastron due to increased accretion and short dips due to temporary circumstellar obscuration.

In particular, the data revealed three stellar spots that are 400K cooler than the stellar photosphere, and together cover about 50 percent of the stellar surface. The data from K2 mission indicate strong periodicity of approximately 3.017 days, which is consistent with the stellar rotational period.

Furthermore, the observations detected 40 short, flare-like brightening events occurring randomly, and lasting between 100 and 200 minutes. The energy released in the flares was measured at between 0.44 and 120 decillion erg, which is typical for young low-mass stars. According to the astronomers, the results suggest that these events are single-star flares happening just above the stellar surface rather than between the two companion stars.

Complex brightening events clustered around the periastrons were also identified in DQ Tau. The researchers assume that they are caused by increased accretion rate.

"This can be explained by pulsed accretion: The stars gravitationally perturb the inner edge of the circumbinary disk during each apoapsis passage and pull some material from the disk that eventually lands on the binary components," the scientists explained.

The study also found that DQ Tau shows short dips of below 0.1 mag in its light curve. This behavior resembles the so-called "dipper phenomenon" observed in many low-mass young stars. Such dips could be caused by dusty material lifted up from the inner edge of the disk.

More information: Spots, flares, accretion, and obscuration in the pre-

main sequence binary DQ Tau, arXiv:2002.05662: [astro-ph.SR]
arxiv.org/abs/2002.05662