Pulsed accretion in pre-main sequence spectroscopic binaries

Á. Kóspál[1], **P. Ábrahám**[2], **A. Moór**[2], **R. Szabó**[2]
[1]European Space Agency (ESA/ESTEC), Noordwijk, The Netherlands
[2]Konkoly Observatory, Budapest, Hungary

Context. Accretion is a fundamental process during the formation of Sun-like stars: in addition to building up the stellar mass, it also shapes the temperature and density structure of the circumstellar disk, thus setting the initial conditions for planet formation. Accretion is time variable, and its fluctuations are responsible for an important fraction of photometric variations in young stars (Herbst et al. 1994).

Pulsed Accretion. A special, recently identified case of variable accretion can be observed in close binaries. Both calculations and observations show that the presence of a companion does not completely prevent mass accretion from the circumbinary disk onto the stars (Carr et al. 2001, Beck et al. 2012, Stempels & Gahm 2004). Numerical simulations by Artymowicz & Lubow (1996) predict **pulsed accretion** in such systems: the accretion rate varies in time with the same period as the binary orbital period. The optical light curves of the T Tauri binary DQ Tau revealed a distinctive brightening close to periastron, which Mathieu et al. (1997) attributed to increased accretion. Jensen et al. (2007) discovered a similar phenomenon in the T Tauri binary UZ Tau E. Pulsed accretion in DQ Tau and UZ Tau E was extensively studied by our group as well (Salter, Kóspál, et al. 2010; Kóspál et al. 2011). Another promising candidate for pulsed accretion is the young eruptive system EX Lup, where our group discovered a probable brown dwarf companion (Kóspál et al. 2014).

Our targets. The study of pre-main sequence binaries is a relatively young field, due in large part to the difficult and time-consuming nature of spectroscopic observations, and sometimes further impeded by a complicated circumstellar environment. To date, orbital parameters have been published for only a few dozen young spectroscopic binaries (SBs). Out of these, six systems fall on the Kepler silicon in the K2 Campaign 2. **V1154 Sco** is a hierarchical triple, consisting of a K5-type SB with a period of 2.42 days and a tertiary component located at $0\farcs29$ separation (Prato et al. 2002). The primary is $1.0\,M_\odot$, the secondary is $0.63\,M_\odot$, and they are on a circular orbit due to the short period. **V1001 Sco** is a K1-type SB with masses of $1.2\,M_\odot$ and $0.22\,M_\odot$, and a period of 10.4 days (Prato et al. 2002) on a slightly eccentric orbit (e=0.17). **ROXR1 14** is an M1-type SB with almost equal masses for the components (the mass ratio is q=0.97, Rosero et al. 2011). The period is 5.72 days, the eccentricity is 0.02. **RX J1622.7−2325Nw** is the SB component of the hierarchical quadruple system identified by Prato (2007). The western component (Nw) is separated by $\sim1''$ from the eastern one (Ne), which itself is a visual binary ($\sim0\farcs1$). RX J1622.7−2325Nw is an equal-mass binary with a period od 3.23 days, eccentricity of 0.30, and spectral type of M1 (Rosero et al. 2011). It is the shortest-period high-eccentricity pre-main sequence SB known to date. **V866 Sco** (also known as AS 205) is a hierarchical triple system with a separation of $1\farcs32$ (Ghez et al. 1993). The secondary component itself is an SB with spectral types of K7 and M0 and masses of 0.74 and $0.54 M_\odot$. **V1151 Sco** is an M3-type SB with a 16.93 days period and eccentricity of 0.1 (Mathieu 1994).

Immediate objectives. As evidenced by H_α emission, our targets show signs of active accretion. We propose to use this unique opportunity to study the accretion process in these binaries and look for pulsed accretion.

- We will execute period analysis on the Kepler light curves for our six targets and compare the significant periods found with the known rotational period of the stars and the known orbital period of the binary components. Kepler's high cadence, high precision, and 80-day-long uninterrupted monitoring will enable us to *separate brightness variations of different origins, such as rotational modulation and variable accretion linked with the binary orbit.*
- We will select candidates for pulsed accretion, compare their properties to other systems known to undergo pulsed accretion, and compare their phased light curves with the Artymowicz & Lubow model. This model predicts that the contrast between apocenter and pericenter brightness is higher with higher mass ratio. The light curves are also expected to show a maximum shortly before pericenter passage, but only for highly eccentric binaries. The maximum occurs at earlier phases for less eccentric systems. Considering the wide parameter range our sample covers in period, eccentricity, and mass ratio, *the proposed program will provide the first obervational proof for the predictions of the Artymowicz & Lubow model.*

Why Kepler? The relatively short period (2–17 days) of our targets means that during the Kepler campaign, we could cover several orbital periods. This is indispensable, because accretion pulses do not happen in each periastron. The 80-day-long Kepler campaign will provide uniquely long and precise light curves, enabling us to determine how frequent and how ubiquitous pulsed accretion is, for a sample twice as large as the currently known pulsed accretors.

References: Artymowicz & Lubow 1996, ApJ 467, L77 • Beck et al. 2012, ApJ 754, 72 • Carr et al. 2001, ApJ 551, 454 • Ghez e al. 1993, AJ 106, 2005 • Herbst et al. 1994, AJ 108, 1906 • Jensen et al. 2007, AJ 134, 241 • Kóspál et al. 2011, A&A 527, A96 • Kóspál et al. 2014, A&A 561, A61 • Mathieu 1994, ARA&A 32, 465 • Mathieu et al. 1997, AJ 113, 1841 • Prato 2007, ApJ 657, 338 • Prato et al. 2002, ApJ 569, 863 • Rosero et al. 2011, AJ 141, 13 • Salter, Kóspál, et al. 2010, 521, A32 • Stempels & Gahm 2004, A&A 421, 1159