Radial velocity variations in EX Lup: hints for a low-mass close companion

Á. Kóspál1, M. Mohler-Fischer2, A. Sicilia-Aguilar3, P. Abraham4, M. Curé2, Th. Henning2, Cs. Kiss1, R. Launhardt5, A. Moór6, A. Müller6

1ESO, Netherlands 2Max-Planck-Institut für Astronomie, Germany 3Universidad Autónoma de Madrid, Spain 4Konkoly Observatory, Hungary 5Universidad de Valparaíso, Chile 6ESO, Chile

Abstract

EXors are low-mass pre-main sequence objects producing repetitive optical outbursts attributed to highly enhanced accretion from the circumbinary disk onto the star. One type of outburst theories requires a close stellar or sub-stellar companion that perturbs the inner part of the disk and triggers the onset of the enhanced accretion. Here, we look for a possible companion to EX Lup, the prototype of the EXor class, using radial velocity (RV) observations. The RVs show large periodic variations that can be explained by the presence of a close companion in the brown dwarf mass range. Chromospheric activity or starspots are less likely to explain the observed RV curve.

Exors

- Low-mass pre-main sequence objects, characterized by repetitive optical outbursts of 1–5 mag, lasting for a few months–few years.
- The outburst is due to enhanced accretion from the inner circumstellar disk (within 0.1 AU) to the star (Herbig 1977, 2008).
- The episodes of highly increased accretion may contribute to the build-up of the final stellar mass.
- The origin of outbursts is still highly debated. Certain outburst theories involve a close stellar or sub-stellar companion that perturbs the disk and triggers the onset of the enhanced accretion.
- The actual physical process could be thermal instability induced by density perturbations due to, e.g., a massive planet in the disk (Lodato & Clarke 2010) or tidal effects from close companions (Bonnell & Bastien 1992).

Motivation

- Do all EXors have companions?
- There are known examples:
  - UZ Tau E (spectroscopic binary, Jensen et al. 2007)
  - YY Tau (separation: 0.66′′, Leinert et al. 1990).
- The triggering mechanism requires a companion that perturbs the inner part of the disk, typically in a few tenths of an AU (radial velocity (RV) methods) are best suited to find such companions.
- Most EXors have never been searched for RV companions, mostly due to the difficulty of measuring RV in young, chromospherically active and/or actively accreting stars.
- Here, we study EX Lup, the prototype of the EXor class, using RV and photometric data.

Companion candidate

- Significant, periodic RV variations (see figure).
- RV phase and amplitude stable for at least 4 years.
- RV curve can be explained by a companion on an eccentric orbit.
- See table for parameters of Keplerian orbital solution.
- 14.7 ± 0.7 × 10^{-1} AU, for a semi-major axis of 3.6 ± 0.5 AU with the Spitzer Space Telescope.

Our attempt to simultaneously reproduce the RV variations and the light curves with a spot model was not successful:

- EX Lup is a slow rotator: v sin i = 3 km s^{-1}.
- Large spots (covering a whole hemisphere) are needed to reproduce the observed RV semi-amplitude of 2.2 km s^{-1} but these would over-estimate photometric variations.
- Spots that would reproduce the observed photometric light curves would significantly under-estimate the RV amplitude.

Conclusion: it is unlikely that the RV variations of EX Lup are caused by hot or cold stellar spots.

References


Our EX Lup papers

1. Sacco et al.: EX Lup in quiescence (2009), A&A 507, 861
2. Abrahám et al.: Episodic formation of cometary material in the outburst of a young Sun-like star (2009), Nature 459, 224

Contact

Áges Kóspál
KONP, 192045 Noordwijk
The Netherlands
Phone: +31 71 545 5966
E-mail: akg@eso.org
Web: http://www.eso.org/Imp/Staff/akospal

EXor/EXor-Tec
Kepplerian 1
2200AGNoordwijk
The Netherlands
Phone: +31 71 545 5966
E-mail: akospal@eso.org
Web: http://www.eso.org/Imp/Staff/akospal