Disk structure and dynamics in intermediate-mass Herbig Ae stars

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Herbig Ae stars are intermediate-mass pre-main sequence stars surrounded by proto-planetary accretion disks, which feed the forming star and become the birthplace of planetary systems. According to the current paradigm, the physics of the circumstellar disks as well as of the planet formation process around Herbig stars is the same as around the lower mass T Tauri stars. The typically bright and well-resolved Herbig systems are prime targets for the new generation interferometers (e.g. ALMA, VLT/MATISSE), and their detailed study is a promising way to better understand the formation of the Solar System.

Variability. One fundamental, but observationally almost unexplored aspect of disk physics is dynamics, which can be characterised via measurements in the time domain. With its ultra-high precision, Kepler will be able to study the optical variability of Herbig Ae stars in unprecedented details. These objects are still accreting matter from the circumstellar disk onto the star, and we expect variability related to the fluctuations of the accretion rate on the dynamic timescale of the inner disk (few days – months). The rotation of the hot accretion spots on the stellar surface can also cause a periodic signal, on a typical timescale of a few days. A commonly observed additional reason of variability in Herbig stars is the UXor-phenomenon, the passing of circumstellar dust clumps in the inner disk in front of the star, typically also on a daily–weekly timescale.

Targets. In the Campaign 2 field of the K2 mission, there are three Herbig Ae stars. **HD 142666** (V1026 Sco) is a bright, A8Ve type star in the Sco-Cen star forming region, at a distance of $\sim$145 pc (Acke et al., 2005). It is surrounded by a gas rich primordial disk, from which the star is actively accreting material (Meeus et al. 1998, Mendigutía et al. 2012). HD 142666 displays large photometric variations with a visual amplitude of about 1.2 mag (Malfait et al. 1998), probably due to variable dust extinction in a close to edge-on disk with clumpy dust distribution (UXor-phenomenon). Using the MOST satellite, Zwintz et al. (2009) also found irregular UXor-type variations with an amplitude as high as $\sim$1 mag. Additionally, they discovered δ Scuti-type periodic variability, and attributed 12 frequencies to pulsation (5.7 – 28 d^{-1}). Studying mid-infrared spectra of HD 142666, our group argued that it changes its brightness at these wavelengths, too (Kóspál et al. 2012). **HD 145718** (V718 Sco) is a Herbig Ae star with a spectral type of A8Ve. At a distance of $\sim$117 pc, it is one of the nearest known Herbig star. It belongs to the 11$\pm$2 Myr old Upper Sco association (de Zeeuw et al. 1999, Pecaut et al., 2012). It harbors a gas rich primordial disk (Dent et al. 2005) viewed at an inclination of $<30°$ (Moór et al., in prep.). HD 145718 exhibits signatures of active accretion in Balmer lines (Guimarães et al. 2006). Using ASAS data, David et al. (2013) identified irregular variations with amplitudes as high as 0.6 mag, which can be attributed to the UXor phenomenon. Remarkably, Sahade & Davila (1963) listed this system as an eclipsing binary, with an approximate period of 2(?) days. If confirmed, HD 145718 is one of the rare pre-main sequence eclipsing binaries, used to test and validate pre-main sequence evolutionary models. **WL 16** is a single B8-A7 Herbig star (Simon et al. 1995; Ratzka et al. 2005) that belongs to the 0.3-3 Myr old nearby ($\sim$130 pc) ρ Oph star forming region (Wilking et al. 2008). Images at different mid-IR wavelengths between 7.9 and 24.5μm published by Ressler & Barsony (2003) revealed that the central star is surrounded by a bright disk with a size of 7$\times$3.5 arcsec (corresponding to a disk diameter of 900 AU), viewed at an inclination of $\sim$63°.

Immediate objectives. Using Kepler in long cadence mode, we will monitor brightness variations in the proposed Herbig Ae systems, by determining typical timescales, variability patterns, and fluctuation amplitudes.

1. Utilizing the long temporal coverage, we will characterise fluctuations of the accretion rate, and we will link the deduced timescales to the acting dynamical processes in the inner disk.
2. The ultra-precise monitoring of UXor eclipses will provide high resolution data on the small-scale structure of the circumstellar disk, enabling us for the first time to characterize internal density inhomogeneities.
3. HD 142666 will be analysed for δ Scuti-type variability. The results will allow us to determine the internal structure and fundamental physical parameters of the star. In order to cover the highest frequencies, here we request preferentially short cadence data. The hypothetical eclipses of HD 145718 will be checked, and used to determine precise stellar parameters, and test evolutionary models.

References Acke et al. 2005, A&A, 436, 209 • David et al. 2005, A&A, 557, 47 • Dent et al. 2005, MNRAS, 359, 663 • Guimarães et al. 2006, A&A, 457, 581 • Kóspál et al. 2012, ApJS, 201, 11 • Malfait et al. 1998, A&A, 331, 211 • Meeus et al. 1998, A&A, 329, 131 • Mendigutía et al. 2012, A&A, 543A, 59 • Pecaut et al., 2012, ApJ 746, 154 • Ratzka et al. 2005, A&A, 437, 611 • Ressler & Barsony 2003, ApJ, 584, 832 • Sahade & Davila 1963, Annales d'Astrophysique, 26, 153 • Simon et al. 1995, ApJ, 443, 625 • Wilking et al. 2008, Handbook of Star Forming Regions, Volume II, 351, ed. Reipurth, B. • de Zeeuw et al. 1999, AJ, 117, 354 • Zwintz et al. 2009, A&A, 494, 1031