Rotation of young brown dwarfs

Aleks Scholz (St Andrews), Paul Dawson (DIAS), Kora Muzic (ESO), Ray Jayawardhana (Toronto)

We propose to use K2 to measure rotation periods of young brown dwarfs.

Stellar rotation is a fundamental parameter in the formation and evolution of stars and planets. Young stars with ages $< 100\,$Myr have much lower specific angular momentum than the cloud cores from which they have formed, indicating that efficient rotational braking occurs in the first few million years (Herbst et al. 2007). It is now generally accepted that the interactions between star and its accretion disk play a crucial role for the angular momentum regulation, but the precise mechanism for the rotational braking is still poorly understood. The traditional idea of disk-locking is not efficient enough to explain the observed rotation rates (Matt et al. 2010); alternative ideas, for example accretion powered stellar winds (Matt et al. 2012) are debated as well. Understanding the angular momentum regulation in young stars has implications for the evolution of disks, for the physics of accretion and winds, as well as for the initial conditions for planet formation (see Bouvier et al. 2013).

The population of young brown dwarfs constitutes a crucial test case in this context. With masses 1-2 orders of magnitude lower than the Sun, brown dwarfs allow us to probe the mass dependence of rotational regulation. Since magnetic field generation and accretion are a function of mass, we expect to see a significant difference in the rotation as well. All star formation regions form brown dwarfs, around 2-5 per 10 stars (Scholz et al. 2013). Although dozens of young brown dwarfs have been discovered over the past years, by our SONYC survey and other projects, their physical properties are still poorly known. The only notable samples of rotation periods for young brown dwarfs have been published for clusters in Orion, by members of our group (Scholz et al. 2004, 2005) and others (Cody et al. 2010, Rodriguez-Ledesma et al. 2009). All these clusters are quite distant ($> 400\,$pc), which limits the potential for follow-up. Most of the ~ 150 young substellar objects with periods are not confirmed spectroscopically. The link between rotation, disk, accretion, and winds is very difficult to investigate with the current sample. As a result, the published studies give conflicting results regarding the efficiency of disk braking in brown dwarfs (see Scholz 2013).

Kepler-2 now provides a unique opportunity to drastically improve the observational foundation for this type of work. In campaign 2, the telescope pointing will include parts of the star forming region Upper Scorpius (UpSco), which is widely dispersed and essentially free of extinction and thus particulary suitable for optical monitoring with large pixels. UpSco is much closer than Orion (140 pc), and it hosts an large population of brown dwarfs. With the full-sky mid-infrared mission WISE, it has become feasible to study the disks for the entire population. High-resolution spectroscopy is also possible for brown dwarfs in UpSco. Objects in UpSco are 5-10 Myr old, the age range where most of the disks disappear and planet formation must be finished or well underway. Probing rotation in this age range is ideal to constrain models for the angular momentum evolution (see Bouvier et al. 2013).

In a recently completed survey, we have identified and characterised 116 UpSco brown dwarfs using multi-band photometry, proper motions, and spectroscopy (Dawson et al. 2012, 2014). For all objects the mid-infrared spectral energy distribution is known from WISE; 27 of them show evidence for a disk (Dawson et al. 2013). This clean and homogenuous sample with spectral types of M6 to L1 and masses of 0.01-0.09 $M_{\odot}$ is perfectly suited for a brown dwarf monitoring program with Kepler. Out of 116, 96 are in EPIC. Herewith we propose to include these 96 brown dwarfs in the target list for K2 campaign 2.

Typical amplitudes for spot-modulated lightcurves from which rotation periods can be derived are 1-2% for brown dwarfs (Scholz et al. 2004); based on previous studies we expect to be able to measure periods for at least half of the sample. This will by far be the largest sample of rotation periods for *confirmed and well-characterised* brown dwarfs. Typical brown dwarf periods range from a few hours to 10 days, i.e. a half hour cadence is suitable. All tools for processing the data are already in place from previous projects. AS and RJ will involve a postdco and a graduate student to facilitate the data analysis. In association with the existing information on the objects and their disks, the periods will be immediately useful. These targets provide plenty of opportunity for other high-impact science. Identifying eclipsing brown dwarf binaries, finding planetary transits, and studying variable accretion in the lightcurves are only three possible alternative science cases.