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Disks, accretion and outflows of brown dwarfs

Brown dwarf activity down to the planetary border

The exploration of disks, accretion and outflows of young brown dwarfs (BD) plays an important role in developing our understanding of BD formation, planet formation, and the physics of circumstellar disks and outflows in general. It is related to fundamental open questions in stellar astronomy, such as:

Do BDs form via the same path as stars?
Can planets form around BDs?
How do disks develop in a low-gravity, -temperature, and -radiation environment?
Down to which minimum mass can we detect disks, accretion and outflows?

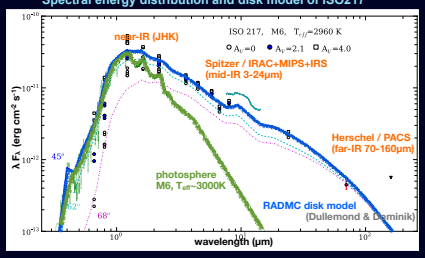
The launch of jets and outflows is a key process in the formation phase. Simulations suggest that outflows are a natural by-product of isolated BD formation and a potential path to overcome the Jeans-mass problem (Machida, Inutsuka+ 2009).

We detect and explore disks, accretion and outflows of BDs down to the planetary border, as presented in the following.

The bipolar outflow and disk of the brown dwarf ISO 217

Joergens, Pohl, Sicilia-Aguilar, Henning 2012, A&A, 543, A151

Spectral energy distribution and disk model of ISO217

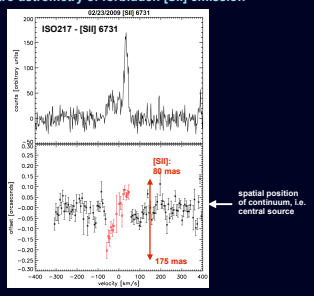


We show that ISO 217 (M6.25) is driving an intrinsically asymmetric bipolar outflow with a stronger and slightly faster red-shifted component based on spectro-astrometry with 30 mas precision of forbidden [S II] emission lines in UVES / VLT spectra.

We show that the velocity asymmetry between both lobes is variable on timescales of a few years and that the suggested strong asymmetry of a factor of two (Whelan et al. 2009) might be smaller than originally anticipated.

We determine the disk properties based on SED modeling and find a flared disk with mass ≥ 4x10^{-6} M_{Sun} , grain growth and an inclination of i ≤ 45 deg.

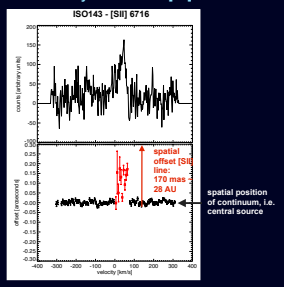
Spectro-astrometry of forbidden [SII] emission



Discovery of an outflow of the very low-mass star ISO 143

Joergens, Kopytova, Pohl 2012, A&A, 548, A124

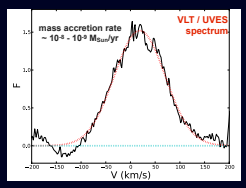
Spectro-astrometry of forbidden [SII] emission



We discover that the very low-mass star ISO 143 (M5) is driving an outflow based on spectro-astrometry of forbidden [S II] emission lines at 6716 Å and 6731 Å observed in UVES/ VLT spectra. This adds another object to the handful of brown dwarfs and very low-mass stars (M5-M8) for which an outflow has been confirmed and which show that the T Tauri phase continues at very low masses.

We find the outflow of ISO 143 to be intrinsically asymmetric. We estimate a mass outflow rate of ISO 143 of ~10−10 M⊙/yr and a mass accretion rate in the range of ~10−8 to ~10−9 M⊙/ yr. The derived Mout/Macc ratio of 1–20% does not support previous findings of this number being very large (>40%) for very low-mass objects.

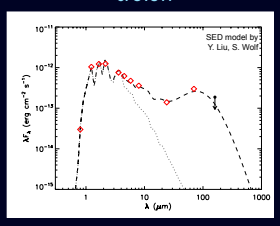
Oxygen emission line O I 8446 of ISO143 as accretion tracer



OTS 44: Disk and accretion at the planetary border

Joergens, Bonnefoy, Liu, Bayo, Wolf, Rojo 2013, A&A, submitted

Spectral energy distribution and disk model of OTS44



OTS 44 is a very low-mass brown dwarf (M9.5), which has a mass around the Deuterium burning limit of 6-17 M_{Jup} (Luhman et al. 2004; Luhman 2007; Bonnefoy et al. 2013). The detection of mid-IR excess emission with Spitzer indicates the presence of a disk (Luhman et al. 2005).

We explore the properties of OTS 44 and its disk based on the detection of cold dust at far-IR wavelengths with Herschel and on the discovery of broad and strong Hydrogen emission lines in optical and IR spectra, e.g. VLT / SINFONI.

We perform a detailed modeling of the spectral energy distribution of OTS 44 using a radiative transfer code (Wolf 2003) and Herschel data (Harvey et al. 2012). We can demonstrate that OTS44 has a substantial disk and determine its mass and geometry.

We discover broad and strong Halpha and Paschen beta emission of OTS 44 giving direct evidence of active accretion of an object at the planetary border. A detailed analysis will be presented in Joergens, Bonnefoy, Liu et al. (2013).

Strong Hydrogen emission lines of OTS44