(Sub)millimeter observations and disk modeling of substellar objects: understanding their formation processes

1 Abstract

How brown dwarfs (BDs) and even isolated planetary mass objects (IPMOs) form, is one of the main open questions in the field of star formation and remains a subject of debate until now. A scaled down version of star formation processes is one of the promising scenario. The circum-(sub)stellar disk serves as a crucial medium to understand their formation. Numerous observations of BDs in recent years have detected disks with properties similar to those found in T Tauri stars, suggesting that BDs may form in a similar way to hydrogen-burning stars. Despite this progress, thorough disk comparisons are required to obtain a clear view of the formation mechanism of BDs and IPMOs.

OTS 44 is one of the only four free-floating planets known to have a disk and the only one detected in the millimeter regime. Recently, we analyzed ALMA, Cycle 3, band 6 (1.3 mm) continuum data and found that the disk dust mass is in the range of $0.07-0.63\,M_{\oplus}$, suggesting that the scaling relation between disk and stellar masses found for larger mass central objects holds down to planetary masses (Bayo et al. 2017). This hints toward OTS 44 forming in a similar way to hydrogen-burning stars. However, the estimates of the masses of the disk and the central object are subject to huge uncertainties and bold assumptions. We have been granted a Cycle 5, ALMA proposal (PI Bayo, ranked B) to derive the dynamical mass of the central object (for the first time a model-independent mass estimate for such object) by spectroscopically resolving the gas content of the disk. We will also place better constraints on the disks dust mass and directly test grain growth via the spectral index provided by the new data. In addition, we have obtained high resolution optical and near-infrarred spectroscopy of members of the same star forming region, Chamaeleon I, that could have been associated with OTS44 during its formation. The wealth of data for OTS 44 needs to be properly modeled in order to compare the disks around substellar objects with those around stellar ones to search for similarities and/or differences (disk size, geometry, etc.) that will shed light over the formation mechanism of isolated substellar objects.

Pending the results of the Cycle 5 successful observations; as a backup project, we plan to analyze the already collected ALMA and APEX data on Barnard 35 dark cloud. This dark cloud is part of the Lambda Orionis Star forming region (LOSFR, that has been subject of study by the PI Bayo since my PhD thesis) and has an estimated age of $\sim$3 Myr (Bayo et al. PhD, among others). The science case behind the gathering of this secondary dataset is closely related to the case of OTS 44 but for somewhat higher masses (still in the substellar domain).

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