Search for Young Brown Dwarfs in the Core of Distant Massive Star Forming Regions

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Primary Science Goals:

The functional form and the universality of the Initial Mass Function (IMF) at a very low-mass regime including brown dwarfs (BDs) are still open questions. So far, the young brown dwarf (YBD) search has been limited to the nearby star-forming regions (< 500 pc). In order to detect and characterize the YBDs in distant massive star-forming regions, we need high sensitivity and high resolution. We present a new set of *J*-, *H*-, and *K*-band data for the W3 Main (d ~ 1.83 kpc) and NGC 7538 (d ~ 2.8 kpc) star-forming regions with higher resolution (FWHM ~ 0.35 arcsec) and sensitivity (K ~ 20 mag) for an area of ~ 2.6 arcmin^2 each centered on W3 IRS 5 and NGC 7538 IRS1-3, respectively. Our motivation is to look for the YBDs associated with the W3 Main and NGC 7538 star-forming regions and to discuss their nature and mass function (MF).

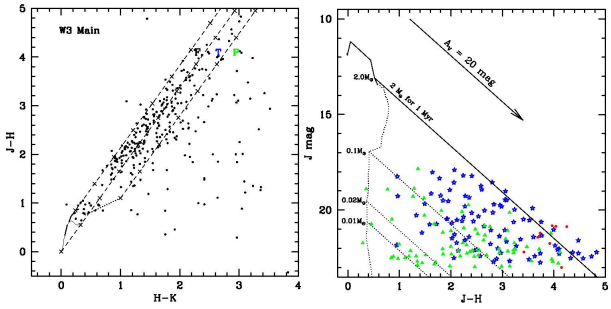
Observations:

Deep imaging observations of W3 Main and NGC 7538 star-forming regions at the NIR wavelengths *J* (λ = 1.25 μm), *H* (λ = 1.64 μm), and *K* (λ = 2.21 μm) were obtained using the CISCO camera mounted on the Subaru 8.2 m telescope.

JHK composite images of W3 Main (*left*) and NGC 7538 (*right*) star-forming regions (*J*: blue; *H*: green; *K*: red) obtained with the CISCO mounted on the Subaru 8.2 m telescope. The FOV is ~ 1.8 × 1.8 arcmin^2. North is up, and east is to the left.

Young Stellar Sources:

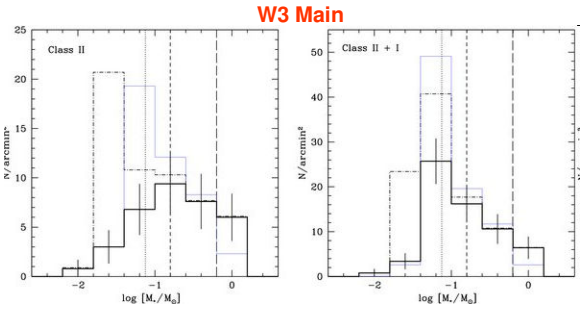
In W3 Main and NGC 7538, there appears to be a substantial substellar population of YSOs based on the mass estimates on the basis of the mass-dereddened *J*-band luminosity relationship.



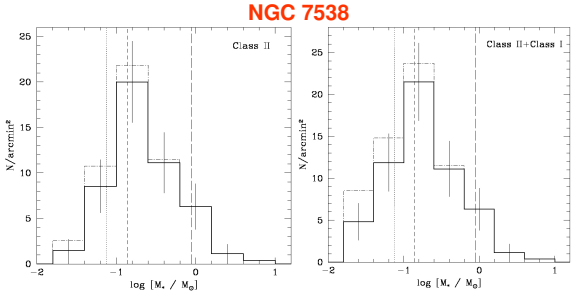
CC and CM diagrams of the W3 Main star-forming region. Class II YSO candidates are indicated by stars, filled triangles represent Class I candidates, and the filled circles show red sources with $H - K > 2$ with *J*-band counterparts. The solid and dotted curves denote the loci of 1 Myr old PMS stars; derived from the models of Palla & Stahler (1999), and Baraffe et al. (1998, 2003).

Mass Function:

We use the presently available theoretical mass-luminosity relation to convert the J-band luminosity function (JLF) into a MF.



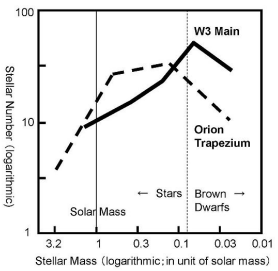
Mass functions for the identified Class II (left) and combined (Class II + I) objects (right) based on the evolutionary models of Baraffe et al. (1998, 2003), and Palla & Stahler (1999), for the age assumption of 1 Myr. The dashed-dotted line shows the MF corrected for the completeness in the respective mass bins. The vertical dotted line represents the star-BD boundary at 1 Myr. The short-dashed and long-dashed lines represent 90% and 100% completeness limits, respectively. The thin continuous line indicates the completeness-corrected MF derived using reddening-corrected JLF with an average extinction subtraction.



Mass functions for the identified YSOs in NGC 7538 region. The vertical dotted line represents the star-BD boundary at 1 Myr. The short-dashed and long-dashed lines represent 90% and 100% completeness limits, respectively.

Result:

According to our results, it is unlikely that the MF shows the presence of cutoff and a sharp turnover around the substellar limit, at least at the hydrogen-burning limit (the MF rises monotonically up to 0.1 *Msun* and shows a sharp decline in the BD regime). If confirmed, these BDs will be the lowest mass members of W3 Main and NGC 7538 IRS 1-3 clusters and therefore provide key clues to a census of very low-mass stars and the IMF down to about 25-30 Jupiter-mass regime for the first time in distant (> 1.8 kpc) massive star-forming regions.



References: Ojha et al., 2009, ApJ, 693, 634 (W3 Main)
Ojha et al., 2011 (submitted) (NGC 7538)

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