2MASS J17112318-2724315: A Low-Mass Protostellar System in the B59 Molecular Cloud

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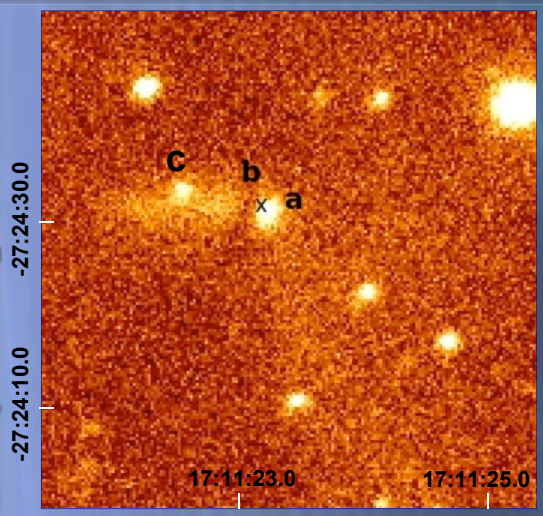
We present NIR CTIO/ISPI observations of a deeply-embedded low-mass (~0.5 Msun) protostar 2M171123 in one of the nearest star-forming regions, the B59 molecular cloud. Three interesting features are noted in our observations:

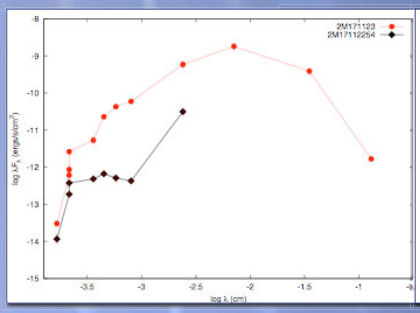
- **Scattered light nebulosity** extending to ~0.05 pc in the north-east direction, with an apparent axis of ~20° aligned with a previously known CO outflow (Onishi et al. 1999). 2M171123 thus possibly traces the edges of this outflow.

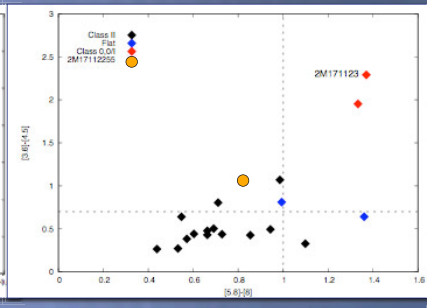
- **A "shadow" or "dark" lane** west of 2M171123, with an apparent thickness of ~360 AU. The shadow lies offset from the protostar. The offset is confirmed by a difference of ~1" between the CTIO and the Spitzer/IRAC positions for 2M171123. We interpret the dark lane as the shadow cast by the protostar onto an optically thick background cloud. A scattering cloud that lies offset from the star acts as a screen onto which a shadow is projected, and is a configuration that allows the star-disk system to be offset from the center of the dark lane.



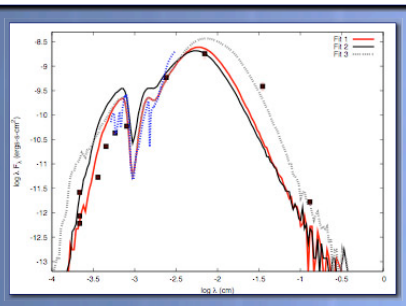
False-color CTIO/ISPI Ks-band image at a resolution of ~0.3" (~40AU). 2M171123 is marked by an 'a', the shadowed lane by 'b', the Spitzer/IRAC position by 'x', and the newly-discovered protostar 2M17112255 by 'c'.

- **Detection of a new low-luminosity protostar 2M17112255**, ~8" (~1000 AU) from 2M171123. This is a Class I system, as indicated by its 2-8μm slope and IRAC colors, with an estimated internal luminosity of ~0.3Lsun and a mass of ~0.12-0.25 Msun, at an age of 0.1-1Myr.





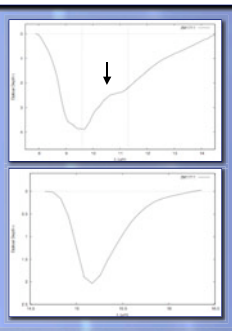
Left: Spectral energy distributions for 2M171123 (red) and 2M17112255 (black). *Right:* IRAC color-color plot comparing the colors for the two protostars with other low-mass candidate members in B59, using data from Brooke et al. (2007).

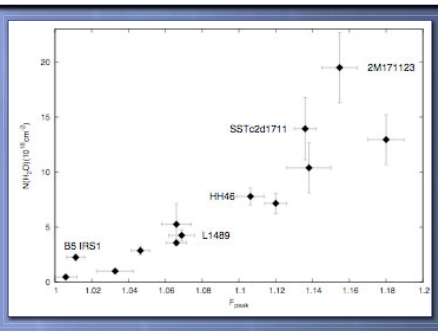


Best-fits obtained from the radiative transfer modeling of 2M171123. Fits 1 and 2 explain the observed Ks-band variability by a varying mass-infall rate. 2M171123 is viewed at an intermediate inclination, and is not an edge-on system.

Parameter	Value
R_*	3.4 $R_\odot$
T_*	3300 K
M_*	0.28 $M_\odot$
$\dot{M}_{env}$	1.8E-5 - 2.5E-5 $M_\odot yr^{-1}$
ρ_1	1.74E-13 - 2.40E-13 g cm^{-3}
$R_{env,min}$	7.8 R_{sub} (~36 R_*)
$R_{env,max}$	4000 AU
R_c	30 AU
θ_{cav}	28°
θ_{in}	53° - 59°
M_{disk}	2.6E-2 $M_\odot$
$\dot{M}_{disk}$	9.54E-7 $M_\odot yr^{-1}$
$R_{d,min}$	7.8 R_{sub} (~36 R_*)
$R_{d,max}$	30 AU
β	1.012
α	2.012
L_*	1.24 $L_\odot$
L_{shock}	1.97 $L_\odot$
L_{disk}	0.034 $L_\odot$
L_{tot}	3.2 $L_\odot$

Fit 3 is for a larger aperture radius of 5000 AU, required to fit the millimeter data, indicating the emission at these wavelengths to include the surrounding dense molecular cloud, other than the protostellar system.





- The 10μm silicate spectrum for 2M171123 shows an 'edge' between 9.8 and 11.3μm, an unusual feature among protostars.
- Such edges are commonly observed in more evolved Class II systems, and indicate the presence of crystalline silicates in the disk.
- The 15μm CO_2 feature for 2M171123 however is smooth and featureless, indicative of envelope temperatures below ~50K and lack of any ice processing.
- We find a strong correlation between the strength in this edge observed near 11.3μm, and the thickness of the ice coating over the silicate grains.
- Protostars that are not deeply embedded or have heated their envelopes sufficiently to melt away a large fraction of the ice coatings exhibit a weaker strength in the 11.3μm edge, confirming the origin of this feature in the thickness of ice coating over the grains.