The Co-evolution of Disks and Stars in Embedded Stages

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When a disk structure is formed around a newly born is an important issue for astrophysics. We are tackling this problem from an astrochemical point of view by using ALMA.

IRAS 15398−3359 is the low-mass Class 0 protostellar source located in the Lupus 1 molecular cloud at a distance of 155 pc. We have observed the CCH and SO emission toward this source at a 0."2 angular resolution (~30 au). The CCH emission traces the infalling-rotating envelope extended along the northwest-southeast axis, while the SO emission has a compact distribution around the protostar within 40 au. The velocity structure of the SO emission indicates a rotating disk structure around the protostar. We evaluate the protostellar mass to be 0.007 $M_{\odot}$ assuming the Keplerian rotation. Thus, this source is found to be a very young protostar. Nevertheless, the rotating disk structure has already been formed around it. This result suggests that the disk structure can be formed in the earlier stage than ever expected [1].

We have searched for other sources like IRAS 15398−3359 to investigate disk formation at the youngest stages of protostellar evolution. Based on the analyses of the ALMA archival data of the $C^{18}O$, SO, and ^{13}CO emission, the protostellar masses of L328-IRS, IRAM 04191-IRS, and Chamaeleon-MMS 1 are roughly estimated to be 0.2 $M_{\odot}$, 0.05 $M_{\odot}$, and 0.03 $M_{\odot}$, respectively. Although L328-IRS is a very low luminosity object (VeLLO) [2], the protostellar mass is much higher than that of IRAS 15398−3359. Instead of the low luminosity, we find that a narrow spectral line width can be an effective indicator to find very-low-mass protostars. Figure 1 shows the relation between the protostellar masses and the disk masses of the sources at the infant stages. It likely suggests co-evolution of disks and protostars.

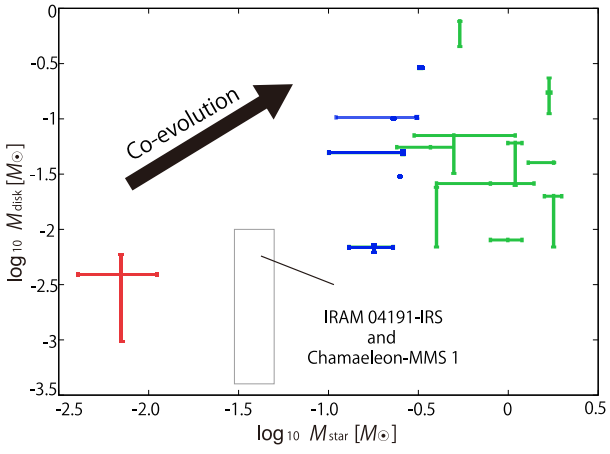

Figure 1: Comparison between the protostellar masses and the disk masses. The red marks with error bars represent IRAS 15398–3359. The blue and green marks show the protostars of $T_{\rm bol}$<70 K (Class 0) and $T_{\rm bol}$>70 K (Class I), respectively [3]. IRAM 04191-IRS and Chamaeleon-MMS 1would be plotted in the slash range.

References

[1] Okoda, Y et al. 2018, ApJL, 864, L25; [2] Lee, C. W., Kim, M., Kin, G., Saito, M., et al. 2013, ApJ, 777, 50; [3] Alves et al. (2017); Chou et al. (2014); Lee et al. (2017), (2018); Sakai et al. (2014a); Tobin et al. (2012), (2015); Yen et al. (2015), (2017)