Studying shell structure in CO outflows in the eDisk survey

A. Feeney-Johansson[1]

[1]*Department of Astronomy, The University of Tokyo, Japan*

In star formation, jet and outflows play a key role, as they extract angular momentum from the protostar-disk system while injecting energy and momentum into the surrounding cloud and envelope [1]. In many sources, evidence for variation in the mass-loss rate of the protostar is seen, most commonly in the form of series of knots along the axis of the jet, which are thought to be caused by internal shocks in the jet due to variations in the jet velocity. Since the accretion rate and mass-loss rate of protostars are thought to be closely related, these variations in mass-loss rate are therefore thought to trace variations in the accretion rate of the protostar. As well as knots in the jet, variation in the mass-loss rate has been seen in the form of wide-angle shell structures in molecular outflows, such as in the HH 46/47 outflow, which are believed to trace the entrainment of ambient gas by a series of outbursts in a wide-angle wind from the protostar and disk[2][3].

We take advantage of the high-resolution 12CO data obtained in the ALMA Large Program "eDisk" to search for similar shell structures in molecular outflows from low-mass protostars. Out of the 19 sources, 6 sources seem to show some level of shell structure in their outflows similar to that seen in previous studies. For three of these source: CB68, GSS30 IRS3, and IRAS32, we were able to fit the shell structure seen with a model which assumes that the shells are caused by previous outbursts in the outflow which entrained ambient gas, as was seen in HH46/47. In CB68, shell models fitted to the data suggest two previous outbursts occurred ~160 yrs ago and ~300 years ago respectively. In Figure 1, the position-velocity diagram along the axis of the outflow shows the two shell models which were fitted. For the other 3 sources, where shell structure was detected, it wasn't possible to fit the shells observed with the entrained ambient gas model, and so alternative explanations are required for the structure detected.

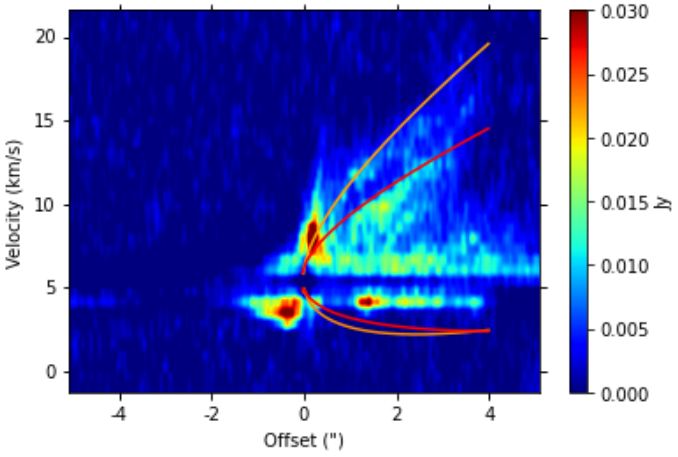

Figure 1: The position-velocity diagram along the outflow axis of CB68 showing the two shell models fitted to the data, tracing the outbursts launched ~160 years ago (red) and ~300 years ago (orange).

References

[1] Frank A. et al., 2014, Protostars and Planets VI (University of Arizona Press), p.451-474
[2] Zhang, Y., Arce H. G., Mardones D. et al., 2019, ApJ, 883, 1.
[3] Lee, C.-F., Mundy, L. G., Reipurth, B., Ostriker, E., Stone, J. M., 2000, ApJ, 542, 925