River in the sky: the first streamer feeding a Class I protostar

M. T. Valdivia-Mena[1], J. E. Pineda[1], D. M. Segura-Cox[2] and Paola Caselli[1]

[1] *Max Planck Institut für Extraterrestrische Physik, Giessenbachstrasse 1, D-85748 Garching, Germany*

[2] *Department of Astronomy, The University of Texas at Austin, 2515 Speedway, Austin, TX 78712, USA*

In the past few years, there has been a rise in the detection of streamers, asymmetric flows of material directed towards the protostellar disk [1, 2, 3, 5]. It is unclear how they affect the process of mass accretion, in particular beyond the Class 0 phase. In this work, we use new NOEMA 1 mm observations of various molecules around Per-emb-50 (a Class I protostar), including $C^{18}O$, H_2CO and SO, in the context of the PRODIGE MPG-IRAM program. With these molecules, we probe the inner core and envelope structures and kinematics. We discover a streamer delivering material towards Per-emb-50 in H_2CO and $C^{18}O$ emission. The streamer's kinematics can be well described by the analytic solutions for an infalling parcel of gas along a streamline with conserved angular momentum [4], both on the sky and the line-of-sight velocities. We estimate a streamer mean infall rate of $1.3\text{x}10^{-6}$, 5 to 10 times higher than the accretion rate towards the protostar. SO and SO_2 emission reveal that the envelope has an asymmetric infall additional to the streamer around Per-emb-50. The presence of SO_2 emission could mark the impact zone of infalling material. The streamer delivers enough mass to sustain its accretion rate and might produce an accretion burst, which would explain the protostar's high luminosity with respect to surrounding Class I sources. Our results highlight the importance of late infall for protostellar evolution: the main accretion phase might extend beyond the Class 0 phase.

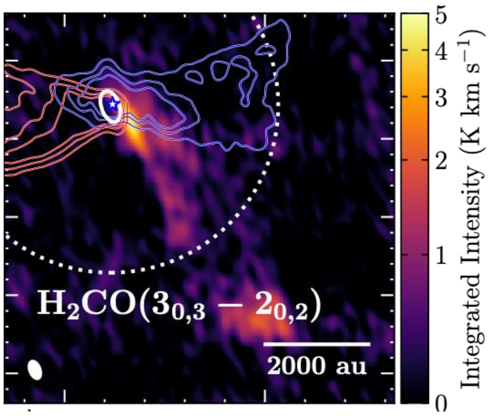

Fig. 1: Integrated intensity of $H_2CO(3_{0,3}$-$2_{0,2})$. The blue star represents the location of Per-emb-50. Red and blue contours correspond to the redshifted and blueshifted emission coming from the outflow, respectively, traced in our $^{12}CO(J=2\text{-}1)$ data. The white contour represents the continuum emission. The white dashed circle represents the primary beam.

References

[1] Alves, F. O., Cleeves, L. I., Girart, J. M., et al., ApJ, 904, L6 (2020)

[2] Garufi, A., Podio, L., Codella, C., et al., arXiv e-prints, arXiv:2110.13820 (2021)

[3] Ginski, C., Facchini, S., Huang, J., et al., ApJ, 908, L25 (2021)

[4] Mendoza, S., Tejeda, E., & Nagel, E., MNRAS, 393, 579 (2009)

[5] Pineda, J. E., Segura-Cox, D., Caselli, P., et al., Nature Astronomy, 4, 1158 (2020)