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Dissecting the kinematics of an infalling envelope with modeling of absorption and emission

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Infall drives the growth of protostars in terms of their mass as well as the structural and chemical complexities. The rich spectra of molecules best probe the infall kinematics at a wide range of spatial scales and physical environments. Molecular emission highlights the infalling gas as specific patterns in position-velocity diagrams and streamers. Moreover, red-shifted absorption against the continuum due to the cold dense gas falling onto the protostar give an unambiguous evidence of infall. While these features indicate ongoing infall, constraining the underlying kinematics requires forward modeling with non-LTE radiative transfer calculations. In BHR 71, a Class 0 protostar, we have modeled the infalling envelope to reproduce the red-shifted absorption in HCO^+ and HCN using LIME. While the model reproduces the spectra toward the continuum source, the synthetic spectra disagree with the observations at off-center positions, hinting a stronger rotation at the inner 50 au region compared to our envelope model. I will discuss the success and the shortcoming of our model as well as possible remedies. I will also discuss the comparison of this model to other transitions of HCO+ and emission features to formulate an infalling envelope constrained by multiple tracers at various scales.

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