

The accretion/ejection properties of young protostars studied with near-infrared spectroscopy

Oral presentation abstract

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ABSTRACT

Sun-like stars acquire most of their final mass during the deeply embedded protostellar phase, when the central embryo is surrounded by a dense, infalling envelope. The youngest stage, the Class 0 phase, is characterized by vigorous accretion and the establishment of the fundamental stellar properties. However, direct diagnostics of accretion are challenging because their main observational signatures arise at near-infrared (NIR) wavelengths, which are heavily extinguished by the surrounding envelope. Consequently, the accretion and ejection mechanisms operating during the Class 0 phase remain poorly constrained. In favorable geometries, scattered NIR light escaping through the blueshifted outflow cavity enables us to probe the immediate circumstellar environment and access the NIR counterpart of these embedded objects.

We present NIR integral-field observations of Class 0 protostars obtained with the James Webb Space Telescope NIRSpec instrument. Numerous H I, H₂, and CO ro-vibrational emission lines (both overtone and fundamental) are detected and analyzed. The rich set of H₂ transitions traces shocks and wind structures along the jet, allowing detailed comparison with shock models and robust estimates of mass-loss rates. CO fundamental emission spatially coincides with the base of the wind/jet system. In several sources, stellar CO overtone absorption lines are detected, indicating either recent strong accretion bursts or relatively quiescent protostars, and enabling—for the first time—the exploration of photospheric properties in these protostellar embryos. In contrast, CO overtone emission is observed in roughly half of the sample, tracing the dense inner accretion disk.

Comparison with K-band spectra of more evolved protostars shows that CO and H I emission lines are systematically more luminous in Class 0 sources, suggesting that accretion is on average more vigorous at this earliest stage. The higher detection rate of CO overtone emission further implies that Exor-like high-accretion episodes are more frequent during the Class 0 phase. Analytical disk modeling of the CO overtone bandheads indicates kinematics consistent with either an accretion-heated inner disk or material infalling directly onto the central protostar. Modeling of the scattered H I recombination emission links these lines to accretion-powered energy release in the innermost circumstellar regions.

The sensitivity and wavelength coverage of JWST/NIRSpec thus provide unprecedented diagnostics of (i) inner disk conditions through the NIR continuum and CO overtone emission, (ii) accretion energetics and mechanisms via infrared H I recombination lines, and (iii) multiphase jet/wind energetics through atomic (e.g., [Fe II]) and molecular (H₂, CO) tracers. Precise extinction measurements, excitation analyses, and spatial mapping of accretion and ejection tracers are now achievable.

Looking ahead, future extremely large telescope instrumentation will provide the missing kinematic dimension. The high spectral resolution of Extremely Large Telescope instruments such as METIS, HARMONI, and ANDES will resolve the currently unresolved line profiles observed with JWST, enabling direct constraints on gas dynamics in the inner disk, accretion funnels, and jet-launching regions. Combined with physically motivated modeling of disk, infall, and wind structures, these observations will allow us to build a comprehensive scenario for the accretion–ejection processes that regulate the assembly of stellar mass and angular momentum at the earliest stages of star formation.

Key words. ISM: jets and outflows – stars: formation – stars: protostars - accretion