

Title: Witnessing the dawn of a new solar system through jets and outflows to reveal early planet formation

Abstract: Protostellar jets and outflows serve as fundamental signatures of the ongoing accretion process and angular momentum removal in young stellar objects. Recent multiwavelength observations, which combine high-resolution submillimeter data from the Atacama Large Millimeter/submillimeter Array and mid-infrared spectroscopy from the James Webb Space Telescope, offer a comprehensive view of the physical, thermal, and chemical stratification within these protostellar systems. High-velocity molecular jets, traced by high-density silicon monoxide and pure rotational molecular hydrogen lines, along with wide-angle carbon monoxide outflows, clearly delineate the mass-loss and accretion history of protostars. More evolved systems, such as the Class I source G205.46-14.56S3 also known as HOPS 315, often exhibit prominent silicon monoxide jets and high mass-loss rates, pointing to extended phases of high accretion. Furthermore, periodic knot structures and velocity variations observed along jet axes indicate episodic ejection events. These pulsed accretion-ejection episodes can be driven by dynamical interactions from an unresolved binary, dense clumps situated within a massive circumbinary disk, or embedded planetary companions. Beyond tracing stellar growth, outflows and jets play a direct role in early planet formation. Large dust grains that grow in the inner disk can be entrained by protostellar outflows and subsequently transported to the envelope, eventually falling back onto the outer disk. This dynamic recirculation process helps circumvent the radial drift barrier, thereby promoting planetesimal formation in the comet-forming region. Additionally, integrating cold molecular tracers like carbon monoxide with warm and hot rotational molecular hydrogen lines reveals complex shock structures and thermal layering along the jet. Ultimately, the synergy between ALMA and JWST demonstrates that protostellar jets and outflows are not merely passive byproducts of star formation, but active participants that regulate disk evolution and establish the physical conditions necessary for planet formation.