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Explosive outflows produced by gravitational interactions

Explosive outflows (EOs) can significantly influence the structure of star-forming environments. EOs present a more complex scenario than conventional bipolar molecular outflows driven by jets and winds. Observed in high-mass star-forming regions, they consist of numerous dense clumps leading gaseous filaments spreading nearly isotropically from a common center. They have been identified in Orion BN/KL, DR21, G5.89-0.39, IRAS 16076-5134, Sh106-IR, and IRAS 12326-6245. Their kinematics resemble a Hubble-like expansion, and they have a similar rate and a kinetic energy comparable to supernovae events, suggesting that EOs may be a common evolutionary stage for massive stars.

The origin of EOs remains uncertain, but current models propose that N-body interactions, resulting in compact binary formation or stellar mergers, release gravitational potential energy, driving these explosive events. The presence of runaway protostars receding from the explosion center in Orion BN/KL reinforces the hypothesis of a violent disintegration of a protostellar multiple system.

We propose that a runaway star could disrupt a dense cluster of prestellar clumps, analogous to compact fingertips producing the Orion BN/KL EO. Using N-body numerical simulations, we analyze the gravitational interactions and energy transfer mechanisms responsible for ejecting cluster members with explosive characteristics. Our study explores the implications of this model in explaining the formation of EOs, providing new insights into the dynamic interactions within young star clusters. We found that when the cluster mass is less than or up to a few times the stellar mass, the collision will produce an explosive outflow, ejecting a significant fraction of the cluster members with velocities larger than the impact velocity. Our models produce the ejections of the cluster members at very high velocities, reinforcing the probability that a close encounter could be responsible for EOs.

Primary author: Dr RIVERA-ORTIZ, Pedro R. (Institute of Radioastronomy and Astrophysics UNAM)

Co-authors: Dr RODRÍGUEZ-GONZÁLEZ, Ary (Instituto de Ciencias Nucleares UNAM); Dr CANTÓ, Jorge (Instituto de Astronomía UNAM); Dr ZAPATA, Luis (Institute of Radioastronomy and Astrophysics UNAM)

Presenter: Dr RIVERA-ORTIZ, Pedro R. (Institute of Radioastronomy and Astrophysics UNAM)

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