Observations of Outflows from Young Stars

John Bally

Department of Astrophysical and Planetary Sciences
Center for Astrophysics and Space Astronomy
University of Colorado, Boulder, USA

Most stars drive powerful highly supersonic outflows during their birth. While young stellar objects (YSOs) frequently power spectacular, highly collimated jets, others expel matter in poorly collimated flows. Young stars provide the best examples of astrophysical jets for detailed investigation for several reasons: A large variety of diagnostic probes from X-rays to radio waves are available to observers. Temporal variations can be directly observed on time-scales ranging from weeks to decades. Variations on time-scales up to a million years can be inferred from the fossil record of shocks and accelerated shells that outflows create. Outflows are variable in just about every variable, including mass-loss rate, ejection velocity, orientation, and degree of collimation. As jets interact with their environments, they can be deflected by side-winds, collisions with clouds along their trajectories, other outflows, or by the motion of their source stars through the surrounding interstellar medium. Such variations and interactions give rise to bewilderingly complex morphologies and kinematics that require a large variety of observations to fully characterize. Some massive YSOs, such as those embedded in the dense clumps of molecular gas behind the Orion Nebula, have powered powerful explosions. In the case of Orion, the trigger appears to have been the ejection of the massive stars from their birth environment by mutual gravitational interactions.

I will present a review of recent multi-wavelength observations of protostellar outflows and jets with an emphasis on objects that might provide tests of models of launch and outflow collimation and which could be simulated in laboratory experiments using high energy-density machines.