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# Exploring how astrophysical jets work using laboratory plasma jets[1]

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Astrophysical jets occur in numerous contexts where there is accretion (e.g., stellar formation, black holes) and are presumed to be driven by magnetohydrodynamic (MHD) forces. This talk describes a laboratory plasma experiment that simulates the essential features of astrophysical jets. The geometry is arranged so the laboratory jets are unaffected by walls and the experimental time scale is such that frozen-in magnetic flux, the condition for ideal MHD, is reasonably approximated. The lab jets evolve through a sequence of reproducible stages consisting of formation, collimation, kink instability, and at sufficiently high electric current, detachment. Diagnostics include imaging at $> 1$ million frames per second, magnetic probing, spectroscopy, and laser interferometry. The collimated nature of both these jets and of arched plasma-filled flux tubes in a related solar corona loop simulation experiment suggest that collimation is a ubiquitous property of magnetic flux tubes conducting axial electric currents. This realization has motivated a collimation mechanism model whereby the accumulation of convected, frozen-in toroidal magnetic flux near the jet tip increases the toroidal magnetic flux density near the tip. Since magnetic flux density is magnetic field strength, this flux pile-up corresponds to an increase of the toroidal field near the tip. Increase of toroidal field increases the MHD pinch force thereby collimating the jet. The model additionally shows that plasma-filled coronal loops can be considered as resulting from two counter-propagating jets colliding head-on; color-coded images of two colliding lab jets confirm this postulate. The experiments have also motivated development of a dusty-plasma dynamo mechanism suitable for driving actual astrophysical jets. This mechanism involves dust grains having a charge to mass ratio so small that their cyclotron frequency becomes comparable to the Kepler frequency. The resulting collisionless orbits spiral across magnetic field lines towards the central object and the accumulation of charged dust grains creates a radial electromotive force appropriate for driving an astrophysical jet. These spiral orbits are not described by MHD but instead result from conservation of canonical angular momentum in combined gravitational and magnetic fields.

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