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The Evolution of Magnetic Tower Jets in the Laboratory and in Astrophysics[1]

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Collimated, powerful jets are found in a large variety of astrophysical objects, ranging from those associated with proto-stars to galactic jets powered by black-holes. A frequent element found in many evolutionary jet models is the presence, at least in some regions, of a dominant toroidal field responsible for accelerating and confining the plasma to narrow channels which transport angular momentum and energy away from the source. In this context we present 3D MHD simulations of scaled laboratory experiments that not only reproduce the important physical processes thought to exist in the astrophysical systems but also provide new insights into the formation, evolution and stability of magnetically produced jets. The laboratory jets are produced using radial wire arrays driven by a 1 MA current pulse. The general outflow structure of a magnetic tower comprises an expanding magnetic cavity, largely collimated by the pressure of an extended plasma background medium, and a magnetically confined jet which forms within the magnetic cavity itself. A shell of swept-up shocked plasma surrounds the cavity. Although this structure is intrinsically transient and instabilities in the jet and disruption of the magnetic cavity ultimately lead to its break-up, a well collimated, radiatively cooled, "clumpy" jet still emerges from the system; notably such morphology is reminiscent of that observed in many astrophysical jets. We also investigate the effects on the laboratory jets of poloidal fields and rotation, which are thought to stabilize the jets observed in space. In collaboration with S. V. Lebedev, A. Frank, E. G. Blackman, D. J. Ampleford, C. A. Jennings, J. P. Chittenden, S. N. Bland, S. C. Bott, G. N. Hall, F. A. Suzuki Vidal, and A. Marocchino.

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