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The Plasma Physics of Astrophysical Jets and Accretion Disks

JAMES STONE, Princeton University

Highly collimated, supersonic outflows (jets) are observed to be associated with an enormous range of astrophysical systems, from newly formed stars to supermassive black holes in the centers of active galaxies. Such jets are thought to be powered by magnetohydrodynamical (MHD) processes associated with accretion of plasma onto the central object. I will review recent astronomical observations of disks and jets in a wide variety of systems, from protostars to black holes. I will then review recent progress in our understanding of the physics of accretion flows, in particular results from numerical MHD simulations of the nonlinear regime of the magnetorotational instability. Various aspects of these results will be discussed in the context of the formation of jets: for example, recent MHD simulations in full GR have shown the formation of relativistic outflows by the interaction of a spinning black hole with the magnetic field of the surrounding accretion flow. In addition, fundamental aspects of the microphysics of the plasma are thought to be quite different in different systems, for example the fully ionized and weakly collisional plasmas accreting onto black holes in low-luminosity sources is in a very different regime than the cold and mostly neutral gas associated with protoplanetary accretion disks. I will discuss how this microphysics might affect the MHD turbulence driven by the MRI, and possibly the formation of jets. Finally, I will outline several important issues that remain to be addressed regarding the relative importance of angular momentum transport and accretion driven by MHD turbulence in the interior of the disk, versus that driven by winds and outflows.