Acceleration / Generation of Large-scale Flows in Astrophysical Objects

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Acceleration of large-scale flows - creation of stellar winds, variety of outflows, jets, & etc. - is often observed in astrophysical conditions. Recent observations prove that solar corona is a highly dynamic arena replete with multi-species multiple–scale spatiotemporal structures. Strong flows are found everywhere in the low atmosphere — in the sub-coronal (chromosphere) as well as in coronal regions. Latest observations from the Solar Dynamics Observatory and the *Hinode* solar physics mission seem to vindicate our suggestion that the interaction of the fluid and the magnetic aspects of plasma may be a crucial element in creating the enormous diversity in the solar atmosphere, thus, indicating that the plasma flows may complement the abilities of the magnetic field in the creation of the amazing richness observed in the coronal structures.

We developed the Magneto-fluid theory based on which we derived the conditions for both catastrophic and steady flow accelerations in stellar atmospheres leading to the generation of large-scale flows / transient jets. We extended the Dynamo mechanism to generalized "Reverse Dynamo" one and showed that they have the same origin – they are manifestation of the magneto-fluid coupling – large-scale magnetic and velocity fields are generated simultaneously and proportionately. Growth rate of macro-fields scales directly with ambient turbulent energy. The composition of the turbulent energy determines the ratio of the large-scale flow / large-scale magnetic field. When dissipation is present the Hall term (through the mediation of short-scale physics) plays a crucial role in acceleration processes. Our 2.5-dimensional simulation with actual dynamical *helicities (both magnetic and generalized)* shows that even if helicities are not in the required range initially, their evolution could bring them in the range where they could satisfy conditions needed to efficiently generate flows (up-flows), thus, proving the several phases of acceleration. The relevant time scales, flow speeds ($\geq$100 km/s), and amplification are dictated by the initial ion skin depth, and the local plasma β. In the presence of dissipation, these up-flows play a fundamental role in the heating of the finely structured stellar atmospheres; their relevance to the solar wind is also obvious.

In the vicinity of a massive object of various scales mass flow creates a spectacular structure combining a thin disk and collimated jet. Despite a wide range of scaling parameters, they exhibit a remarkable similarity that must be dictated by a universal principle. A generalized Beltrami condition has been formulated as a succinct representation of such a principle. We propose a pure fluid-mechanical model of disk-jet structure, jet collimation in which magnetic field can be easily invoked. In model the *fluid generalized vorticity* plays the same role of *a magnetic field*. The *helicity* of the *generalized vorticity* is the key parameter characterizing the self-organization of a disk-jet system - the singularity at the center of the Keplerian rotation forces the flow to align with the *generalized vorticity* (appears as an axle penetrating the disk), i.e. the jet is a Beltrami flow.