3rd Asia-Pacific Conference on Plasma Physics, 4-8,11.2019, Hefei, China

Laboratory exploration of astrophysical outflow morphology regulated by magnetized disk wind

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Astrophysical outflows of Young Stellar Object (YSO) and Planetary Nebula (PN) exhibit morphologies including collimated jet, less-collimated bipolar lobes (butterfly nebula), quasi-spherical winds etc. It was believed that the outflow topology was generated by wind-wind interaction. Experiments in laboratory have demonstrated the jet produced by magnetic field, inertial collimation in nested ambient outflow, and radiation cooling respectively. While in YSO or PN, the central outflow was always surrounded by magnetized slow disk wind that essentially includes the forenamed three effects.

Here we explored the astrophysical outflow surrounded by magnetized disk wind in laboratory via experiments and simulations. We represented most of the outflow morphologies observed in universe. Moreover, we found that outflow morphologies were dominated by a simple physical law. When the outflow velocity is higher than twice of the Alfven speed of the magnetized disk wind (Mach Number Ma>2), it presented as a collimated jet. Otherwise, the outflows exhibit as blocked jet, bipolar lobes, or quasi-spherical winds. The critical condition for jet generation of Ma=2 was consistent with the theory of quasi-parallel magnetized shock.