Large-scale collimation properties of outflows launched from Keplerian accretion discs

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ABSTRACT

It is generally accepted that the launching of fast collimated outflows requires a large-scale magnetic field threading a central object (black hole or star) and/or its surrounding accretion disc. However, the collimation mechanism far from the central object has not yet been fully understood. In Jannaud, Zanni, and Ferreira (2023), we investigated a mechanism in which the inner jet is self-collimated due to a dominant hoop stress. We performed numerical simulations in which a jet-emitting disc (JED) spans the entire lower computational boundary. These were the first simulations of their kind to demonstrate the steady recollimation shocks predicted by steady-state analytical studies.

However, the large radial extent of the JED prevented a complete study of the connection between the accelerating and asymptotic electric circuits, as well as the influence of the outer medium. In Jannaud, Ferreira, and Zanni (2026), we perform a set of axisymmetric, ideal, non-relativistic magnetohydrodynamic (MHD) outflow simulations. In these simulations, only the innermost disc region launches an outflow. And, only the innermost part of the outflow appears as a self-collimated jet.

Outflows of finite radial extent also produce steady recollimation shocks at large distances from the central object. Standing recollimation shocks are therefore not an artifact of self-similarity, but a generic feature of outflows emitted from magnetized Keplerian accretion discs. They may produce observable signatures in both AGN and protostellar outflows, such as stationary emission knots, a decrease in the rotation rate, or changes in polarization. For protostellar outflows, we recover the need for an outer MHD wind to provide the pressure required to confine the inner jet.