Jet formation from massive young stars: Magnetohydrodynamics versus radiation pressure

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Observations indicate that outflows from massive young stars are more collimated during their early evolution compared to later stages.
Our paper investigates various physical processes that impacts the outflow dynamics, i.e. its acceleration and collimation.
We perform axisymmetric MHD simulations particularly considering the radiation pressure exerted by the star and the disk.
We have modified the PLUTO code to include radiative forces in the line-driving approximation.
We launch the outflow from the innermost disk region ($r < 50$,AU) by magneto-centrifugal acceleration.
In order to disentangle MHD effects from radiative forces, we start the simulation in pure MHD, and later switch on the radiation force.
We perform a parameter study considering different stellar masses (thus luminosity), magnetic flux, and line-force strength.
For our reference simulation - assuming a $30msun$ star, we find substantial de-collimation of 35% due to radiation forces.
The opening angle increases from 20^circ to 32^circ for stellar masses from $20msun$ to $60msun$.
A small change in the line-force parameter $alpha$ from 0.60 to 0.55 changes the opening angle by $sim 8^circ$.
We find that it is mainly the stellar radiation which affects the jet dynamics. Unless the disk extends very close to the star, its pressure is too small to have much impact.
Essentially, our parameter runs with different stellar mass can be understood as a proxy for the time evolution of the star-outflow system.
Thus, we have shown that when the stellar mass (thus luminosity) increases (with age), the outflows become less collimated.

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