Jet and outflow model, Federrath+2014

1. Geometry

Accretion disk around the sink particle.

The sink particle with radius r_{sink} . Two opposite spherical cones with outflow radius r_{out}

and half-opening angle θ_{out}.

2. Mass Transfer

In each timestep Δt, the mass being added to the spherical cones is:

$$M_{out} = \dot{M}_{out}\,\Delta t = f_m\,\dot{M}_{acc}\,\Delta t$$

Where f_m is a mass fraction of user's choice, typically between 0.1 and 0.4, with default 0.3 The actual f_m should be a function of distance from the accretion disk, but it is insensitive to change in the disk physical conditions.

Each timestep adds M_{out} uniformly to the gas within the cones and subtracts it from the sink particle to conserve mass.

Smoothing function for the mass within the cones:

$$R(r, r_{out}) = \begin{cases} \sin\left(\pi \dfrac{r}{r_{out}}\right), & r \le r_{out} \\ 0, & r > r_{out} \end{cases}$$

$$\Theta(\theta, \theta_{out}) = \begin{cases} \cos\left(\dfrac{\pi}{2} \dfrac{\theta}{\theta_{out}}\right), & |\theta| \le \theta_{out} \\ 0, & |\theta| > \theta_{out} \end{cases}$$

3. Momentum Transfer

$$\vec{P}_{out} = \pm\frac{1}{2} M_{out} \vec{V}_{out}$$

Where $\vec{V}_{out}$ is the Kepler speed at the foot point of the jet: $V_{kep} = \sqrt{\frac{G\,M_*}{R_*}}$.

The actual speed depends on mass of the sink particle:

$$|\vec{V}_{out}| = \sqrt{\frac{G\,M_{sink}}{R_*}}$$

Outflow has two components, one is the low-speed, wide-angle flow, the other is the high-speed, collimated jet. Normalize the velocity profile using the same angular smoothing function from above:

$$V(\theta, \theta_{out}) = \frac{1}{4}\,\Theta(\theta, \theta_{out}) + \frac{3}{4}\,\Theta(\theta, \frac{\theta_{out}}{6})$$

4. Angular Momentum Transfer

$$\vec{L}_{out} = f_a \left(\vec{S}'_{sink} - \vec{S}_{sink}\right) \cdot \frac{\vec{S}'_{sink}}{\left|\vec{S}'_{sink}\right|}$$

Where f_a is the angular momentum fraction with typical values between 0.5 and 2, and default at 0.9

5. Summary of all Parameters

	Symbol	Default
Outflow opening angle	θ_{out}	$30°$
Mass transfer fraction	f_m	0.3
Jet speed normalization	$\lvert\vec{V}_{out}\rvert$	$100\ \mathrm{km\ s^{-1}}$
Angular momentum fraction	f_a	0.9
Outflow radius	r_{out}	$16\ \Delta x$