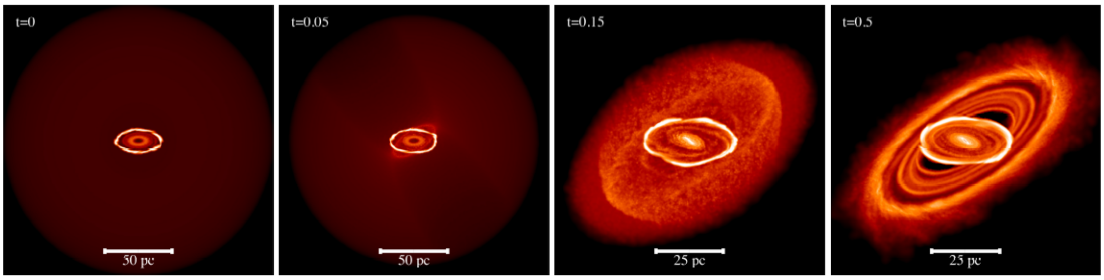
Counter-Rotating Flows - checklist

Juan Manuel Carmona Loaiza - jcarmona@sissa.it

March 29, 2016



The main parameters of our simulations when letting fall a single gaseous shell into the SMBH are its initial angular momentum, l_0; the level of turbulence, $v_{\rm turb}$; and the mass of the central black hole $\rm M_{BH}$ (newly introduced for this study). In the following list I propose a series of simulations to be done in order to better understand the implications that counter-rotating flows proposed in Carmona-Loaiza et al. (2014, 2015) have for SMBH accretion.

1 Sanity check: reproducing analytical estimates.

As sanity check, we need to perform test simulations (low resolution?) in which we vary the parameters l_0 and $\rm M_{BH}$ and see how the accreted mass, $\rm M_{acc}$, and circularization radius, $r_{\rm circ}$ compare to analytical estimates. We would be testing the following quantities: $r_{\rm rirc}(l_0, \rm M_{BH})$ and $\rm M_{acc}(l_0, M_{BH})$ by performing the following simulations:

- Fix $v_0 = 0.3\,(l_0 = 0.018)$ and let $\rm M_{BH} = 10^{\{6,7,8,9\}}$.
- Fix $\rm M_{BH} = 10^8$ and let $v_0 = \{0.1, 0.2, 0.3, 0.5, 0.7\}$

Number of simulations: 8.

We should reproduce the plots shown in Figure 1.

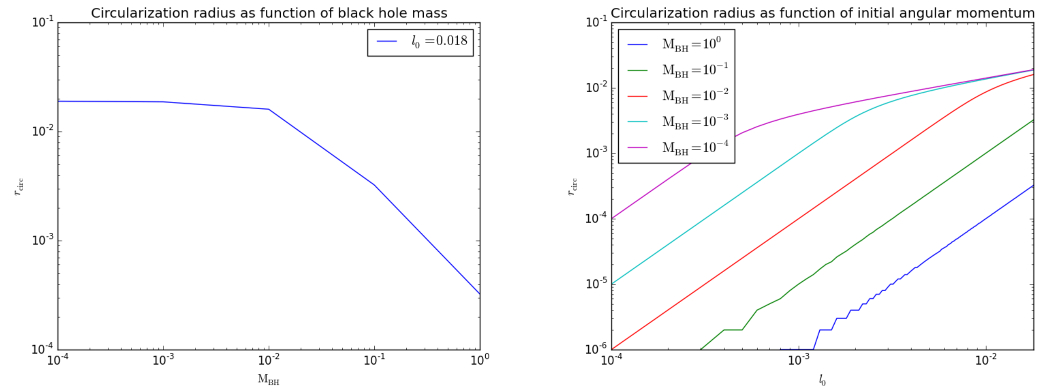


Figure 1: In the left panel we fix l_0, the initial mean angular momentum of the shell, and observe how is the rircularization radius $r_{\rm rirc}$ changes when varying $\rm M_{BH}$. In the right panel we do the opposite: keep fixed $\rm M_{BH}$ and see how the circularization radius behaves with changing l_0. This analytical computations should be reproduce by our simulations. Otherwise we should understand and estimate the source of error.

Additionally, we should make two more simulations with different accretion radius:

- $r_{\rm acc} << \tilde{r}$ (or even with no $r_{\rm acc}$) and measure $M(r < \tilde{r})$.
- $r_{\rm acc} = \tilde{r}$ and measure $\rm M_{acc}$.

Number of simulations: 2-4.

Ideally we should expect $M(r < \tilde{r}) = \rm M_{acc}$, however, due to numerical viscosity this won't be the case. This couple of simulations should tell us how much we are overestimating the accretion of mass with respect to the accretion radius and the circularization radius (if $\tilde{r} = r_{\rm rirc}$).

2 How turbulence affects accretion and shape of the disc.

Additionally, it would be desirable to have a measure of how turbulence affects the density profile of the disc that is created after the infall of the shell has finished, together with the accreted mass. For this, the following simulations are proposed (Basically reproducing the results by Hobbs et al. 2011):

- Fix $v_0 = 0.3$, $M_b h = 10^8$, and let $v_{\rm turb} = 0.1, 0.2, 0.3, 0.5, 0.7, 1.0$

Number of simulations: 6.

As a sanity check, I would propose an extra group of simulations to measure how well the effects of turbulence are being captured by our resolution and which is the minimum resolution to reach convergence, both in shape and in accreted mass:

•Fix $v_0 = 0.3$, $\mathrm{M_{BH}} = 10^8$, and $v_{\mathrm{turb}} = \{v_\alpha, v_\beta\}$,
• Repeat for $N_{\mathrm{particles}} = 100$k?, 200k, 500k, 1M?

Number of simulations: 2-8,

with $v_{\alpha,\beta}$ representing the turbulence velocities for which the resulting disc was thinner/wider (or the accretion was greater/smaller).

3 Misaligned inflows

At this stage I would create a brand new disc with my own desired density profile, $\Sigma(\mathrm{M_{disc}}, r_{\mathrm{disc}})$, to put it inside a new gaseous shell. Only at this point is that the interaction between the inner disc and the shell will be studied, treating misalignment, θ_{tilt}, and the properties of the disc, r_{disc} and $\mathrm{M_{disc}}$, as new parameters. As from my previous studies we already know something about how the accretion grows when misaligned inflows interact, and from the other simulations we're planning we should gather knowledge of the behaviour of $\mathrm{M_{acc}}$ with respect to v_{turb} and $\mathrm{M_{BH}}$, we can focus this time on the new parameters in flows for which $L_{\mathrm{z,disc}} = -L_{\mathrm{z,shell}}$. I would propose the following simulations, which would tell us something new and interesting to extract some conclusions:

- Fix Σ and θ_{tilt}. Test three different values of v_{turb}.
- Fix Σ and v_{turb}. Test three different values of θ_{tilt}.
- Fix v_{turb}, θ_{tilt} and $\mathrm{M_{disc}}$. Test three different values of r_{disc}.
- Fix v_{turb}, θ_{tilt} and r_{disc}. Test three different values of $\mathrm{M_{disc}}$.

Number of simulations: 9

[Grand total number of simulations to be done: 27 - 35]