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3D COLLAPSE AND ACCRETION IN SLOWLY ROTATING POLYTROPES

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Using Gadget 2 to model the collapse and accretion of polytropic envelopes with different initial angular momentum onto a BH, we observed the formation of an accretion disk due to rotation. We also tested the accretion of a non rotating polytropic envelope onto a BH using a Paczynski-Wiita potential to account for some relativistic effects on the gas. These series of tests will help develop the necessary modifications to Gadget 2 in the context of the collapsar model for GRBs.

In order to make a "full" 3D study of the collapse and accretion for rotating material in an astrophysical problem, we consider the *collapsar* scenario (Woosley 1993), which consists on a PreSN star whose Fe core and outer envelopes, are about to collapse due to the shutdown of nuclear reactions at the central region. In our scenario, the Fe core collapses directly to form a BH which accretes the infalling outer envelopes. To model gas dynamics, the simulations of this scenario will be made using the code `Gadget 2` based on SPH (*Smoothed Particle Hydrodynamics*) (Volker 2005). In this work we show the current modifications to the code and some tests made to account for the accretion onto a BH.

Assuming a rigid body angular momentum distribution, we tested the collapse and accretion on 2 $M_\odot$ polytropic stars ($\gamma = 5/3$) with central density $\rho_c \simeq 2.5 \times 10^9$ g cm^{-3} by considering that the most interior 1 $M_\odot$ turned suddenly into a BH. The outer layers of the star would collapse due to the lack of pressure support and get close enough to the BH to be accreted. To account for accretion, we included a sink particle on the code, with an accretion radius $r_{\rm acc} = \eta G M_{\rm BH}/c^2$, where $\eta > 2$ is a factor that determines how far from the Schwarzschild radius the accretion takes place and the gas particles are swallowed by the BH. For this tests we considered a value of $\eta = 10$. We expresed the results in "natural units" by considering $G = 1$ and scaling units to the mass and radius of the initial polytropic star.

These tests show that given enough angular momentum, the gas would create an accretion disk near the BH. The left panel of Figure 1 shows spherical accretion due to low angular momentum, while the right panel shows disk formation from material rotating fast enough.

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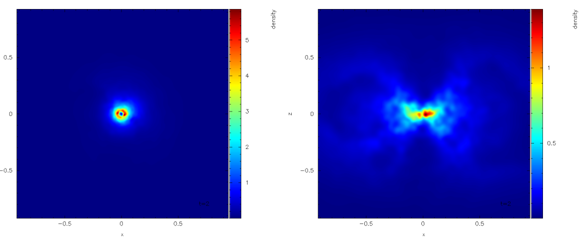

Fig. 1. Density on the XZ plane for polytropes with different rotation rates after $t = 2t_{\rm dyn}$.

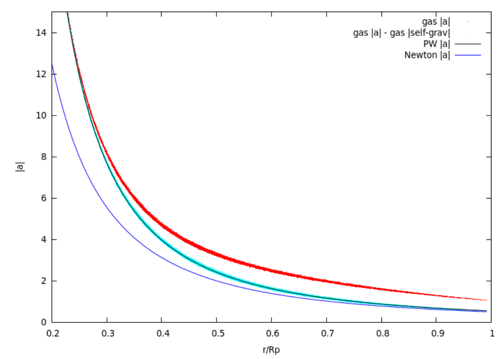

Fig. 2. The blue solid line and the black solid line represent the newtonian and the PW accelerations of a test particle due to the BH. The red dots represent the acceleration of gas particles considering self-gravity, and the cyan dots represent the acceleration of gas particles without self-gravity.

We included a Paczynski-Wiita potential for the BH and tested the PW potential by observing the collapse of a 1 $M_\odot$ non-rotating, polytropic envelope with very low internal energy (to avoid dispersion on the accelerations) and taking into account its self-gravity to compare its acceleration due to the BH potential. Now that the PW potential has become fully functional, the modifications on the code will focus towards a more detailed EOS and cooling/heating processes needed in the collapsar model.

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