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SELF-CONSISTENT SPECTRA FROM GRMHD SIMULATIONS WITH RADIATIVE COOLING: A LINK TO REALITY FOR SGR A*

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Abstract. Cosmos++ (Anninos et al., 2005) is one of the first fully relativistic magneto-hydro-dynamical (MHD) codes that can self-consistently account for radiative cooling, in the optically thin regime. As the code combines a total energy conservation formulation with a radiative cooling function, we have now the possibility to produce spectra energy density from these simulations and compare them to data. In this paper, we present preliminary results of spectra calculated using the same cooling functions from 2D Cosmos++ simulations of the accretion flow around Sgr A*. The simulation parameters were designed to roughly reproduce Sgr A*'s behavior at very low (10^{-8}-10^{-7} $M_\odot$/yr) accretion rate, but only via spectra can we test that this has been achieved.

Keywords: Sgr A*, MHD, radiation mechanisms: general, plasmas, radiative transfer, diffusion, acceleration of particles.

1 Methodology

Given some characteristics like temperature, mass density and magnetic pressure from the simulation, we can generate broad-band spectra with emission coming from Bremsstrahlung, Synchrotron and Compton effects. These signatures can then be compared to data (Fig. 1).

Simulation characteristics are time-averaged over one stable orbits (2.5-3.5 cycle) before generating a spectrum. We obtain then a steady-state emission spectrum to compare to data. Up-to-now, thirteen models have been simulated, set by the following parameters space:

1. Cooling = [ON, OFF]
2. $\dot{M} = 10^{[-8,-9]}\ M_\odot/\mathrm{yr}$
3. $\frac{Ti}{Te} = [1, 3, 10]$
4. Spin factor = [0, 0.5, 0.7, 0.9, 0.9]
5. Magnetic field configuration = [1, 4] -loop

The reference simulation has been chosen to have the following parameters:

1. Cooling = ON
2. $\dot{M} = 10^{-9}\, M_\odot/\mathrm{yr}$
3. $\frac{Ti}{Te} = 3$
4. Spin factor = 0.9
5. Magnetic field configuration = 4-loop

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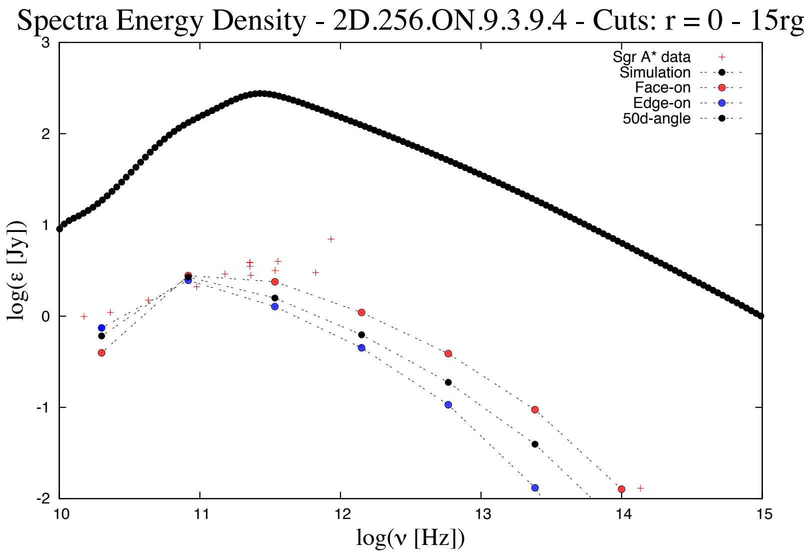

Fig. 1. Sgr A* data (*plus symbol and line*) from Melia & Falcke (2001). We show here synchrotron emission from the reference simulation B4S9T3M9C without taking into account inclination and grav. redshift (*line of black filled-circle*) followed by SEDs of the same simulation with three different angles of inclination: edge-on (*blue filled-circle*), 50 deg (*black filled-circle*) and face-on (*red filled-circle*)

2 Preliminary results

This work is still in development. Further simulations of Sgr A* are ongoing. But from our first results we can already draw some interesting conclusions:

1. Synchrotron emission is higher than expected. It is also broader. This divergence between models and data might come from the fact that we didn't take into account *inclination* considerations, *gravitational redshift* from region close to the black hole and *Doppler effect*.

2. Bremsstrahlung emission is too faint, as expected, most of the X-rays are dominated by cooler bremsstrahlung emission from the outer radii (e.g. Quataert (2002)), a part of the accretion disk which is not simulated presently.

3. Turning on cooling routines seems to have more effects on simulations with high accretion rate.

4. Tuning black hole spin to maximum generates too much magnetic field, hence too much emission.

5. Tuning temperature ration Ti/Te to 10 gets us closer to data.

6. So does tuning magnetic field configuration to 4-loop.

3 Conclusion

These spectra show Dibi et al. (see proceedings article, this volume) first set of runs are a good start in modeling Sgr A* even though they are generating too much power. We have great expectations in model B4S9T10M9 and it will be interesting to see how its spectrum behave when inclination and gravitational redshift effects will be taken into account.

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