Outflows in Radiative simulations of Ultra luminous X-ray sources

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The main objective

We present results General Relativistic Radiation magnetohydrodynamics simulations of super-Eddington accretion onto a $10M_{\odot}$ Schwarzschild Black hole. The mass accretion rate onto the BH is $\sim 40\dot{M}_{Edd}$ while strong outflows are present which may collimate radiation energy along polar axis.

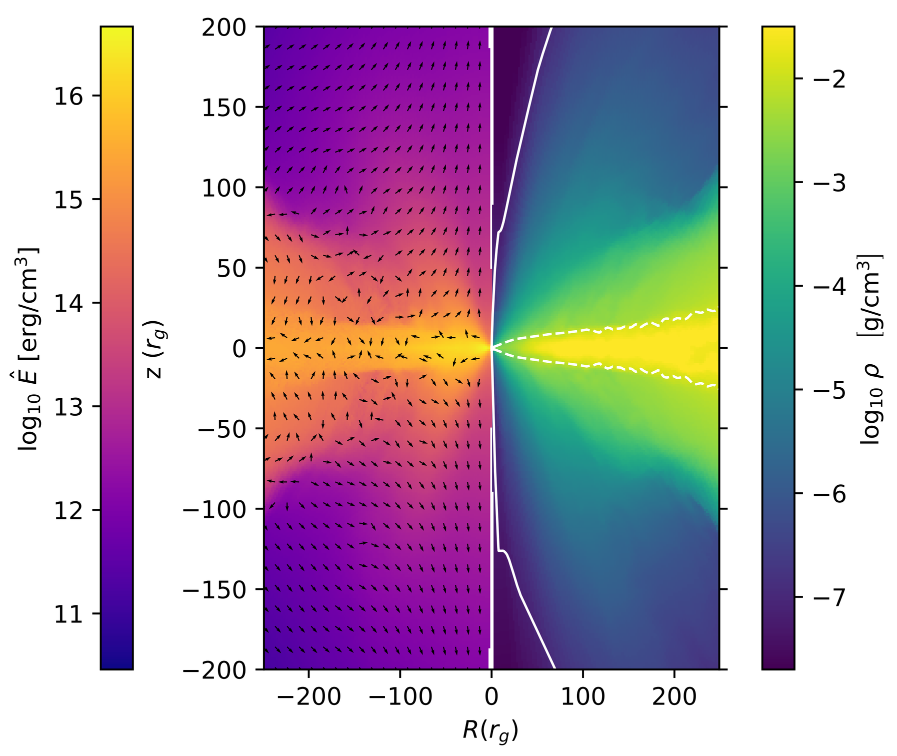
The main objective of this work is to measure the emission from ULXs that will reach a distant observe. Here I show some *preliminary* results of our work. In particular, I discuss about the geometrical and optical ***structure*** of the accretion disk and I show the magnitude and direction of various ***fluxes***.

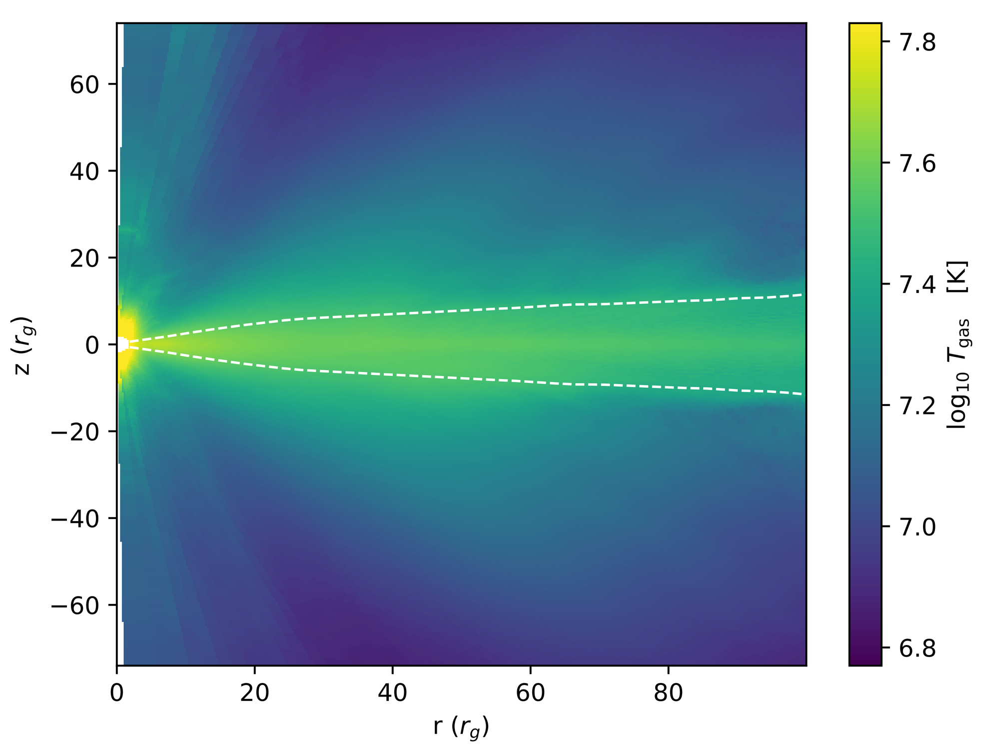
Structure

The figure shows the gas density (right pannel) and radiation energy density in the fluid frame (left pannel)

The solid and the dashed line in the figure show the location of the surface of the photosphere and disk scaleheight respectively.

The arrows show the direction of radiation flux in the fluid frame.

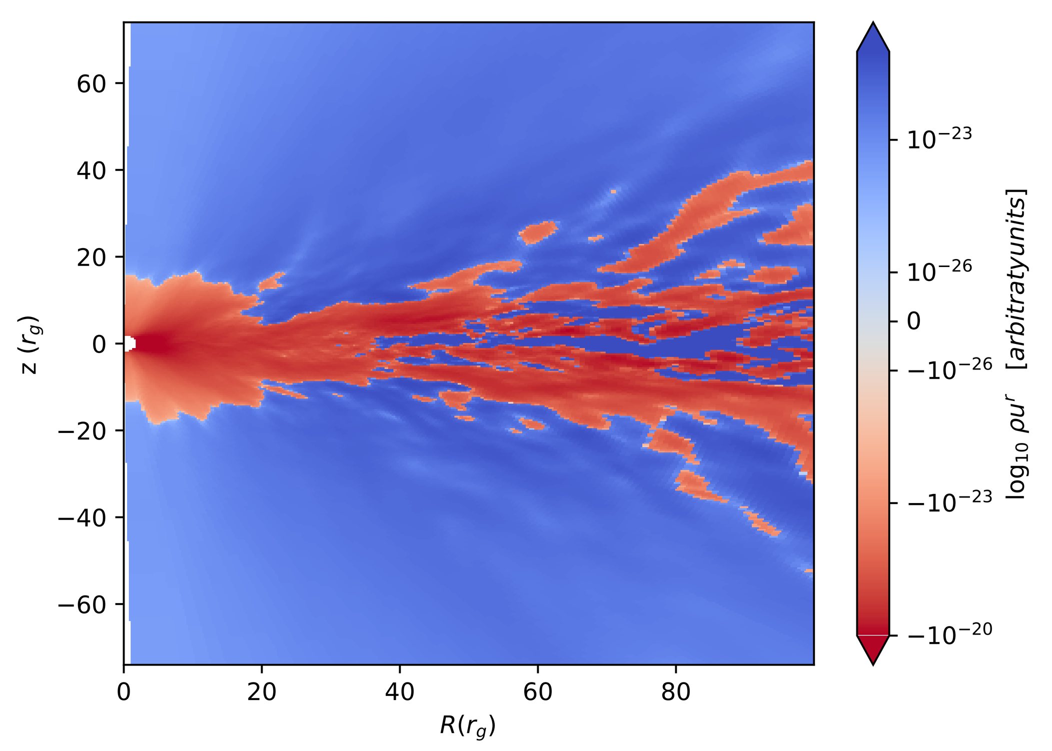




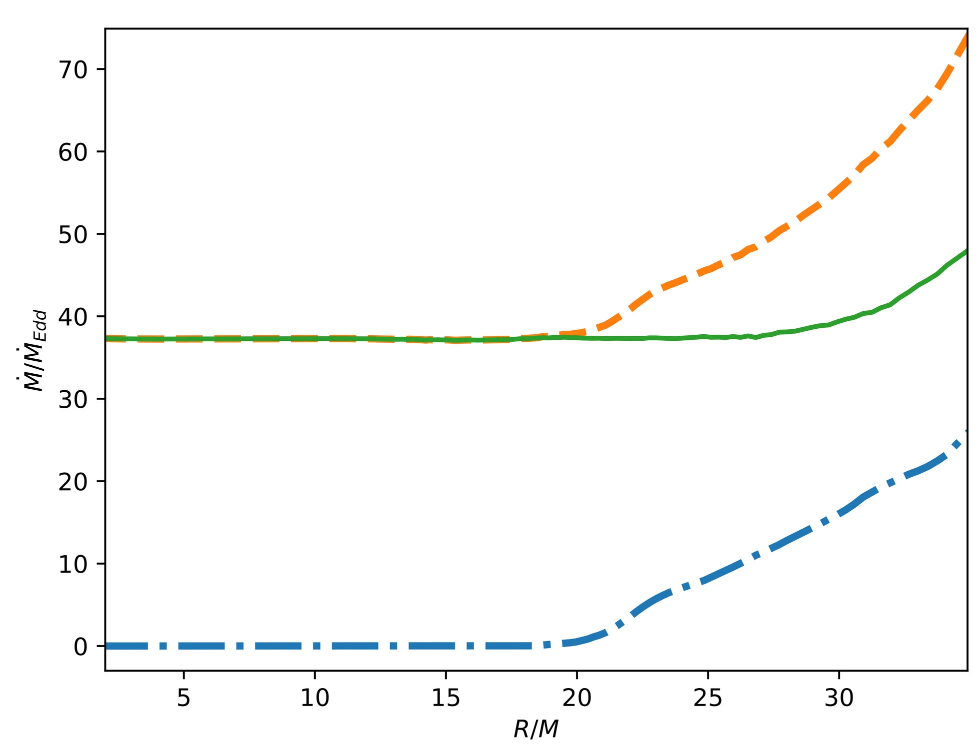
Initial condition

The 2.5D (axisymetric with a mean field dynamo) simulation were initialized by an equilibrium torus (Penna et al., 2013). Magnetic instabilities drive turbulence which lead to outwards transfer of angular momentum and accretion to occur. The initial torus density determines the final steady accretion rate and thus, also affect the final the geometrical structure of the disk. The inner edge of the torus is set to $R_{in} = 35M$ and the initial angular momentum on the equatorial plane is set up as a fraction of the Keplerian Ω multiplied by a factor $\xi = 0.995$ for $R > R_1 = 20M$. Inside R_1, the angular momentum is constant. The torus is initially threaded with a quadrupolar magnetic field, such that the maximum magnetization in the torus is $\beta = p_{mag}/p_{gas} = 20$, where p_{mag} is the magnetic pressure.

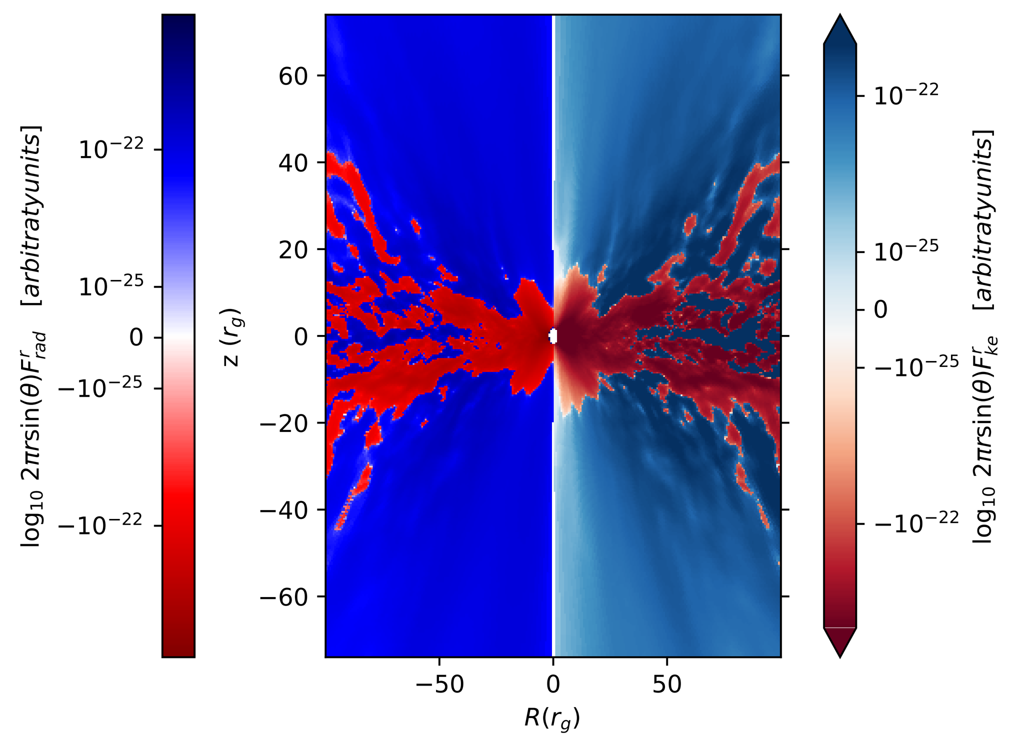
Rest mass flux



The figure below shows the time average mass accretion rate as a function of radius.The solid line shows the net accretion rate and the dashed-dotted line the outflow rate and the inflow rate is denoted with the dashed line. The simulation has reach to a steady state in the inflow equilibrium up to a radius of $\sim$ 25M.



Radiation & Kinetic Fluxes



Conclusions

The dense and hot part of the disk is obscured by an optically and geometrically thick region of lower density and temperature of $\sim$ 2.5keV. Photons emitted from the disk are scattered many times in the optically thick region which may resembles a corona that comptonizes soft photons to X-rays.

From this preliminary study we draw the following main conclusions:

- We locate the photosphere, the last scattering surface, close to the polar axis.
- The Radiation escaping towards to an observer along the polar axis.
- We measure the kinetic and radiation fluxes, we found strong outflows that collimate the radiation flux along the polar axis.

We show simulations of a non-spinning black hole. For spinning black hole one would expect stronger outflow and the radiation to be more collimated compared to the results of a Schwarzschild BH we show here.

In future work, we plan to extend the simulation in time and reach to an equilibrium state further away in radius, which would allow making further conclusion regarding the decomposition the total energy flux into its components and integrate to find the luminosity escaping from the surface of the photosphere and measure the isotropic apparent luminosity that reaches a distant observer according to the viewing angle. Finally, we also plan to study how the BH spin would the affect these results.