Topical projects in research (FFYS7039). 2 points.

Accretion disk.

Consider accretion disk around a black hole of mass M. Compute:

(1) The surface temperature $T_s(r)$. Find the location of the temperature maximum, $r_{\rm max}$. Plot T_s versus $r/R_{\rm S}$ in logarithmic scale, i.e. $\log T_s$ vs. $\log(r/R_{\rm S})$. Here $R_{\rm S} = 2GM/c^2$.

(2) Assuming that the disk locally emits as a black body with intensity described by Planck function $B_\nu(T_s)$, compute the disk spectrum as seen by a distance observer.

(3) Compute the Thomson optical depth to the disk midplane, $\tau_0(r)$ for $r_* < r < r_{\rm out}$, and the ratio H/r. Compute the ratio $P_{\rm gas}/P_{\rm rad} = 2nkT/(aT^4/3)$ as a function of radius. Plot H/r, τ_0, and $P_{\rm gas}/P_{\rm rad}$ versus $r/R_{\rm S}$ in log scale.

For numerical evaluations, take $M = 10M_\odot$, inner disk radius $r_* = 3R_{\rm S}$, outer disk radius $r_{\rm out} = 10^5 R_{\rm S}$, accretion rate $\dot{m} = \dot{M}c^2/L_{\rm Edd} = 1$, where $L_{\rm Edd} = 2\pi R_{\rm S} m_p c^3/\sigma_{\rm T}$ is the Eddington luminosity, $\alpha = 0.01$. Assume the disk inclination to the line of sight $i = 30^o$.

For analytical work consider dimensionless variables $x = r/R_{\rm S}$, and scale all other variables using some typical values, e.g. $\bar{l}(r) = l(r)/\sqrt{GM_\odot R_{\rm S}}$.

For all calculations use Newtonian and pseudo-Newtonian potentials, and compare the results.