ENERGY BALANCE BETWEEN DISK AND CORONA

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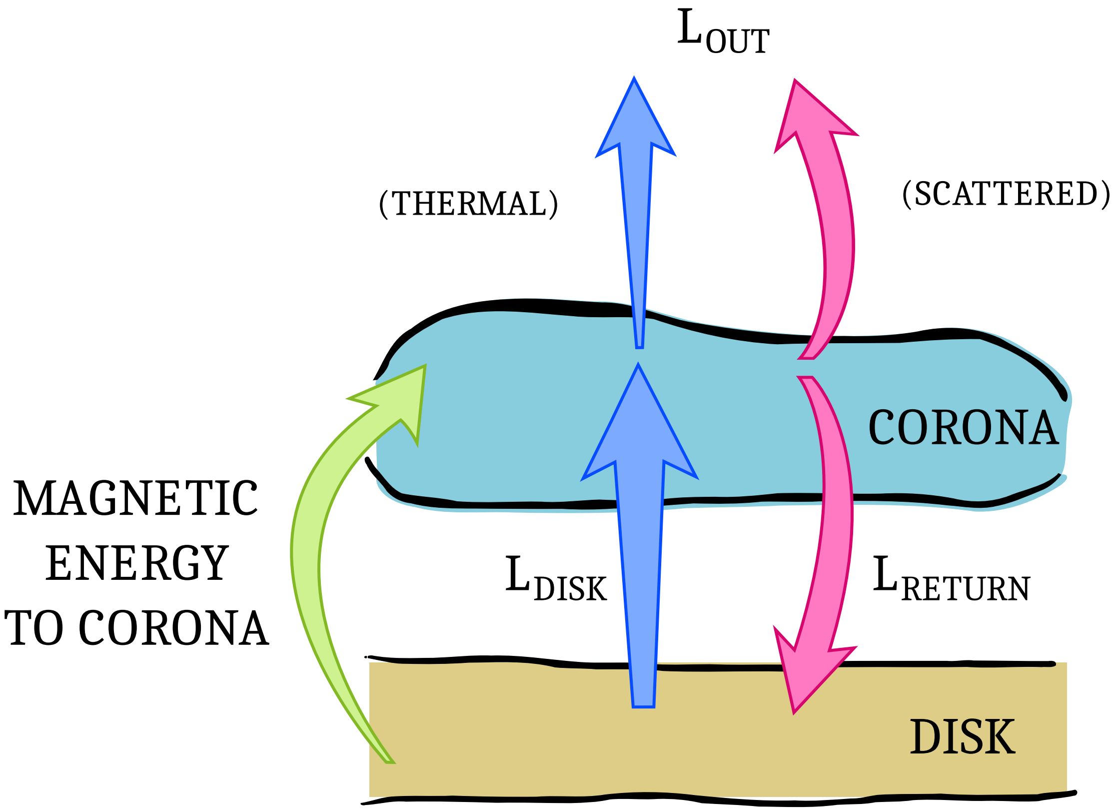
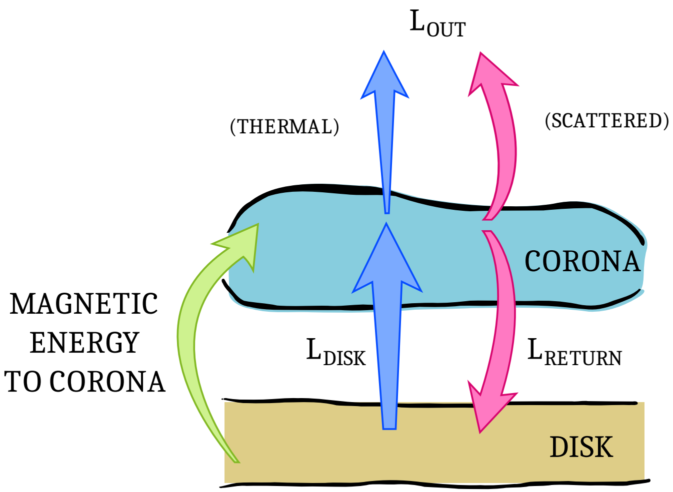
The Model



L OUT
(THERMAL)
(SCATTERED)
CORONA
MAGNETIC
ENERGY
TO CORONA
L DISK
L RETURN
DISK

Equations for disk-corona energy balance II.



$$L_{\mathrm{OUT}} = e^{-\tau}\, L_{\mathrm{DISK}} + \tfrac{1}{2}\left[(1-e^{-\tau})L_{\mathrm{DISK}} + L_{\mathrm{SC}}\right]$$

$$L_{\mathrm{RET}} = \tfrac{1}{2}\left[(1-e^{-\tau})L_{\mathrm{DISK}} + L_{\mathrm{SC}}\right]$$

$$L_{\mathrm{DISK}} = L_{\mathrm{RAD}} + L_{\mathrm{RET}}$$

$$L_{\mathrm{ACC}} = \begin{cases} \text{(radiative cooling)} & L_{\mathrm{RAD}} = \alpha\, L_{\mathrm{ACC}} \\ \text{(magnetic fields)} & L_{\mathrm{SC}} = (1-\alpha)\, L_{\mathrm{ACC}} \end{cases}$$

$$\Longrightarrow \; L_{\mathrm{OUT}} = L_{\mathrm{ACC}}$$

(energy conservation)

Equations for disk-corona energy balance III.

$$L_{\mathrm{OUT}} = (1-k)\, L_{\mathrm{DISK}} + k\, e^{-\tau}\, L_{\mathrm{DISK}} + \tfrac{1}{2}\left[k(1-e^{-\tau})L_{\mathrm{DISK}} + L_{\mathrm{SC}}\right]$$

$$L_{\mathrm{RET}} = \tfrac{1}{2}\left[k(1-e^{-\tau})L_{\mathrm{DISK}} + L_{\mathrm{SC}}\right]$$

$$L_{\mathrm{DISK}} = L_{\mathrm{RAD}} + L_{\mathrm{RET}}$$

$$\Longrightarrow\ L_{\mathrm{OUT}} = L_{\mathrm{ACC}}$$

(energy conservation)

Equations for disk-corona energy balance IV.

$$L_{\mathrm{OUT}} = \left[(1-k) + k\,e^{-\tau} + \tfrac{1}{2}k(1-e^{-\tau})\right]\,L_{\mathrm{DISK}} + \tfrac{1}{2}(1-\alpha)\,L_{\mathrm{ACC}}$$

$$L_{\mathrm{RET}} = \left[\tfrac{1}{2}k(1-e^{-\tau})\right] + \tfrac{1}{2}(1-\alpha)\,L_{\mathrm{ACC}}$$

$$L_{\mathrm{DISK}} = \alpha\,L_{\mathrm{ACC}} + L_{\mathrm{RET}}$$

$$\frac{L_{\mathrm{DISK}}}{L_{\mathrm{ACC}}} = \frac{1+\alpha}{2-k(1-e^{-\tau})}$$

$$\alpha \in [0,1] \implies \gamma \le \frac{L_{\mathrm{DISK}}}{L_{\mathrm{ACC}}} \le 2\gamma$$

$$\gamma = \left[2-k(1-e^{-\tau})\right]^{-1} \qquad \gamma \in \left[\tfrac{1}{2},1\right]$$

Equations for disk-corona energy balance V.

$$
\begin{aligned}
L_{\mathrm{OUT}} &= \text{thermal} + \text{scattered} \\
&= (\text{black-body}) + (\text{nthcomp})
\end{aligned}
$$

$$L_{\mathrm{NTHCOMP}}(T^{\mathrm{eff}}_{\mathrm{DISK}}, \Gamma, T_e) = \tfrac{1}{2}(1 - e^{-\tau})\, k\, L_{\mathrm{DISK}} + \tfrac{1}{2}\, L_{\mathrm{SC}} + \tfrac{1}{2}\, k\, e^{-\tau}\, L_{\mathrm{DISK}}$$

$$L_{\mathrm{OUT}} = (1 - k)\, L_{\mathrm{DISK}} + k\, e^{-\tau}\, L_{\mathrm{DISK}} + \tfrac{1}{2}\left[k(1 - e^{-\tau}) L_{\mathrm{DISK}} + L_{\mathrm{SC}}\right] \rightarrow$$

$$\rightarrow L_{\mathrm{OUT}} = \left[1 - k + \tfrac{1}{2}\, k\, e^{-\tau}\right]\, L_{\mathrm{DISK}} + L_{\mathrm{NTHCOMP}}(T^{\mathrm{eff}}_{\mathrm{DISK}}, \Gamma, T_e)$$

Equations for disk-corona energy balance VI.

$$L_{\mathrm{NTHCOMP}} = \tfrac{1}{2}(1-e^{-\tau})\,k\,L_{\mathrm{DISK}} + \tfrac{1}{2}\,L_{\mathrm{SC}} + \tfrac{1}{2}\,k\,e^{-\tau}\,L_{\mathrm{DISK}}$$

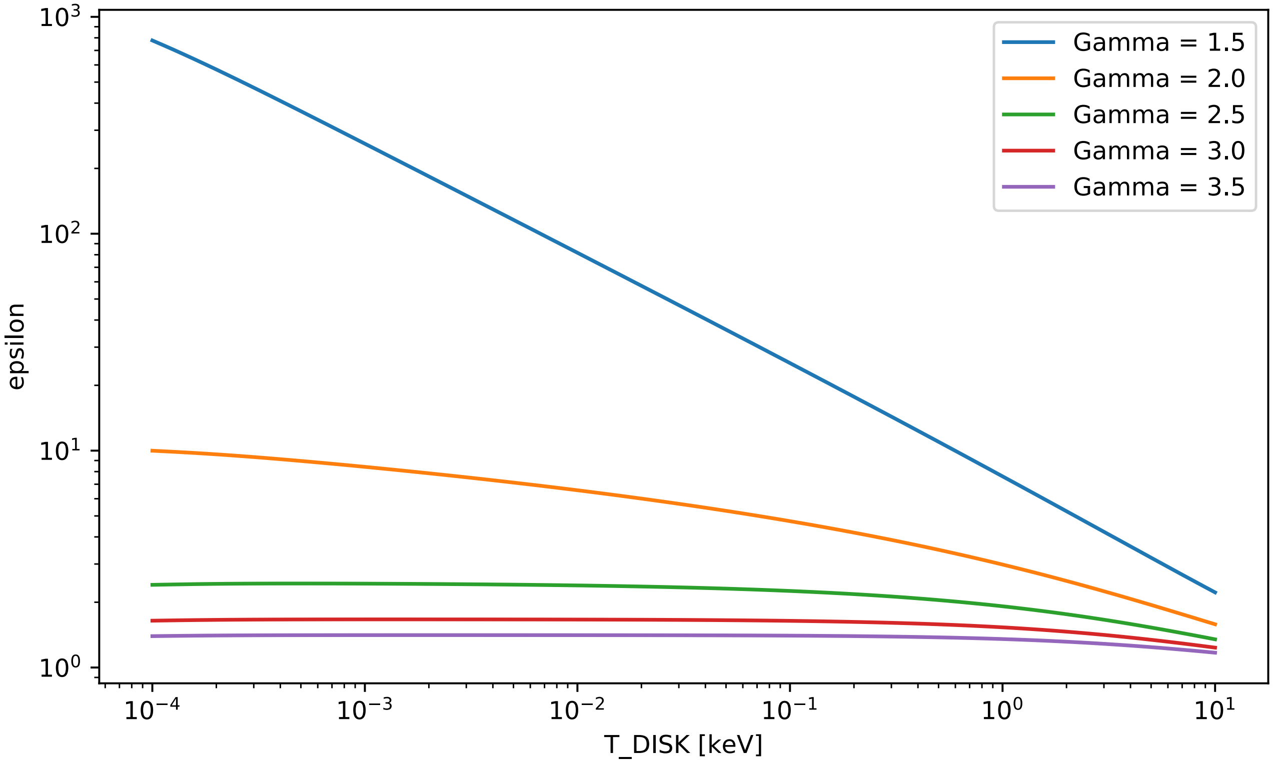
$$N_{\mathrm{NTHCOMP}} = \tfrac{1}{2}\,k\,N_{\mathrm{DISK}}$$

$$\bar{E}_{\mathrm{NTHCOMP}} = \frac{L_{\mathrm{NTHCOMP}}}{N_{\mathrm{NTHCOMP}}} = L_{\mathrm{NTHCOMP}} / (\tfrac{1}{2}\,k\,\sigma_p\,{T^{\mathrm{eff}}_{\mathrm{DISK}}}^{3})$$

$$\bar{E}_{\mathrm{DISK}} = \frac{L_{\mathrm{DISK}}}{N_{\mathrm{DISK}}} = L_{\mathrm{DISK}} / (\sigma_p\,{T^{\mathrm{eff}}_{\mathrm{DISK}}}^{3})$$

$$\epsilon = \frac{\bar{E}_{\mathrm{NTHCOMP}}}{\bar{E}_{\mathrm{DISK}}} = \frac{2}{k}\,\frac{L_{\mathrm{NTHCOMP}}}{L_{\mathrm{DISK}}}$$

Equations for disk-corona energy balance - ϵ



Equations for disk-corona energy balance VII.

$$L_{\rm OUT} = \left[1 - k + \tfrac{1}{2}\, k\, e^{-\tau}\right]\, L_{\rm DISK} + L_{\rm NTHCOMP}\,(T_{\rm DISK}^{\rm eff}, \Gamma, T_e)$$

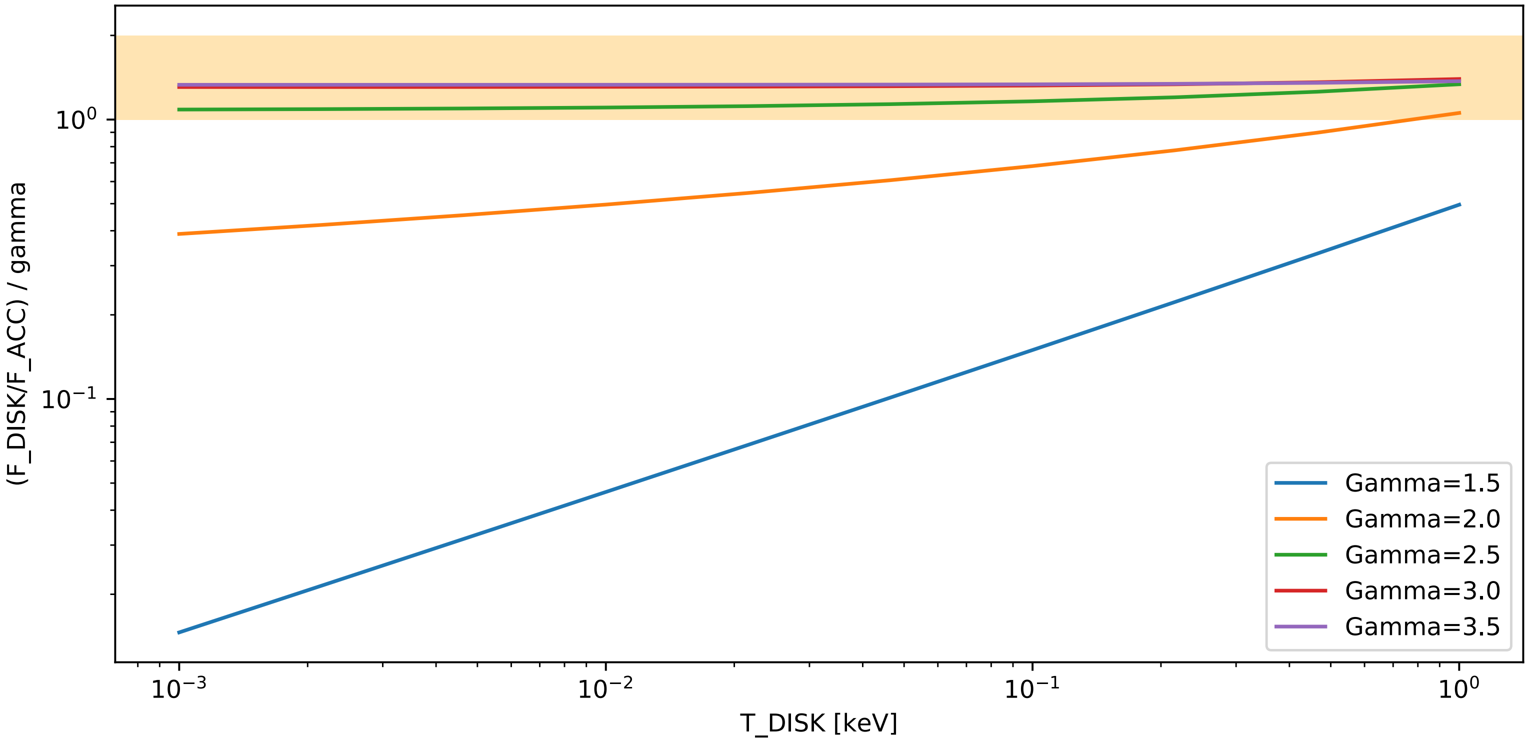
$$\frac{L_{\rm OUT}}{L_{\rm DISK}} = 1 - k + \tfrac{1}{2}\, k\, (\epsilon + e^{-\tau}) = \frac{2 - k(1 - e^{-\tau})}{1 + \alpha}$$

$$k = \frac{2(1 - \alpha)}{\alpha(\epsilon + e^{-\tau}) + (\epsilon - e^{-\tau}) + 2\alpha}$$

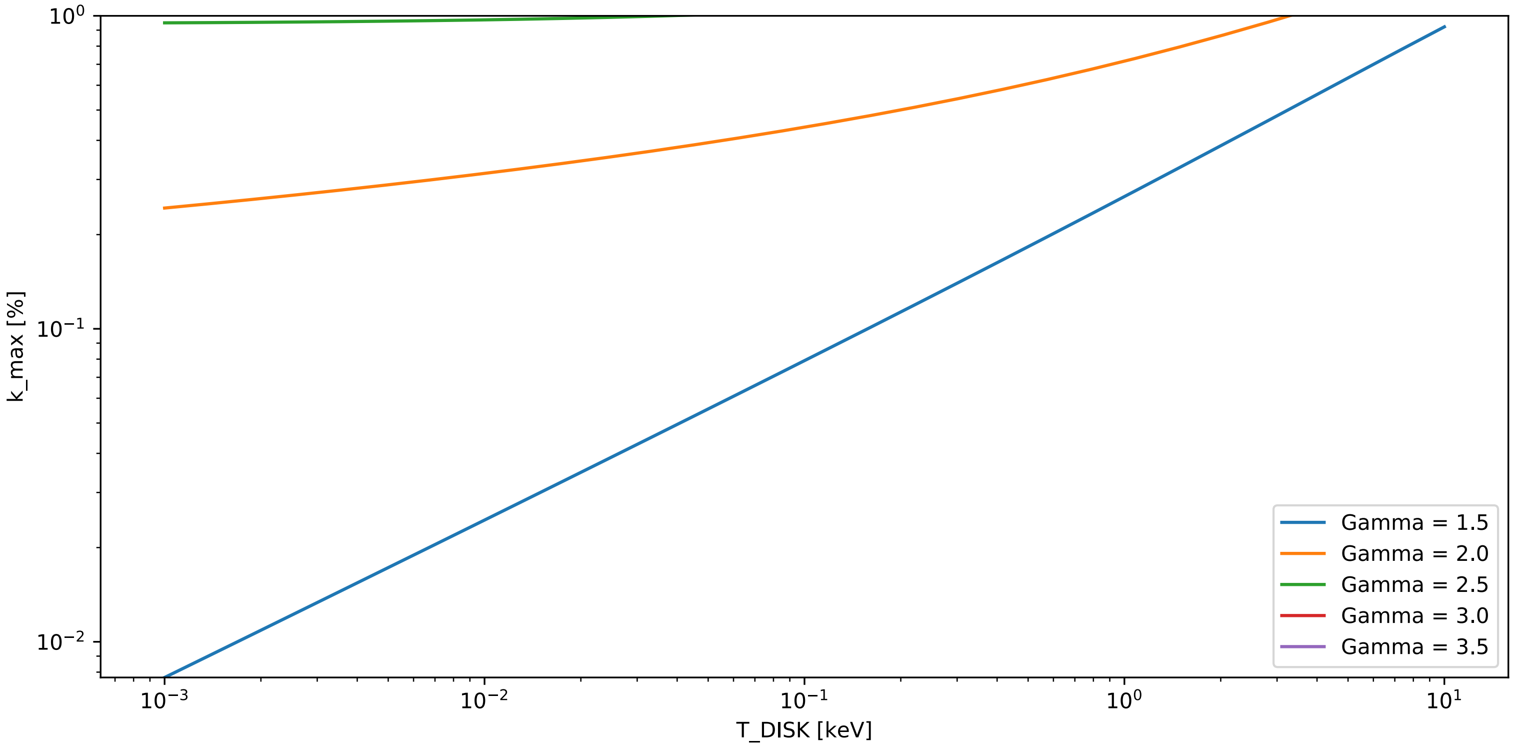
$$k \leq \frac{2}{\epsilon - e^{-\tau}}\ , \quad \epsilon > 1$$

(NOTE: LOCAL ANALYSIS ONLY)

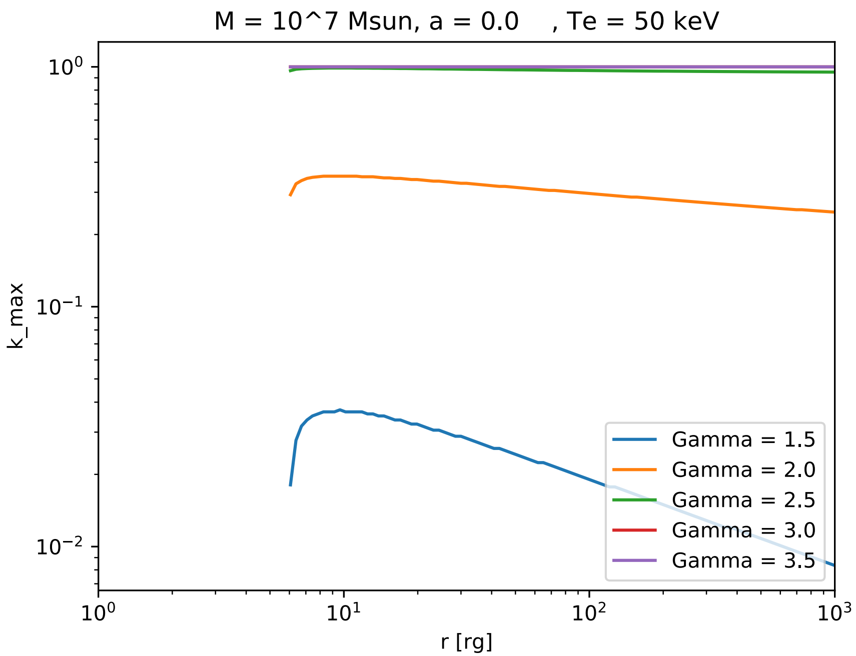
Conditions for energy balance

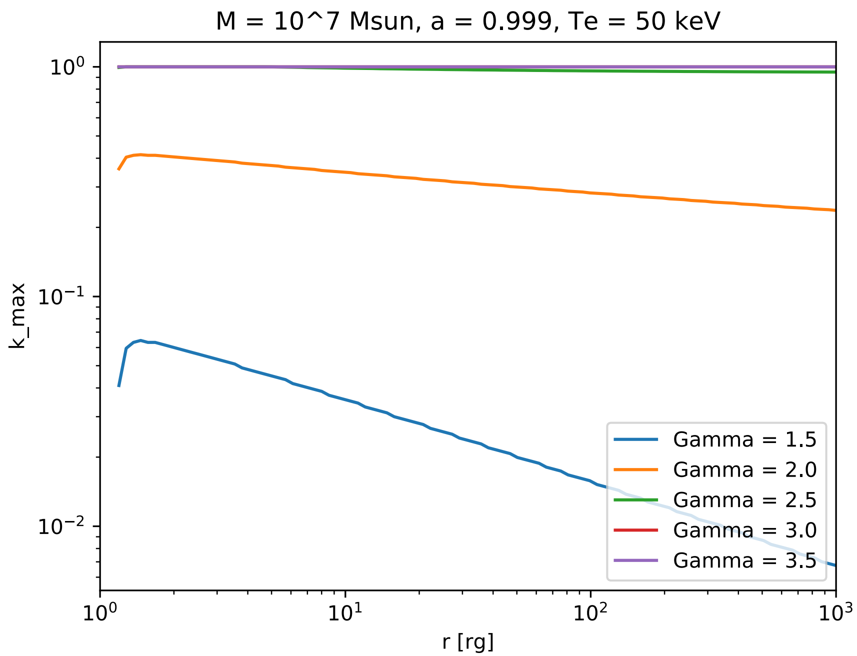


Maximal coverage factor



Maximal coverage factor





Summary

Slab geometry corona with 100% coverage can only work for steepest photon indexes.

Cold parts of the disk do not produce enough power to energize coronal electrons.

$$\Longrightarrow$$

In most cases, corona must be patchy and/or temporaly flaring and spatially limitted.