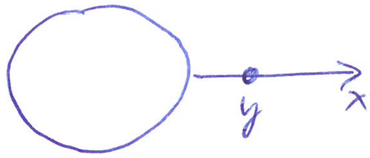
$\boxed{\text{Corona}}$

→ how to estimate the density from the observations



$y \perp x$; $y \parallel$ l.o.s.

→ spherically symmetric corona

E_k ... emission in the local volume for the l.o.s.

$$\rho^2 = \left(\frac{r}{R_\odot}\right)^2 = x^2 + y^2 \Rightarrow \rho\, d\rho = y\, dy = \sqrt{\rho^2 - x^2}\, dy$$

observed intensity:

$$I(x) = \int_{-\infty}^{\infty} E_k(\rho)\, dy = 2\int_0^{\infty} E_k(\rho)\, dy =$$

$$= 2\int_0^{\infty} \frac{\rho\, E_k(\rho)}{\sqrt{\rho^2 - x^2}}\, d\rho$$

E_k unknown, $I(x)$ measured ⇒ we invert

inverse Abel tranform:

$$\Rightarrow E_k(\rho) = -\frac{1}{\pi}\int_{\rho}^{\infty} \frac{dI/dx}{\sqrt{x^2 - y^2}}\, dx$$

ansatz: intensity of the K-corona is due to the Thomson scattering ~~of~~ on free electrons

$$\rightarrow E_k(\rho) = \sigma_T\, n_e\, \frac{1}{4\pi}\int I_\odot(\vartheta)\, d\Omega^*$$

$$d\Omega = r\, d\vartheta\, d\varphi$$

we compare the two solution e.g. in a form of the series:

$$n_e(\rho) = n_{e0}\left(\frac{1.55}{\rho^6} + \frac{2.99}{y^{16}}\right); \quad n_{e0} = 10^{14}\, m^{-3}$$

rough estimate at $1R_\odot$ distance:

$$E_k \sim \sigma_T\, n_e\, R_\odot I_\odot; \quad E_k(R_\odot) \sim 10^{-6} I_\odot$$

$$\Rightarrow n_e \sim \frac{E_k(R_\odot)}{\sigma_T R_\odot I_\odot} \sim \underline{4 \times 10^{13}\, m^{-3}}$$

=V=

$\boxed{\text{Emission lines}}$

→ X-rays and EUV regions

emission line of the $(m-1)$-times ionized element X (X^{+m}), there in transition $j \to i$ electron levels.

$$X_j^{+m} \to X_i^{+m} + h\nu_{ij}$$

emissivity: $P_\nu = \underbrace{N_j(X^{+m})}_{\text{density}} \underbrace{A_{ji}}_{\text{Einstein coefficient}} h\nu_{ij} \underbrace{\varphi_\nu}_{\text{emission profile}}$

$$\int \varphi_\nu \, d\nu = 1$$

coronal approximation — j-level populated from the ground state g by collisions with electrons.
Depopulation radiatively

then: $P_{gj} = \underbrace{A_X}_{[X/H]\text{ abundance}} \underbrace{G(T, \lambda_{gj})}_{\text{contribution function}} \frac{hc}{\lambda_{gj}} \underbrace{N_e^2}_{\text{electron density}}$

$A_X N_e \sim [X]$

radiative flux at distance R

$$F(\lambda_{gj}) = \frac{1}{4\pi R^2} \int_V P_{gj} \, dV =$$

$$= \frac{1}{4\pi R^2} A_X \int G(T, \lambda_{gj}) \frac{hc}{\lambda_{gj}} N_e^2 dV =$$

$$= \frac{1}{4\pi R^2} A_X \int G(T, \lambda_{gj}) \frac{hc}{\lambda_{gj}} Q(T) dT$$

where: $N_e^2 dV = \underbrace{Q(T)}_{\text{differential emission measure (DEM)}} dT$

DEM – measure of the amount of radiating plasma as a function of temperature from the other side:

for 1-D: $EM = \int N_e^2 \, dz$ emission measure

$$EM = \int N_e^2 \, dz = \int N_e^2 \frac{dz}{dT} \, dT = \int \underbrace{N_e^2 \left(\frac{dT}{dz}\right)^{-1}}_{DEM = Q(T)} dT$$

$$N_e^2 \, dV = \underbrace{N_e \, dV}_{\text{number of free electrons}} \, N_e \leftarrow \text{electron density}$$

number of free electrons: excitation of the electrons to higher levels by collisions ⇒ intensity of the ~~emitting~~ emitted radiation depends on it

for the region

$$L = 4\pi R^2 \, F(\lambda_{gj}) = \int N_e^2 \, P(T) \, dV = \int Q(T) P(T) \, dT$$

$$P(T) = A_x \, G(T, \lambda_{gj}) \, \frac{hc}{\lambda_{gj}}$$

↳ radiative losses → only function of T (weak)

$\Rightarrow L \sim N_e^2 \Rightarrow$ coronal brightness above active regions is mostly due to larger N_e

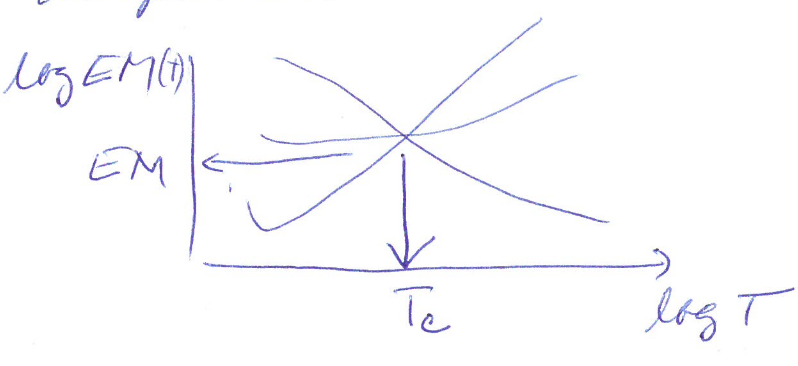
Diagnostics

for isothermal plasma: $F = \frac{1}{4\pi R^2} G(T_e) \, EM(T)$

$$\Rightarrow \underbrace{EM(T)}_{\text{EM loci}} = 4\pi R^2 \frac{F}{G(T)}$$

EM loci → strong dependence on T

diagnostics: EM(T) for several ions:



isothermal plasma – all EM(T) curves cross in one point ↳ (EM, Te)

if not → plasma multithermal

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more ions   EM(T) for different transitions
              of the same ion indistinguishable

the best → various ions of the same species
              (lesser inaccuracies from atomic
              physics)

a large number of line → vertical shift
   of crossections can be used to derive
   the abundances