Bounds on Dark Matter Lifetime from the Cosmic Dawn

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based on: 1803.11169 with A. Podo

SCUOLA NORMALE SUPERIORE

INFN

$$\tau_{\text{DM}} > \text{age of the Universe} \sim 10^{17}\,\text{s}$$

can we say more ?

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Yes!

An absorption profile centred at 78 megahertz in the sky–averaged spectrum

Judd D. Bowman[1], Alan E. E. Rogers[2], Raul A. Monsalve[1,3,4], Thomas J. Mozdzen[1] & Nivedita Mahesh[1]

after recombination and prior re-ionization

$$1100 \lesssim z \lesssim 10$$

most of the Universe matter is in the form of neutral Hydrogen

HI cloud

$z \sim 10$ dark ages $z \sim 1100$
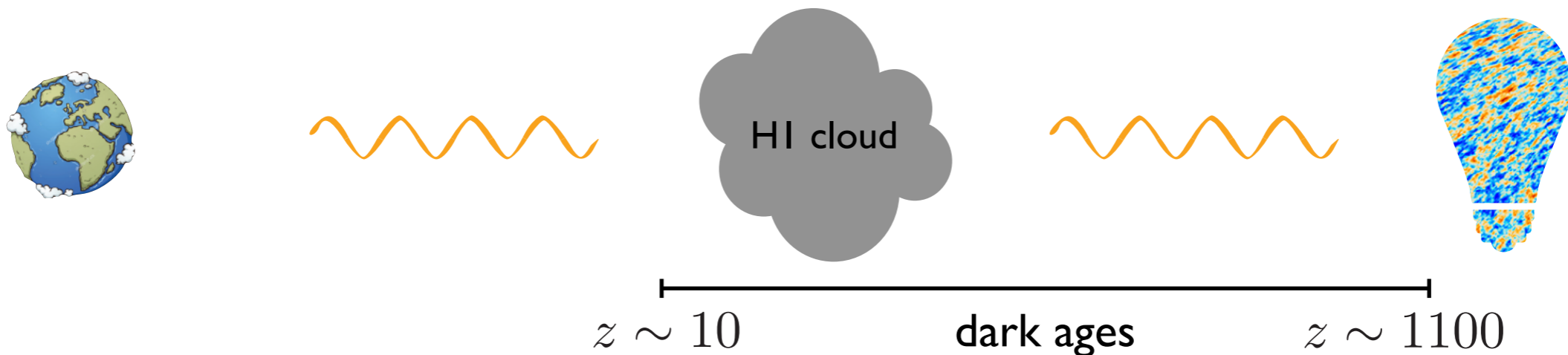
CMB has to propagate through HI clouds to reach us
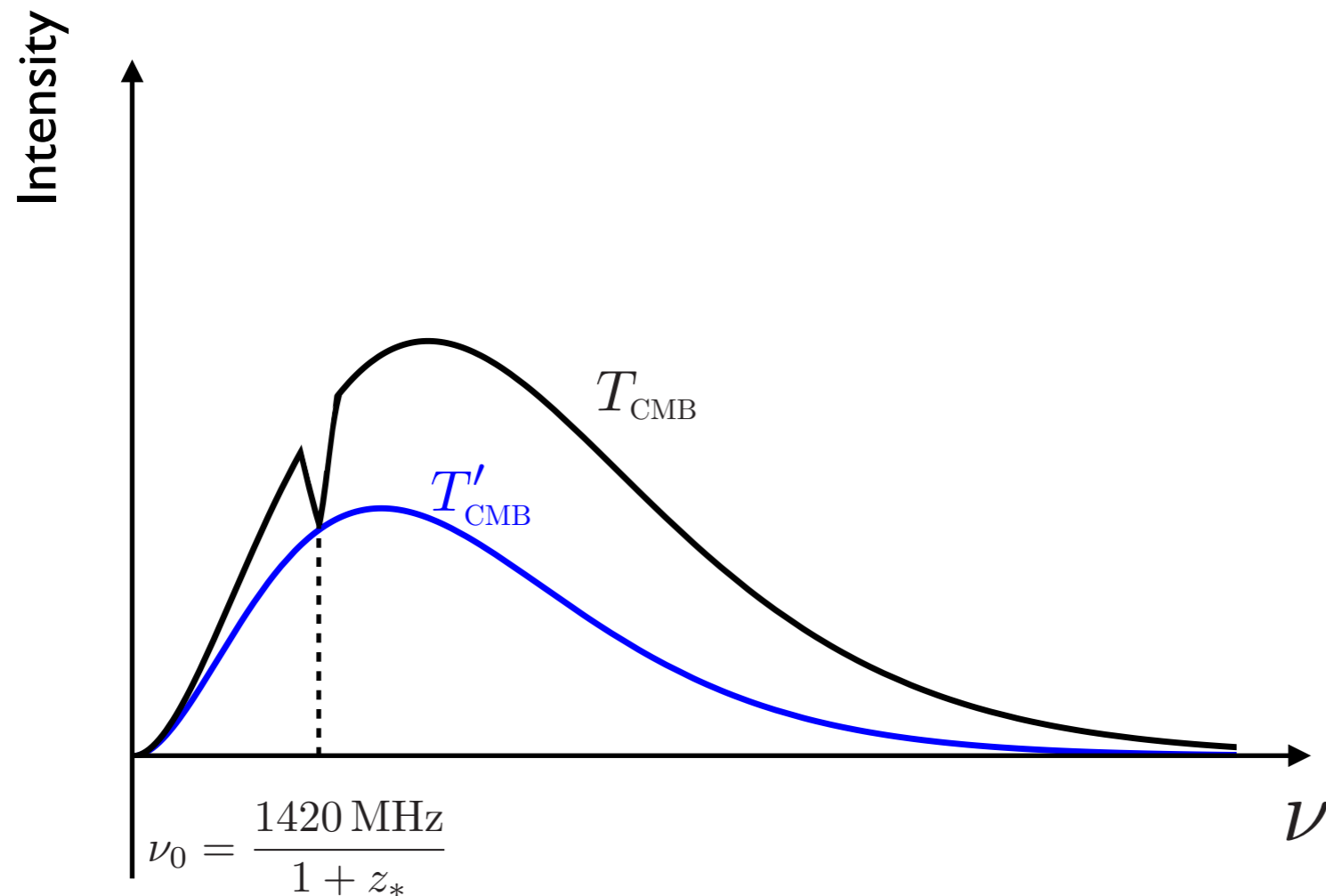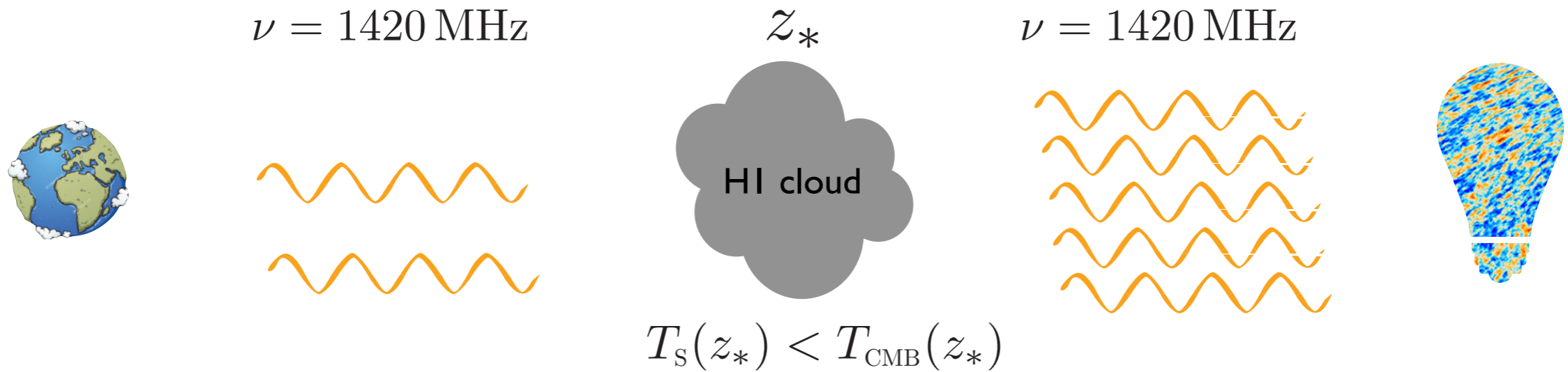
1s

$\Delta E = 5.9 \times 10^{-6} \, \text{eV}$
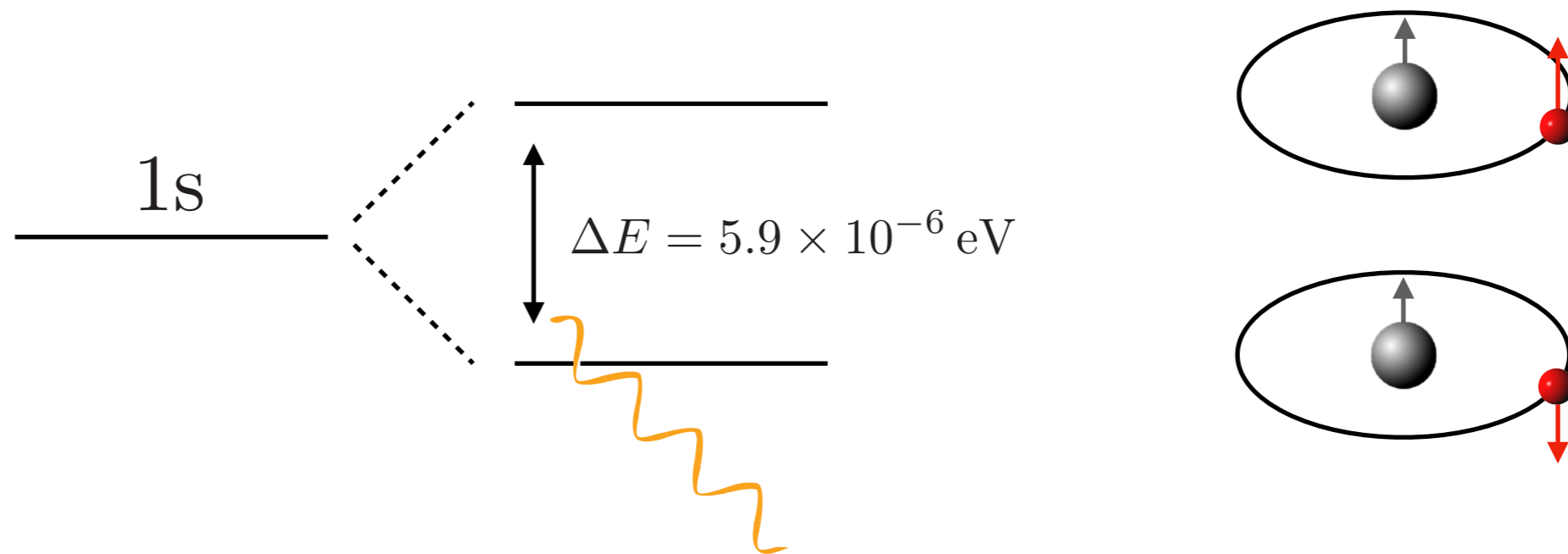
$\nu = 1420.4057 \, \text{MHz}$

$\lambda = 21.106144 \, \text{cm}$

relative occupation of the hyperfine levels is parametrized in term of the spin temperature

$$\frac{n_1}{n_0} \equiv \frac{g_1}{g_0} e^{-\Delta E / T_S}$$

$$\nu = 1420 \,\mathrm{MHz}$$
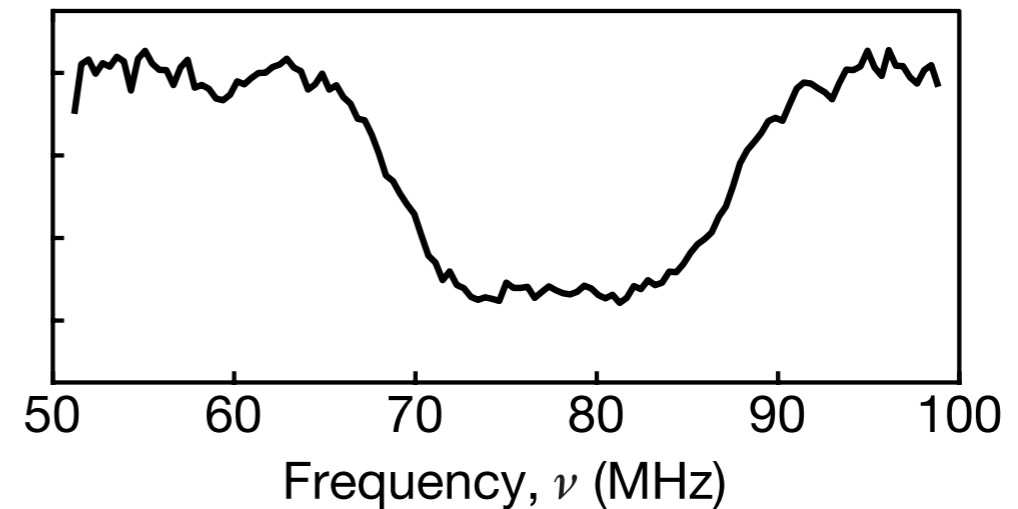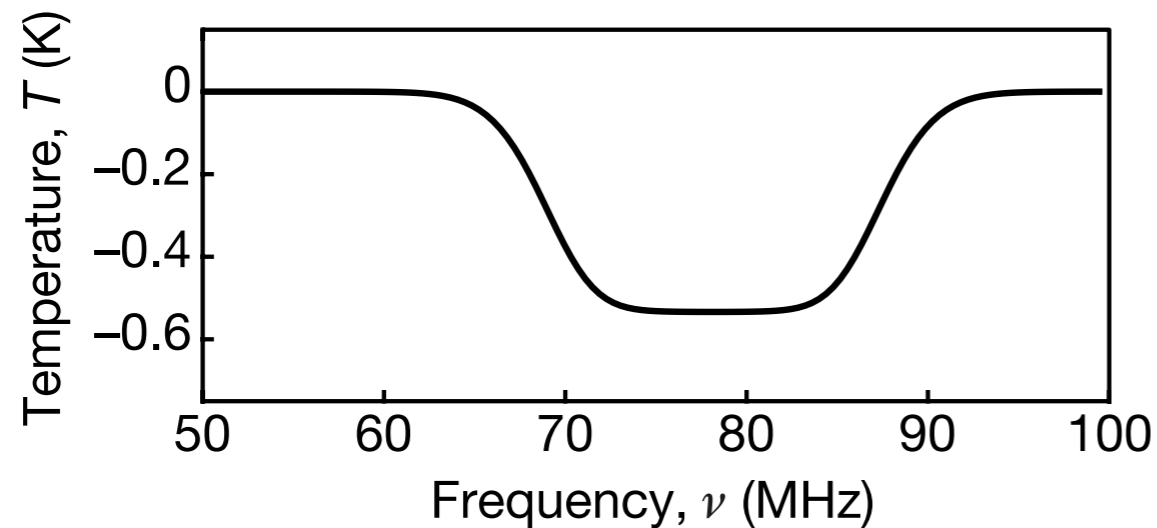
$$z_*$$

$$\nu = 1420 \,\mathrm{MHz}$$

HI cloud

$$T_{\mathrm{S}}(z_*) < T_{\mathrm{CMB}}(z_*)$$

Intensity

$$T_{\mathrm{CMB}}$$

$$T'_{\mathrm{CMB}}$$

$$\nu_0 = \frac{1420 \,\mathrm{MHz}}{1 + z_*}$$

$$\nu$$

$$\delta T_b \equiv T'_{\mathrm{CMB}} - T_{\mathrm{CMB}}$$

$$\delta T_b \propto \left(1 - \frac{T_{\mathrm{CMB}}}{T_{\mathrm{S}}} \right)$$

$$T_{\mathrm{gas}} < T_{\mathrm{S}}$$

absorption feature centered around 78MHz

Bowman et al., Nature, 2016

location of the line ⟷ **when**

$$\nu_0 \simeq 78\,\text{MHz} \qquad z_* \simeq 17$$

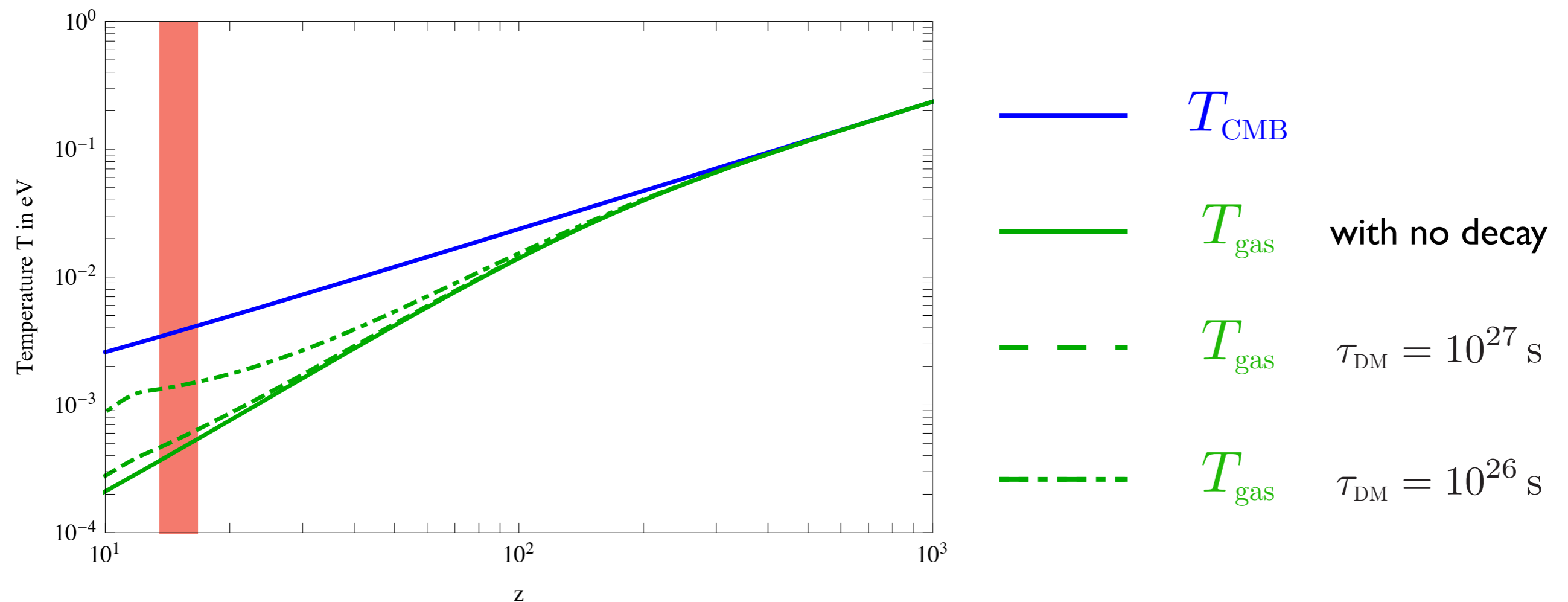**line strength** ⟷ **gas properties @ z_***

$$\delta T_b \simeq -500\,\text{mK} \qquad T_{\text{gas}} < T_{\text{s}} \lesssim 5\,T_{\text{CMB}}$$
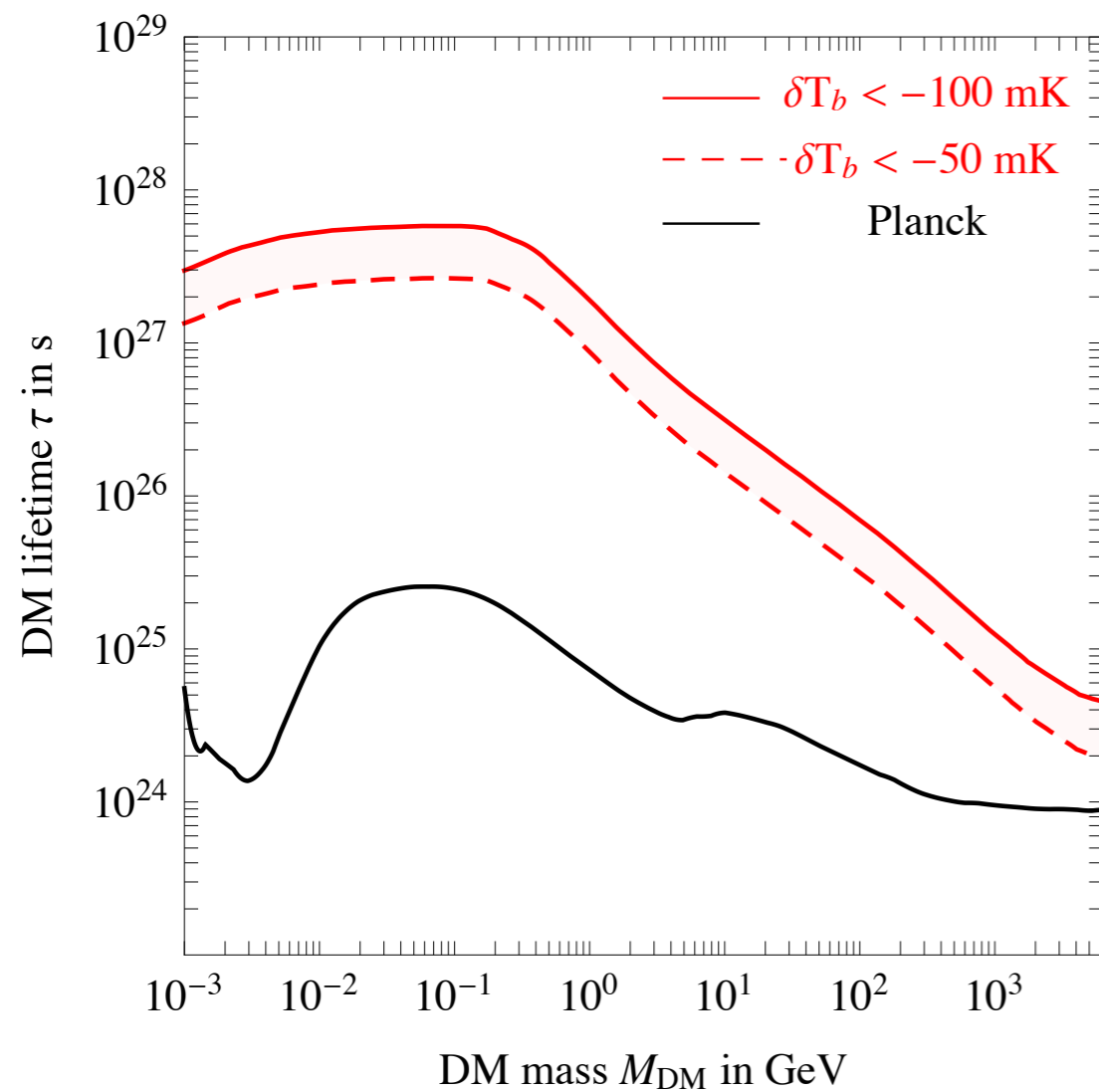
the energy released in **DM decays** heat the IGM

$$\left(\frac{dE}{dV dt}\right)_{\text{deposited}} = f(z, M_{\text{DM}})\rho_{\text{DM},0}\, \tau_{\text{DM}}^{-1}(1+z)^3$$
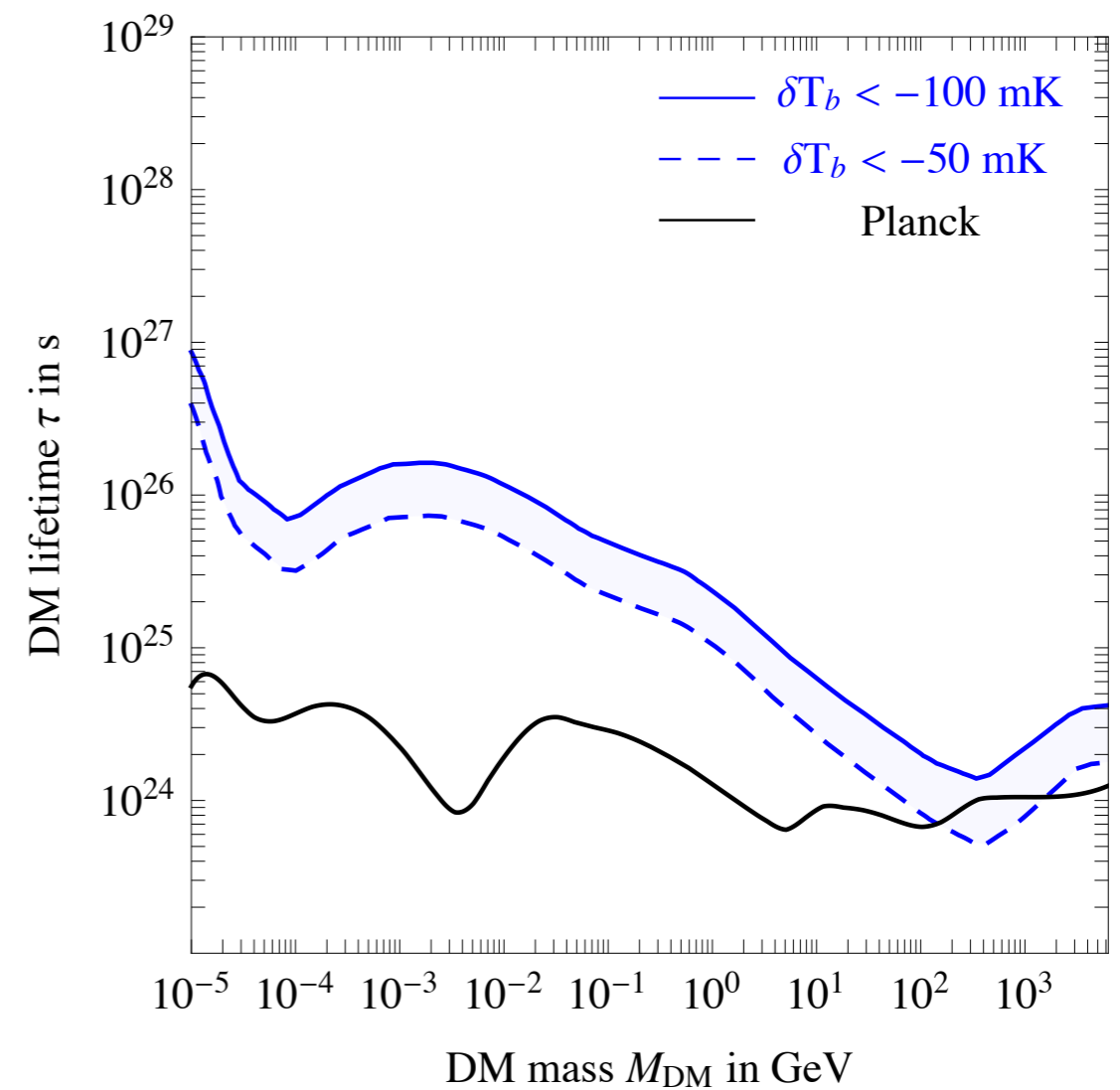

T_{CMB}

T_{gas} with no decay

T_{gas} $\tau_{\text{DM}} = 10^{27}\,\text{s}$

T_{gas} $\tau_{\text{DM}} = 10^{26}\,\text{s}$

we require that DM decays do not reduce the signal by more than a factor 2 or 4

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