Thermal Radiation of Hot Electrons

Leon Oleschko
01.04.2025

Laser Power

The laser has a power of:

$$P(t) \propto e^{-(t-t_0)/2\sigma^2}$$

with a total energy:

$$E = \int S(t)dt = P_{\text{Average}}/f \approx 1.2\,\text{W}/100\,\text{MHz} = 12\,\text{uJ}$$

Absorption

only a fraction $A = 1$ is absorbed into a volume given by the laser radius $r \approx 200\,\text{um}$ and the optical depth $d \approx 250\,\text{nm}$:

$$V = \pi r^2 \cdot d$$

$$S = \frac{P}{V} A$$

with $[S] = W/m^3$

e^- Gas

The temperature change due to absorption can be calculated with the molar Volume $V_m = M/\rho$ and the specific heat capacity $c_e = 1/M \; dQ/dT$.

The lattice relaxation time $g \approx 300\,\text{fs}$.

Diffusion is neglected. Radiative cooling is also ignored.

$$\frac{dT_e}{dt} = \frac{V_m}{c_e(T)} S - \frac{T_e - T_l}{g} - \frac{T_e - T_{\text{Room}}}{\tau_e}$$

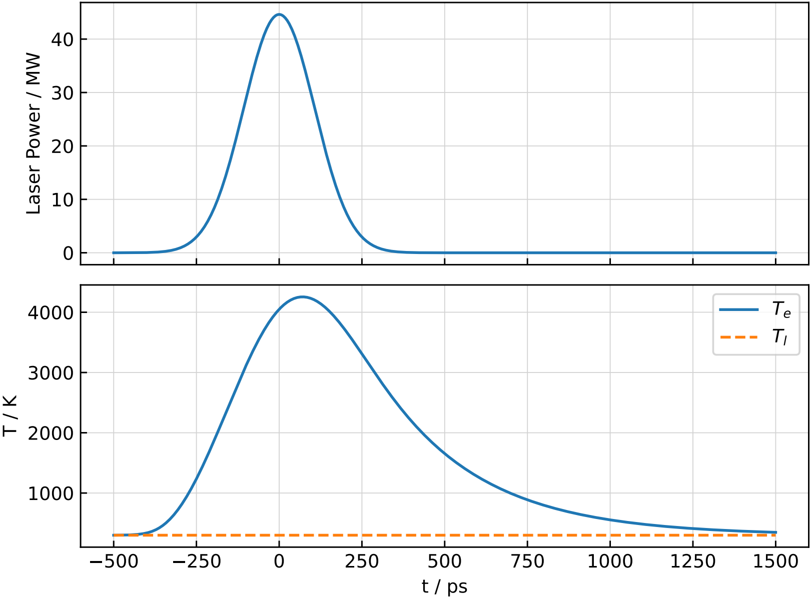
"Hot electron cooling in graphite", Stange et al. 2015

Lattice Temperature

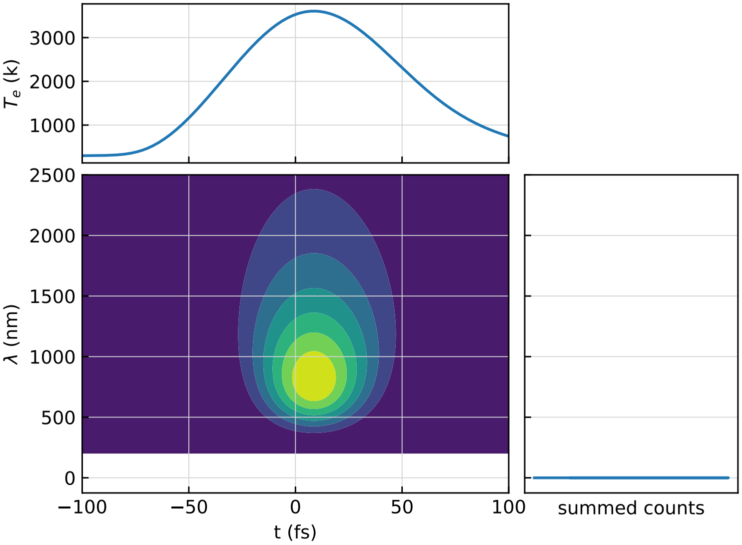
For now the lattice temperature is assumed to be constant.

For the lattice it is similar with the diffusion $\tau_l \approx$:

$$\frac{dT_l}{dt} = \frac{T_e - T_l}{g} - \frac{T_e - T_{\text{Room}}}{\tau_l}$$



Laser Power / MW
40
30
20
10
0
T / K
4000
3000
2000
1000
T_e
T_l
−500
−250
0
250
500
750
1000
1250
1500
t / ps



3000
2000
1000
T_e (k)
2500
2000
1500
1000
500
0
λ (nm)
−100
−50
0
50
100
t (fs)
summed counts