Thermal Radiation of Hot Electrons

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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 $d \approx 250\,\text{nm}$:

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

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

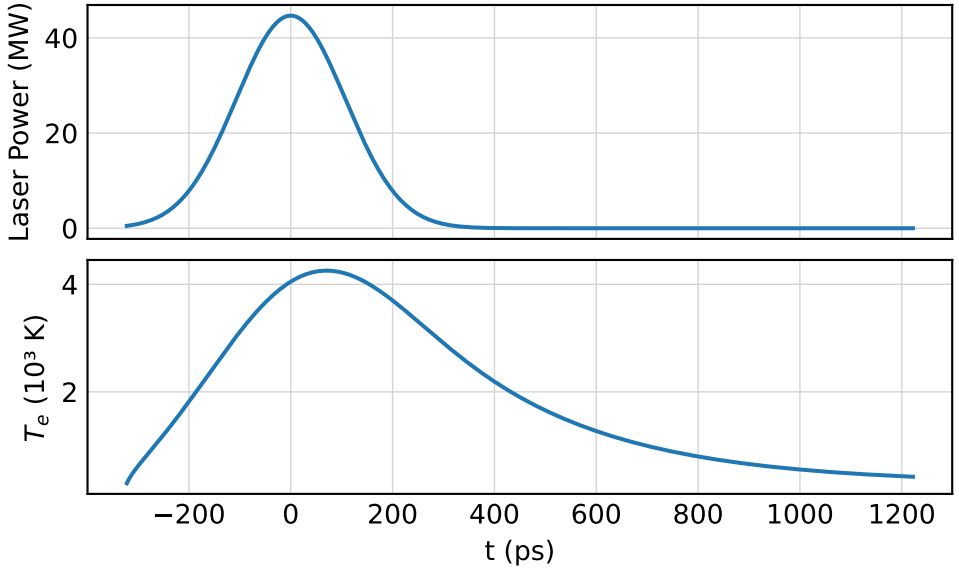
with $[S] = W/m^3$

e^- Gas

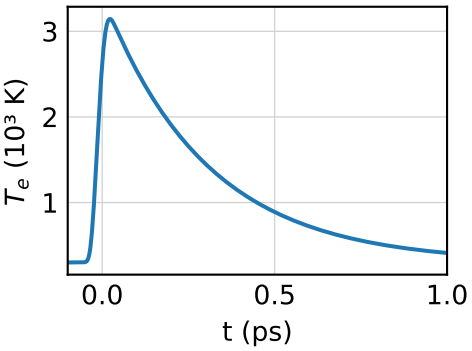
The temperature change due to absorption can be calculated with the molar Volume $V_m = M/\rho$ and the specific heat capacity $c_e = 1/M \; dQ/dT$.
The lattice relaxation time $g \approx 300\,\text{fs}$.
Diffusion is neglected. Radiative cooling is also ignored.

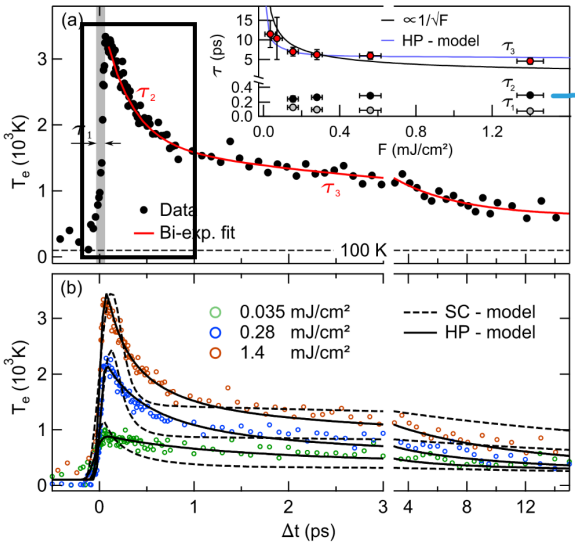
$$\frac{dT_e}{dt} = \frac{V_m}{c_e(T)} S - \frac{T_e - T_l}{g}$$

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

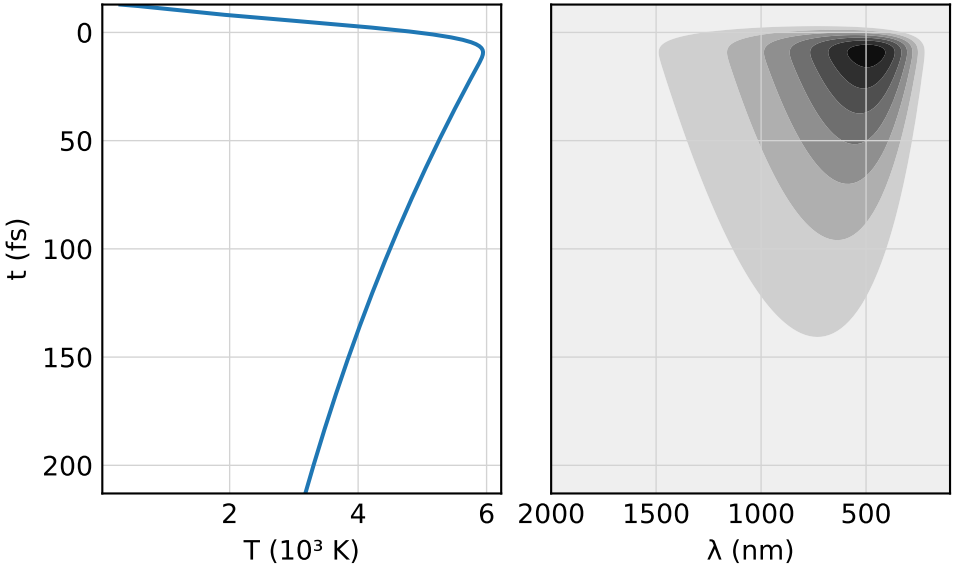

Laser Power (MW)
40
20
0
T_e (10^3 K)
4
2
−200
0
200
400
600
800
1000
1200
t (ps)

Validation

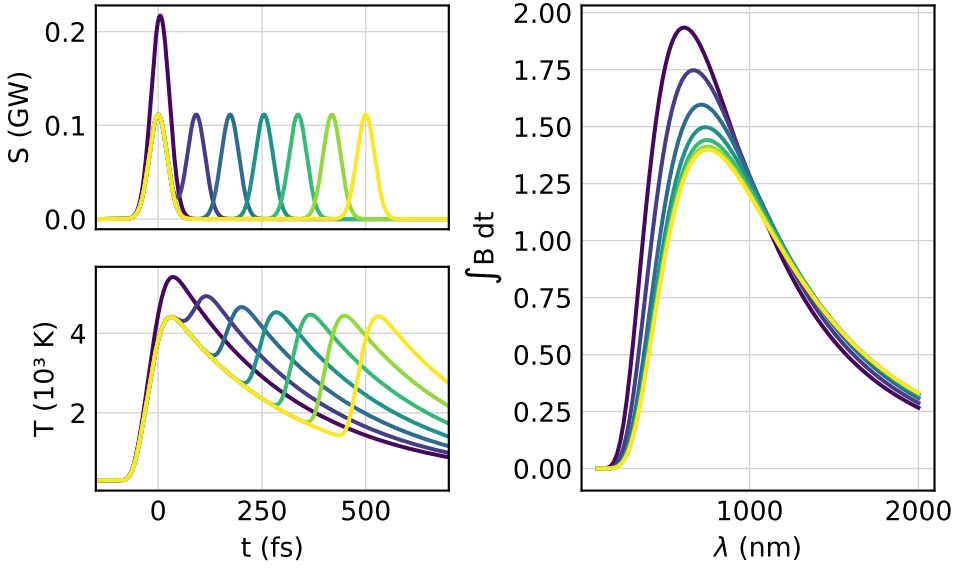




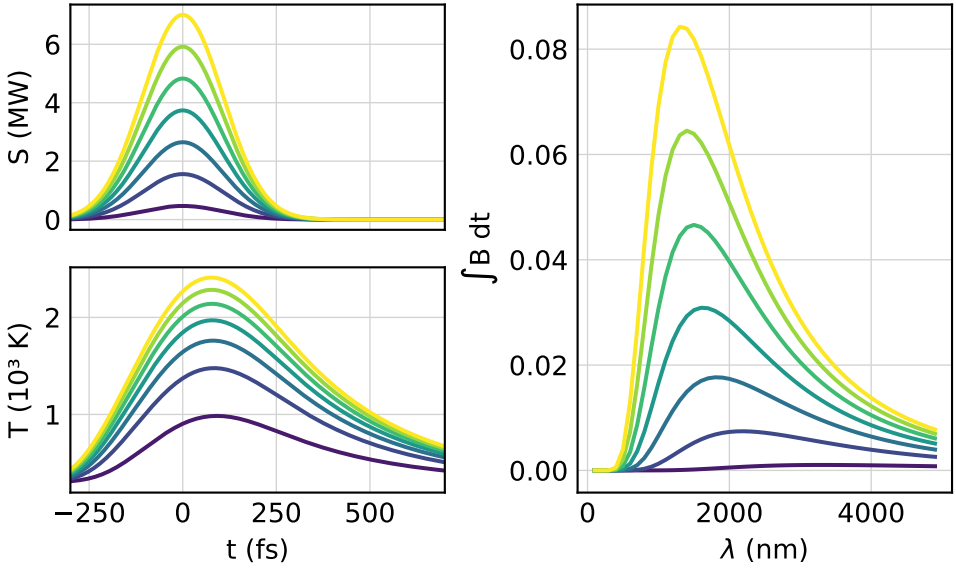
"Hot electron cooling in graphite", Stange et al. 2015 (Fig. 4)



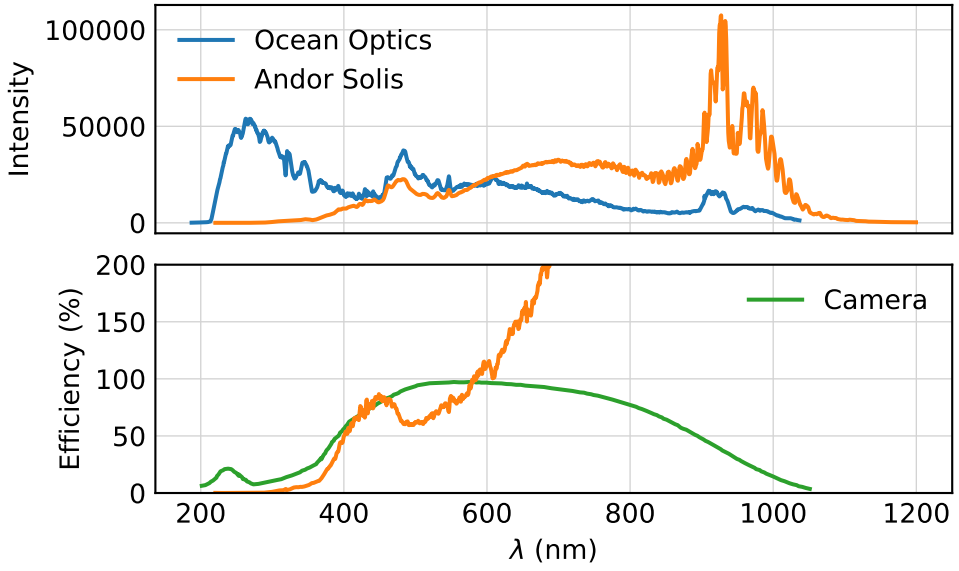
Thermal radiation after 50 fs Laser pulse

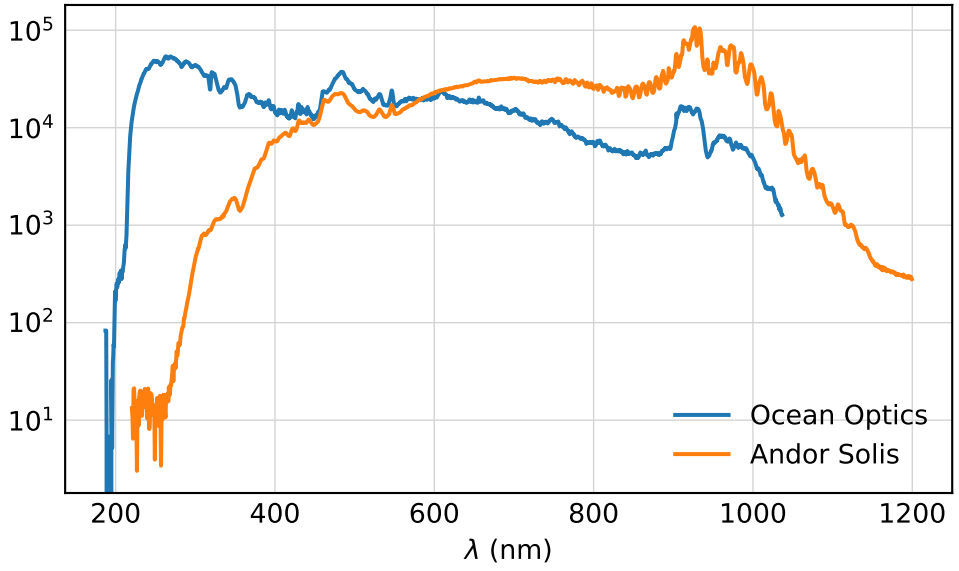


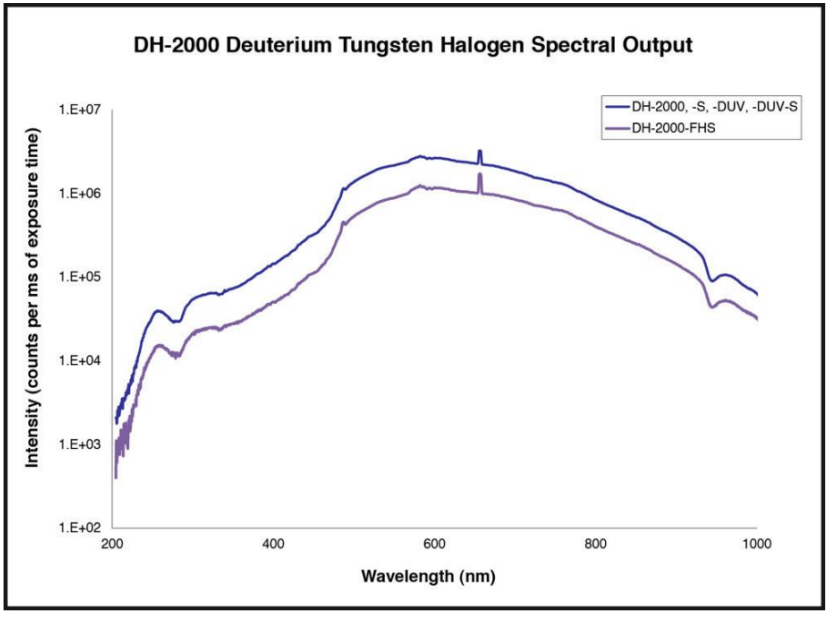
Consecutive 50 fs Laser pulses

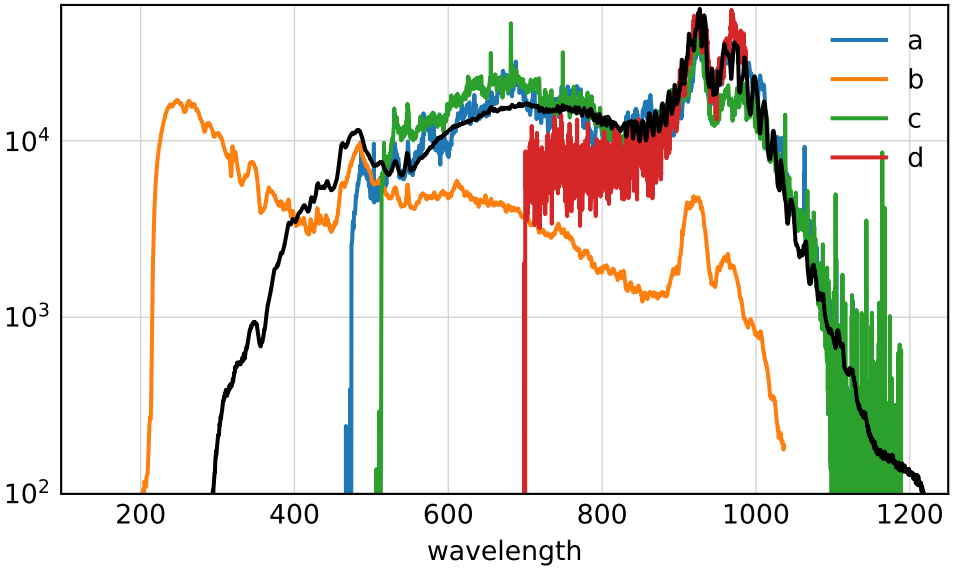


250 fs Laser pulse with different fluence

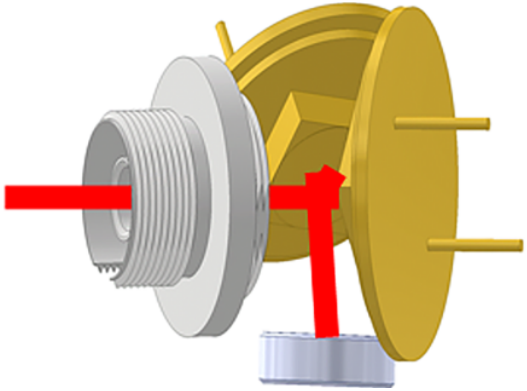

Intensity
100000
50000
0
Ocean Optics
Andor Solis
Efficiency (%)
200
150
100
50
0
Camera
200
400
600
800
1000
1200
λ (nm)

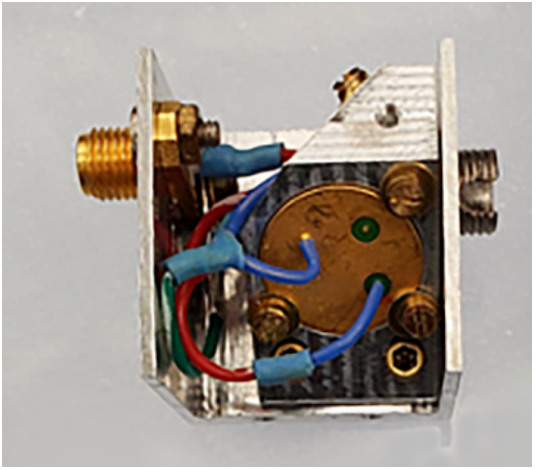

10^5
10^4
10^3
10^2
10^1
200
400
600
800
1000
1200
λ (nm)
Ocean Optics
Andor Solis


DH-2000 Deuterium Tungsten Halogen Spectral Output
DH-2000, -S, -DUV, -DUV-S
DH-2000-FHS
Intensity (counts per ms of exposure time)
1.E+07
1.E+06
1.E+05
1.E+04
1.E+03
1.E+02
200
400
600
800
1000
Wavelength (nm)


a
b
c
d
10^4
10^3
10^2
200
400
600
800
1000
1200
wavelength

Schematic





"Infrared Trap Detector", NIST 2024

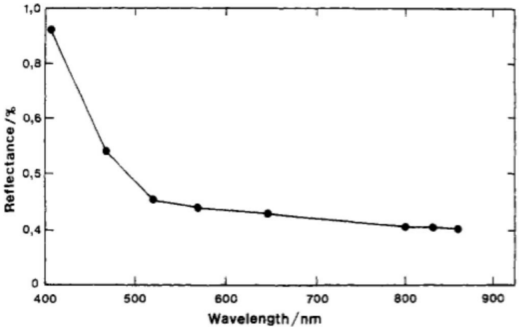


Figure 2. The mean residual reflectance from ten trap detectors as a function of wavelength.

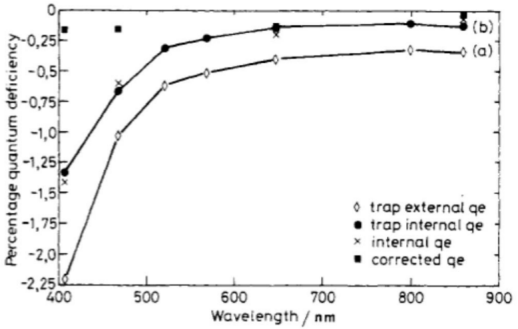


Figure 3. The mean quantum deficiency, both external and internal, of ten trap detectors plotted as a function of wavelength, curves (a) and (b) respectively. The internal quantum deficiency and the deficiency corrected using the self-calibration technique for a single Hamamatsu S1337 photodiode are also plotted.

"Trap Detectors and their Properties", Fox 1991