Optical Gain

In this tutorial we present how can be calculated the optical gain upon optical irradiation. The irradiation parameters are the *Photon energy of the irradiation*, *Line width*.

Physics model

The transition rate per volume element can be expressed with the following sum: $$ R = R_{ab} - R_{ba} = \frac{2}{V} \sum_{k_a} \sum_{k_b} \frac{2 \pi}{ \hbar} |H_{ba}| ^2 \delta(E_b - E_a - \hbar \omega)(f_a-f_b) $$

In order to make evaluate the sum much faster we calculate the H_{ba} matrix element at $k_a = 0; k_b = 0$ (Remark: $k_a = k_b$), and we neglect the k dependence of it. Then we can simplify the sum in the following form, if the irradiation has the $\gamma(E, w)$ broadening function, where E is the irradiation energy, and w is the line width.

$$ R(E, w) = C_0(E) \int dE_a dE_b \gamma(E_a-E, w) \cdot H(E_a-E) \cdot [n(E_a) - p(E_b)] $$

Here $C_0(E)$ is an energy dependent constant: $$ C_0 = \frac{\pi e^2 \hbar}{n_r c \epsilon_0 m_0^2 E} $$

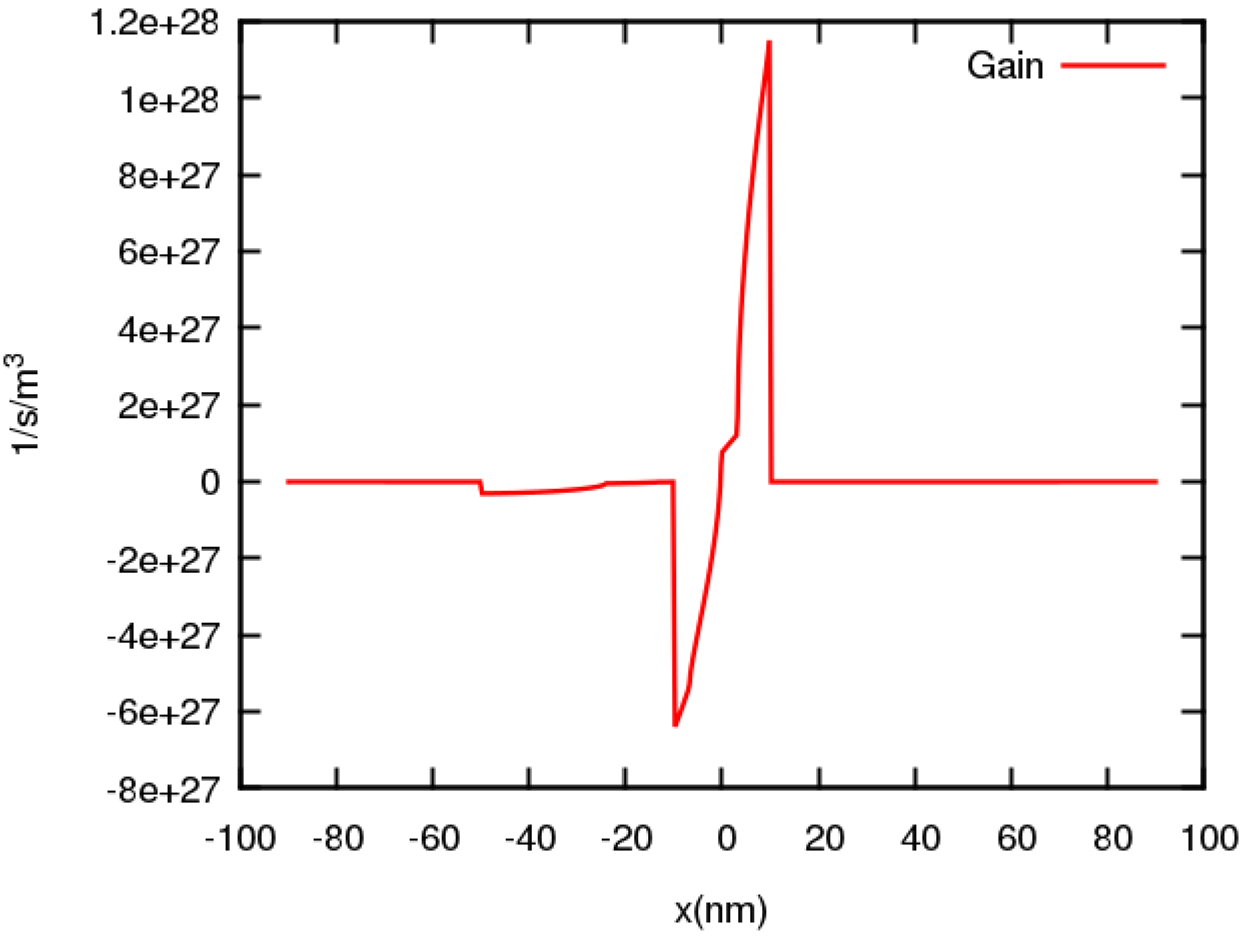
Input file structure

A new keyword has been introduced to handle an optical device, *opticaldevice{}*

```
opticaldevice{
    name = "quantum_region_name"
    line_broadening = 1           #Line broadening model (1: Lorentzian)
    photon_energy = 1             #Photon energy in (eV)
    line_width = 1                #Line width in (eV)
}
```

An in the run paragraph you have to also add *solve_optical_device{}* in order to include it the simulation flow.

Results


1.2e+28
1e+28
8e+27
6e+27
4e+27
2e+27
0
-2e+27
-4e+27
-6e+27
-8e+27
1/s/m^3
-100
-80
-60
-40
-20
0
20
40
60
80
100
x(nm)
Gain