

Optical Gain

In this tutorial we calculate the optical gain upon optical irradiation. The irradiation parameters are the

- photon energy of the irradiation and the
- 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 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 as follows,
$$R(E, w) = C_0(E) \int \gamma(E_a - E, w) \cdot H(E_a - E) \cdot [n(E_a) - p(E_b)] dE_a dE_b,$$
 where E is the irradiation energy, w is the line width and we assume that the irradiation has the $\gamma(E, w)$ broadening function.

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

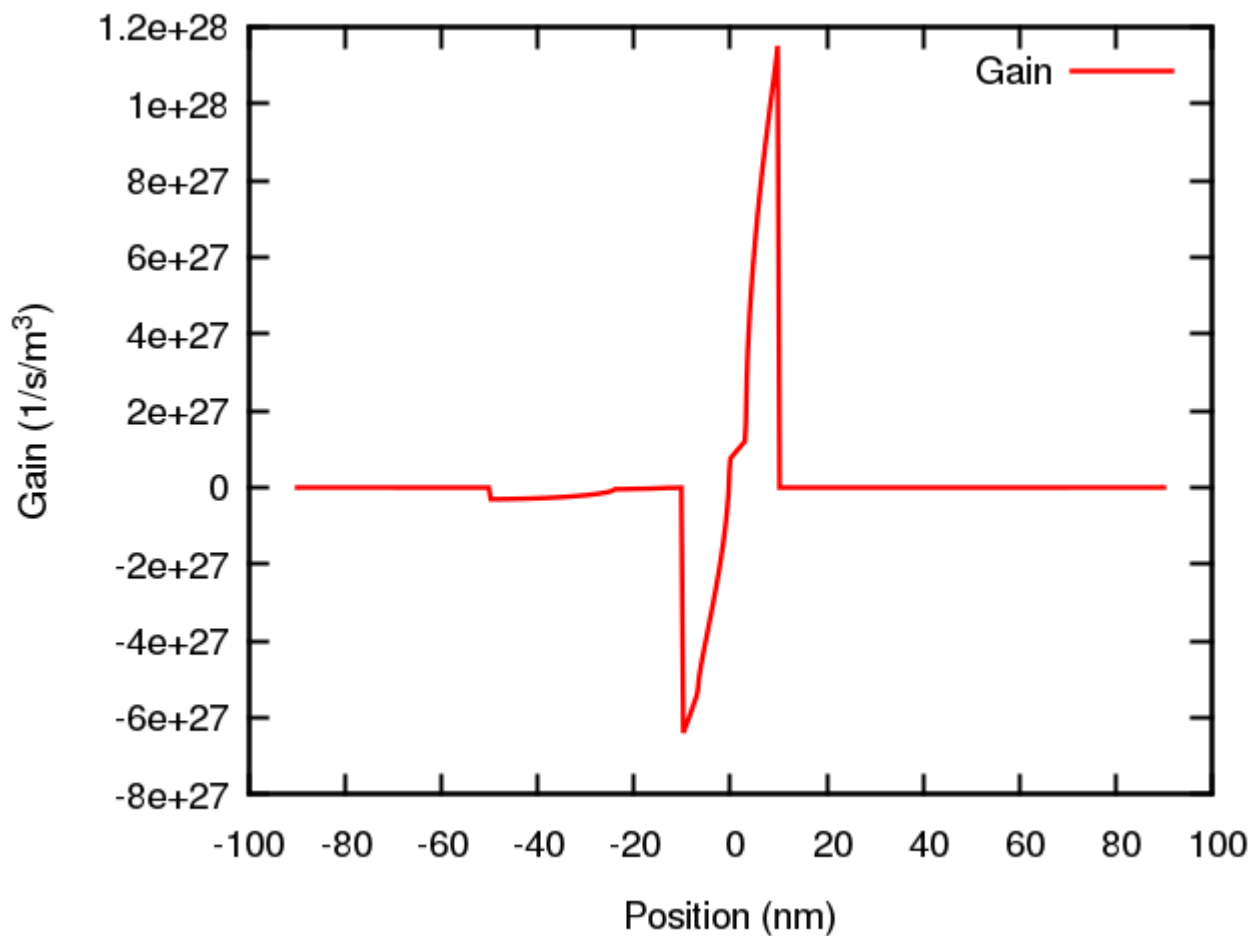
Input file structure

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   = 1.0         # Photon energy in (eV)
  line_width      = 1.0         # Line width in (eV)
}
```

The run keyword requires `solve_optical_device{}` to be included.

Results



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