Photon-assisted transport and gain clamping

Photon-assisted transport

Photon-assisted transport can be modeled by considering electromagnetic (EM) modes at specific energies.

```
<EMfield>
<EMmode>
<PhotonEnergy unit="mV">253.0</PhotonEnergy>
</EMmode>
</EMfield>
```

Note that in the current version (2020-11-16), only a single EM mode is supported at a time.

The electric field in this EM mode can be either imposed (detection mode) or calculated self-consistently (gain clamping).

The detection mode is relevant to study quantum cascade detectors and/or to study the role of photon-assisted transport.

The electric field can be set in the following way:

```
<EMfield>
<EMmode>
<PhotonEnergy unit="mV">253.0</PhotonEnergy>
<ElectricField unit="V.m^-1">1.0e6</ElectricField>
</EMmode>
```

Relation to gain calculation

The gain feature calculates the linear response to an a.c. incoming field. In this case, the d.c. current is not modified. On the other hand, the photon-assisted transport is modeled through the use of a self-energy to describe the influence of absorption and stimulated emission on d.c. transport. In the case of the electron-photon self-energy, a gain is also calculated at the specified EM mode energy. However, the calculated gain slightly differ from the one calculated using linear response, even for small intensities, as broadening effects are not treated within the same approximations in the two cases. This is all the more the case when going to small photon energy (i.e. long wavelengths).

Gain clamping

Gain clamping is relevant to the simulation of quantum cascade lasers. Indeed, when the gain surpasses the cavity losses, lasing starts and the gain is clamped to the cavity losses.

To simulate gain clamping, the following command should be used:

```
    <Gain>
       ...
       <Cavity_Losses unit="cm^{-1}">2.76</Cavity_Losses>
       <GainClamping>yes</GainClamping>
    </Gain>
```

Note that in this case, the EM electric field should be set to zero:

```
<EMfield>
<EMmode>
<PhotonEnergy unit="mV">253.0</PhotonEnergy>
<ElectricField unit="V.m^-1">0.0</ElectricField>
</EMmode>
```