pointing out also in this respect the necessity of providing the cell with special contacts as will be explained below.

In the hot carrier solar cell, the electron gas (semiconductor properties exhibiting a band gap does not seem to be essential for its operation) is in equilibrium at the lattice temperature T_a despite the absence of phonon interaction. This equilibrium is reached through other interactions as, for example, the interaction with thermal photons. Out of the equilibrium, electrons are thermalised by elastic scattering between them that allows a set of energy-dependent chemical potentials, one for the electrons of each energy. Furthermore, transference of energy between electrons exists through mechanisms that include impact ionisation and Auger recombination (this terminology is used in the context of semiconductors, which, as mentioned, we think is not necessary for this cell) according to reactions like $e_1^- + e_2^- \leftrightarrow e_3^- + e_4^-$. Actually in this equation transference of energy between electrons is produced by couples so that $\hat{\varepsilon}_1 + \hat{\varepsilon}_2 = \hat{\varepsilon}_3 + \hat{\varepsilon}_4$ where $\hat{\varepsilon}$ is electron (not photon) energy. However, the equilibrium of the reaction also establishes that the electrochemical potentials of the electrons (that we still call ε_F) are related by $\varepsilon_F(\hat{\varepsilon}_1) + \varepsilon_F(\hat{\varepsilon}_2) = \varepsilon_F(\hat{\varepsilon}_3) + \varepsilon_F(\hat{\varepsilon}_4)$. Therefore, the electrochemical potential of the electrons is a linear function of the energy in the form

$$\varepsilon_F(\hat{\varepsilon}) = \beta\hat{\varepsilon} + \varepsilon_{F0} \tag{4.73}$$

where the Fermi energy reference ε_{F0} becomes the same for both electrons and holes.

Since the Fermi function for electrons is written as

$$\frac{1}{\exp\left[\dfrac{\hat{\varepsilon} - \beta\hat{\varepsilon} - \varepsilon_{F0}}{kT_a}\right] + 1} = \frac{1}{\exp\left[\dfrac{\hat{\varepsilon} - \varepsilon_{F0}/(1-\beta)}{kT_a/(1-\beta)}\right] + 1} \tag{4.74}$$

the electron distribution can be regarded equivalently as a distribution at the lattice temperature T_a but characterised by a varying electrochemical potential given by equation (4.73) or as a hot carrier distribution with a constant electrochemical potential given by $\mu_{hc} = \varepsilon_{F0}/(1-\beta)$ and a *hot carrier* temperature $T_{hc} = T_a/(1-\beta)$.

If the interaction with phonons is introduced, through the reaction $e_1^- + \text{phonon} \leftrightarrow e_2^-$, where $e_{1(2)}^-$ represents an electron with energy $\hat{\varepsilon}_{1(2)}$, the fact that the phonon chemical potential is zero leads to $\varepsilon_F(\hat{\varepsilon}_1) = \varepsilon_F(\hat{\varepsilon}_2)$. However, $\hat{\varepsilon}_1 \neq \hat{\varepsilon}_2$ but $\hat{\varepsilon}_2 = \hat{\varepsilon}_1 + \varepsilon$, where ε is the phonon energy and, therefore, $\varepsilon_F(\hat{\varepsilon}_1) = \varepsilon_F(\hat{\varepsilon}_2)$ is only fulfilled if $\beta = 0$ and consequently all the electrons have the same electrochemical potential ε_{F0} and are at the lattice temperature. Phonon interaction is not considered to occur in what follows.

If the interaction with photons is considered now, $e_1^- + \text{photon} \leftrightarrow e_2^-$, the equilibrium of the reaction is represented by $\varepsilon_F(\hat{\varepsilon}_1) + \mu_{\text{ph}} = \varepsilon_F(\hat{\varepsilon}_2)$ where μ_{ph} is the photon chemical potential. Taking into account equation (4.73), it is obtained that $\mu_{\text{ph}} = \beta(\hat{\varepsilon}_1 - \hat{\varepsilon}_2) = \beta\varepsilon$ where ε is the energy of the photon involved. The result is that we have an energy-dependent photon chemical potential μ_{ph}. The Bose function that describes the occupation probability of the photon energy level ε becomes

$$\frac{1}{\exp\left[\dfrac{\varepsilon - \beta\varepsilon}{kT_a}\right] - 1} = \frac{1}{\exp\left[\dfrac{\varepsilon}{kT_a/(1-\beta)}\right] - 1} \tag{4.75}$$