Plasmon-induced hot carriers in metallic nanoparticles

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Plasmon-induced hot carriers are attracting an increasing research interest due to their enormous potential applications to photocatalysis, photodetection and solar energy harvesting. However, despite the enormous experimental effort, a complete theoretical characterization of the hot carrier generation process is still missing. In this work \cite{1} we analyze the properties of plasmon-induced hot carriers in silver nanoparticles and nanoshells. To accomplish this task we develop a simple model in which the conduction electrons of the metal are described as free particles in a finite spherical potential well, and the plasmon-induced dynamics is obtained through Fermi’s golden rule. We explicitly confirm that the inclusion of many-body interactions has a minor impact in the results. Using the developed model we show that the rate of hot carrier generation closely follows the plasmonic spectral profile. Furthermore, our analysis reveals that the particle size and the hot carrier lifetime play a central role in determining the production rate and the energies of the generated hot carriers. In particular, larger sizes and shorter lifetimes result in higher production rates but smaller energies, and vice versa. We characterize the efficiency of the hot carrier generation process introducing a figure of merit that measures the number of high energy carriers generated per plasmon. We analyze, as well, the spatial distribution and directionality of these excitations. The results presented here contribute to the basic understanding of plasmon-induced hot carrier generation thus providing a solid background for this emerging field.

\begin{figure}[h]
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\includegraphics[width=\textwidth]{figure1.png}
\caption{(a) Schematic representation of the system under study. (b) Number of hot electrons generated per unit of time and volume as a function of the frequency of the external illumination, for different particle diameters. The intensity of the external illumination is 1mW$\mu$m$^{-2}$. (c) Normalized absorption for the silver nanoparticle calculated in the quasi-static limit.}
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