Energy loss and Stopping power of relativistic electrons interacting with a monoatomic layer (2D materials) using an oscillators model approximation

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In this talk, we derive relativistic analytical expressions for the energy loss of an external charged particle, interacting with a 2D material.
We model this material as a monolayer of atoms represented by harmonic oscillators, with isotropic or anisotropic electronic vibration modes, adapting the oscillator model from [1].
We develop the model for a wide range of incident energies and considering different trajectories of the particle. We obtain several useful analytical expressions for the energy loss considering isotropic and anisotropic in-plane oscillators, for parallel and perpendicular trajectories of the particle.
The results shown for stopping power and energy loss are analysed for generic materials by the use of adequate normalization factors, absorbing the dependencies on the specific properties of the material, namely the oscillator's areal density η and their resonant frequency ω.
In the perpendicular case the total energy loss $E_{perpendicular}$ depends on the value of the frequency ω due to the adiabatic behaviour at large distances.
We notice that in an anisotropic 2D-oscillators system, the energy loss due to single oscillator (and therefore the integrated quantities as stopping power and total energy loss) presents a reduction with respect to the isotropic case, especially in the parallel trajectory. We ascribe this effect to the lower availability of oscillation modes, and hence to a reduction of the interaction channels.
Finally, we remark that the present model stands out for its generality, and provides a direct evaluation of the energy loss processes in a generic 2D material. In particular, we apply or medel to the case of graphene and phosphorene, the so-called "miracle materials", for their singular and unique properties.

References

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