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CHANNELING OF PROTONS THROUGH CARBON NANOTUBES

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Abstract. We investigate how dynamic polarization of carbon valence electrons influences both the angular and spatial distributions of protons channeled in a (11, 9) single-wall carbon nanotube placed in vacuum and in different dielectric media. Proton speeds between 3 and 10 a.u., corresponding to energies of 0.223 and 2.49 MeV, are chosen with the nanotube length varied between 0.1 and 1 μm (Borka et al. 2006, 2008). In all performed calculations we describe the interaction between proton and carbon atoms on the nanotube wall using the Doyle-Turner potential. The image force on proton is calculated using a two-dimensional hydrodynamic model for the dynamic response of the nanotube valence electrons and the dielectric media surrounding the nanotube. The angular distributions of channeled protons are generated using a computer simulation method which solves the proton equations of motion in the transverse plane numerically. The best level of ordering and straightening of carbon nanotube arrays is often achieved when they are grown in a dielectric matrix, so such structures present the most suitable candidates for future channeling experiments with carbon nanotubes. Consequently, we investigate here how the dynamic polarization of carbon valence electrons in the presence of various surrounding dielectric media affects the angular distributions of protons channeled through (11, 9) single-wall carbon nanotubes. Our analysis shows that the inclusion of the image interaction causes qualitative changes in the proton deflection function, giving rise to a number of rainbow maxima in the corresponding angular and spatial distribution. We propose that observations of those rainbow maxima could be used to deduce detailed information on the relevant interaction potentials, and consequently to probe the electron distribution inside carbon nanotubes. Also, our analysis shows that the presence of dielectric media surrounding the nanotube influences both the positions of extrema in the proton deflection functions and the positions and appearance of rainbows in the corresponding angular and spatial distributions. In addition, we analyze the possibility of production of nano-sized beams by carbon nanotubes.

References

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