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Formation of moving exotic muonium atoms during channeling of antimuons in carbon nanotubes under external electromagnetic radiation

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The paper proposes obtaining exotic moving muonium atoms Mu through the capture of valence electrons from carbon atoms by antimuons μ^+channeled (the channeling effect is described, for example, in [1]) along the axes of carbon nanotubes (CNTs). The probability of such captures, as in previous works [2,3], is calculated using non-stationary perturbation theory. However, in [2, 3], exotic atoms arose due to internal interactions, but in this study, the calculations are conducted under the conditions of resonant interaction with external electromagnetic waves acting on the channeled particles. We assume that this monochromatic wave has a frequency ω, is described by the vector-potential $\vec{A}(\vec{r},t)$, and propagates along the axis of the CNTs. Physically, this process can be represented as follows. Under the influence of an electromagnetic field, a valence electron from the state described, for example, in [4], leaves the carbon atom (ionization occurs) and is captured into one of the s-states of the Coulomb spectrum of the antimuon. In this case, the motion of the antimuon in the CNT channel is free along the z-axis with a longitudinal momentum $p_z = \mu_+ v$ and quantized in the transverse degrees of freedom. The probability of such capture under the influence of a perturbation $\hat{W}(\vec{r},t) = -\frac{i\hbar e}{\mu c}\vec{A}(\vec{r},t)\cdot\nabla$ in this work is calculated in the first approximation analogously to the calculations performed in the study of the photoelectric effect (see, for example, [5]).

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