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Electron shell and alpha-decay

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The influence of the electronic surrounding (the electron shell of an atom or an ion and the electron gas in solids) on the alpha-decay width is analyzed. Both decreasing of the penetrability of the potential barrier due to nonzero electron density in the internal (relatively to the outer turning point) area and the change of the outer boundary conditions on the resonance solution (reflection of the alpha-particle wave in the classically-allowed area) were taken into account. The latter effect is a consequence of the fact that the Coulomb parameter η of the asymptotic resonance wave function $G(\rho) + iF(\rho)$ where $G(\rho)$ and $F(\rho)$ are irregular and regular Coulomb wave functions is determined by the potential acting between the alpha-particle and the residual system (a nucleus + electrons) and thus is not coincide with the alpha-nucleus Coulomb parameter η'. The Hartree-Fock-Dirac atomic wave function is used for the description of the density of the electron shell. The numerical integration of the radial Schrödinger equation was performed directly by means of the Runge-Kutta and (for the reliability of the solution which is frequently-oscillating in very long interval of variation of the argument ρ) by the Stoermer methods. Equivalent results are obtained by these two approaches. The relationship between the sub-barrier amplitude of the resonance wave function and the alpha-decay width Γ presented in [1] is used for evaluation of the effect.
The effect turns out to be not so great. As an example the relative difference between the alpha-decay widths of the bare nucleus of 232Th and the Th atom turns out to be equal to 1.0 percent. Our calculations demonstrate that the relativistic effect manifesting itself in the motion of the electrons of inner shells makes a significant contribution to the effect. The effect decreases slightly with increasing of the alpha-particle energy.

1. S.G.Kadmensky, W.I.Furman // Alpha-decay and related nuclear reactions. M.: Energoatomizdat. 1985. (in

Primary author: Prof. TCHUVILSKY, Yury (INP Moscow State University)

Presenter: Prof. TCHUVILSKY, Yury (INP Moscow State University)

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