The electron localized states in the screened charge field

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An certain interest to this problem is caused by a great value of applications in statistical physics of ionized systems, nuclear physics, scattering theory, astrophysics. We suggested two different variants for analytical solving of Schrodinger equation for the electron in a dot charge field with potential

$$V(r) = -z\frac{e^2}{r}\exp\left(-\varkappa\, r\right).$$

In the first case the equation for the radial function by the standard substitution $R(\rho) = \rho^l\omega_l(\rho)\exp(-\sqrt{-\varepsilon_l}\rho)$ is led to onedimensional integral equation for the function $\omega_l(\rho)$. For the case of radial function, which correspond to $1s$, $2p$, $3d$, $4f$,... electron states, the solution of this equation can be presented in the form of parametric integral of infinity dimension.

The condition $\omega_{l,0}(0|\sqrt{-\varepsilon_l}) = 1$ leads to the energy spectrum equation for the fixed orbital quantum number, which depends on dimensionless screening parameter $\xi = \varkappa\, a_0$. Another condition $\omega_{l,0}(0|0) = 1$ determines the critical values of parameter $\xi_{l,0}$, when the energy level passes in to continuous spectrum. The selfconsistens procedure of approximate factorization for integrals with infinity dimension is developed. On this base the energy levels and wave function dependence on ξ is investigated. A set of $\xi_{l,0}$ for the mentioned quantum states is calculated.

In the second case, which is applicable for any electron quantum states, the solution the differential equation for $\omega_l(\rho|\sqrt{-\varepsilon_l})$ is presented in the form of series $\omega_l(\rho|\sqrt{-\varepsilon_l}) = \sum\limits_{n=0}^{\infty} a_n^l(\xi|\sqrt{-\varepsilon_l})\rho^n$, where coefficients $a_n^l(\xi|\sqrt{-\varepsilon_l})$ are defined by the recurrent relations. By the exact and approximate summation of the asymptotic series the energy spectrum, wave function and critical values of the screening parameter $\xi_{l,n}$ for quantum states with any quantum numbers l, n are calculated.