

Study of spatial structures in α -cluster nuclei with valence neutrons

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The Feynman Path Integral method using parallel computing based on NVIDIA CUDA technology was used earlier for calculations of the probability densities and energies of the ground states for α -cluster nuclei ^{12}C (3α), ^{16}O (4α), ^{20}Ne (5α), ^{24}Mg (6α), ^{28}Si (7α) and for nuclear molecules ^9Be ($2\alpha + n$), ^{10}Be ($2\alpha + 2n$), ^{13}C ($3\alpha + n$), ^{14}C ($3\alpha + 2n$) [1–4]. This approach is applied for studying spatial structures in heavier α -cluster nuclei with valence neutrons ^{17}O ($4\alpha + n$), ^{18}O ($4\alpha + 2n$), ^{21}Ne ($5\alpha + n$), ^{22}Ne ($5\alpha + 2n$), ^{25}Mg ($6\alpha + n$). The nuclear parts of pairwise potential $V_{\alpha-\alpha}$ and pairwise pseudopotential $V_{\alpha-n}$ have hard central cores and are the combinations of Woods–Saxon functions. In work [5], it was shown that the two- α -cluster core is retained in the ^9Be nucleus, while in the ^{10}Be nucleus, two extra neutrons “destroy” the α -cluster structure. The results of the calculations demonstrate that this conclusion is true for the studied nuclei as well. In addition, the structures of the ^{17}O (the experimental quadrupole deformation parameters is $\beta_2 = -0,905 \pm 0,15$, [6]), ^{18}O ($\beta_2 = +0,152 \pm 0,046$, [6]), ^{20}Ne ($\beta_2 = +0,741 \pm 0,134$, [6]), ^{21}Ne ($\beta_2 = +0,463 \pm 0,059$, [6]), ^{22}Ne ($\beta_2 = +0,585 \pm 0,152$, [6]), ^{24}Mg ($\beta_2 = +0,172 \pm 0,082$, [6]) ^{25}Mg ($\beta_2 = +0,388 \pm 0,025$, [6]), ^{26}Mg ($\beta_2 = +0,331 \pm 0,086$ [6]) nuclei are calculated using the shell model of strongly deformed nuclei. The Schrödinger equation is solved taking into account the spin-orbit interaction using the expansion in Bessel series [7]. Close agreement of the calculated radial charge densities and root-mean-square charge radii with experimental data is obtained for the shell-model mean-field potential corresponding to the α -cluster model.

References

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