

The method of the separable approximation for Skyrme force and effects of complex configurations in the structure of exotic nuclei

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The study of the properties of medium-heavy and heavy nuclei far from the stability line requires the development of new theoretical approaches. In the series of works, making use of the energy density functional we suggest a new method allowing to the separable form of the Hamiltonian. The method enables one to perform the calculations in very large configurational spaces. The generalized equations of the quasiparticle-phonon model have been applied to the study of low-energy spectra of neutron-rich nuclei, in particular, the mixed-symmetry states. The self-consistency condition in the particle-particle channel gave an opportunity to study the role of the surface interaction for the g -factor description in the case of the 2^+ states. The influence of complex configurations on the characteristics of giant and pygmy resonances was investigated. Anharmonic effects weakly affect the width of the giant dipole resonance (GDR). This effect is crucial for describing the width in the case of the isoscalar giant monopole and quadrupole resonances. The inclusion of two-phonon configurations gives a considerable contribution to low-energy $E1$ strength and an essential increasing of the pygmy dipole resonance width of neutron-rich nuclei. We have studied for the first time the properties of the double- γ decay of the lowest quadrupole state. It is shown that the $\gamma\gamma$ -decay width is sensitive to the mixing of the simple and complex configurations. The one-phonon GDR configuration and the two-phonon configuration [$\text{GDR} \otimes 2_1^+$] play a key role in the width calculation. The generalized electric dipole polarizability is discussed as a new observable.

The presented series of works consists of 16 original articles: Phys. Rev. C – 8, Eur. Phys. J. A – 2, Nucl. Phys. A – 1, Universe – 1, Phys. Part. Nucl. – 1, Phys. At. Nucl. – 3; two of them are published in 2021.

List of papers

1. *Van Giai Nguyen, Stoyanov Ch., Voronov V. V.* Finite rank approximation for random phase approximation calculations with Skyrme interactions: An application to Ar isotopes. // *Phys. Rev. C.* — 1998. — Vol. 57. — P. 1204–1209.
2. *Severyukhin A. P., Stoyanov Ch., Voronov V. V., Van Giai Nguyen* Quasiparticle random phase approximation with finite rank approximation for Skyrme interactions. // *Phys. Rev. C.* — 2002. — Vol. 66. — P. 034304-1–7.
3. *Severyukhin A. P., Voronov V. V., Stoyanov Ch., Van Giai Nguyen* Separabelized Skyrme interactions and quasiparticle RPA. // *Phys. At. Nucl.* — 2003. — Vol. 66. — № 8. — P. 1434–1438
4. *Severyukhin A. P., Stoyanov Ch., Voronov V. V., Van Giai Nguyen* Nuclear structure calculations with a separable approximation for Skyrme interactions. // *Nucl. Phys. A.* — 2003. — Vol. 722. — P. 123c–128c.
5. *Severyukhin A. P., Voronov V. V., Van Giai Nguyen* Effects of phonon-phonon coupling on low-lying states in neutron-rich Sn isotopes. // *Eur. Phys. J. A.* — 2004. — Vol. 22. — P. 397–403.
6. *Severyukhin A. P., Voronov V. V., Van Giai Nguyen* Effects of the particle-particle channel on properties of low-lying vibrational states. // *Phys. Rev. C.* — 2008. — Vol. 77. — P. 024322-1–8.
7. *Severyukhin A. P., Voronov V. V., Van Giai Nguyen* Description of low-lying state structures with Skyrme interaction. // *Phys. At. Nucl.* — 2009. — Vol. 72. — № 10. — P. 1733–1737.
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10. *Severyukhin A. P., Arsenyev N. N., Pietralla N.* Proton-neutron symmetry in ^{92}Zr , ^{94}Mo with Skyrme interactions in a separable approximation. // *Phys. Rev. C.* — 2012. — Vol. 86. — P. 024311-1–8.
11. *Severyukhin A. P., Arsenyev N. N., Pietralla N., Werner V.* Impact of variational space on $M1$ transitions between first and second quadrupole excitations in $^{132,134,136}\text{Te}$. // *Phys. Rev. C.* — 2014. — Vol. 90. — P. 011306(R)-1–5.
12. *Arsenyev N. N., Severyukhin A. P., Voronov V. V., Van Giai Nguyen* Influence of complex configurations on properties of the pygmy dipole resonance in neutron-rich Ca isotopes. // *Phys. Rev. C.* — 2017. — Vol. 95. — P. 054312-1–10.

13. *Severyukhin A. P., Arsenyev N. N., Pietralla N., Werner V.* Proton-neutron structure of first and second quadrupole excitations of ^{90}Sr . // *Eur. Phys. J. A.* — 2018. — Vol. 54. — P. 4-1-8.
14. *Arsenyev N. N., Severyukhin A. P., Voronov V. V., Van Giai Nguyen* Low-energy $E1$ strength distributions of ^{68}Ni .// *Phys. Part. Nucl.* — 2019. — Vol. 50. — № 5. — P. 528-531.
15. *Arsenyev N. N., Severyukhin A. P.* Origin of low- and high-energy monopole collectivity in ^{132}Sn . // *Universe.* — 2021. — Vol. 7. — № 5. — P. 145-1-13.
16. *Severyukhin A. P., Arsenyev N. N., Pietralla N.* First calculation of the $\gamma\gamma$ -decay width of a nuclear 2_1^+ state: the case of ^{48}Ca . // *Phys. Rev. C.* — 2021. — Vol. 104. — P. 024310-1-6.