NUCLEAR PROPERTIES

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INTRODUCTION

In this work, we study the changes in the nuclear properties by performing systematic calculations on the selected isotopic and isotonic chains of nuclei with increasing temperature. The finite temperature Hartree–Fock–Bogoliubov (FT-HFB) calculations are performed using the Skyrme-type SkM* functional and mixed-type pairing interaction. The changes in the pairing properties, internal excitation energies, entropy, two-neutron separation energies, and neutron skin thickness of nuclei are systematically studied. It is shown that both the internal excitation energy and entropy are sensitive to the changes in the pairing properties of nuclei below the critical temperatures. At high temperatures and after T≥1 MeV, both of them increase rapidly. The nuclei near the neutron drip lines are affected more by the temperature effects since the continuum effects start to become dominant around these regions. On the other hand, the internal energy and entropy are not sensitive to the increase in the proton number, and the changes remain almost stable along an isotonic chain with increasing temperature. We also found that some nuclei near the neutron drip lines become bound at finite temperatures, whereas they are unstable against the two-neutron emission (S2n≤0 MeV). Investigation of the neutron skin thickness of nuclei shows that the temperature has a big impact on nuclei close to the neutron drip lines, and it considerably increases the neutron skin thickness of these nuclei at high temperatures.`

Effects due to the temperature dependence of the nuclear binding energy upon the equation of state (EOS) for hot nuclear matter are studied. Nuclear contributions to the free energy are represented by temperature dependent liquid drop model terms. Phase coexistence is assumed for temperatures of the order of 1MeV ≤ T ≤ 6 MeV, baryon number densities ? of the order of 10?4 fm?3 ≤ ? ≤ 10?1 fm?3 and lepton fractions of the order of 0.2 ≤ y1 ≤ 0.4. It is found that the total pressure of the system is not affected by the temperature dependence of the nuclear free energy, in spite of changes observed in the nuclear pressure due to the different parametrizations used to represent the nuclear binding energy.
The nuclear symmetry energy (NSE), as a fundamental quantity in nuclear physics
and astrophysics, represents a measure of the energy gain in converting asymmetric nuclear matter to a symmetric system [1–3]. Its value depends on the
density ρ and temperature T. Experimentally, the nuclear symmetry energy is
not a directly measurable quantity and is extracted indirectly from observables
that are related to it (e.g., [4, 5])
The temperature-dependent densities of these nuclei are
calculated within a self-consistent Skyrme-HFB method using the cylindrical
transformed deformed harmonic-oscillator basis (HFBTHO densities) [15, 16].
The kinetic energy density is calculated either by the HFBTHO code or by the
TF expression up to T2
term [17]. We have used two parametrizations of the
Skyrme force, namely, SLy4 and SkM*, which were able to give an appropriate
description of bulk properties of spherical and deformed nuclei in the past. In
addition, we present some results for the 208Pb nucleus with densities obtained
within the ETF method and the rigorous density functional approach
(RDFA) [20]. The effect of temperature on the rms radii of protons and neutrons
and the formation of neutron skin in hot nuclei is also analyzed and discussedThe correlations between global description of the ground state properties (binding energies, charge radii) and nuclear matter properties of the state-of-the-art covariant energy density functionals have been studied. It was concluded that the strict enforcement of the constraints on the nuclear matter properties (NMP) defined in Dutra et al. [Phys. Rev. C 90, 055203 (2014)PRVCAN0556-281310.1103/PhysRevC.90.055203] will not necessarily lead to the functionals with good description of the binding energies and other ground and excited state properties. In addition, it will not substantially reduce the uncertainties in the predictions of the binding energies in neutron-rich systems. It turns out that the functionals, which come close to satisfying these NMP constraints, have some problems in the description of existing data. On the other hand, these problems are either absent or much smaller in the functionals which are carefully fitted to finite nuclei but which violate some NMP constraints. This is a consequence of the fact that the properties of finite nuclei are defined not only by nuclear matter properties but also by underlying shell effects. The mismatch of phenomenological content, existing in all modern functionals, related to nuclear matter physics and the physics of finite nuclei could also be responsible.