Microscopic Study of Nuclear "Pasta": Quantum Molecular Dynamics Approach

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Structure of cold dense matter at subnuclear densities is investigated by quantum molecular dynamics (QMD) [4] simulations. We succeeded in showing that the phases with slab-like and rod-like nuclei etc., which are referred to as nuclear "pasta" [3,4], can be formed dynamically from hot uniform nuclear matter without any assumptions on nuclear shape (see Fig. 1). We also observe intermediate phases, which has complicated nuclear shapes. Geometrical structures of matter are analyzed with Minkowski functionals, and it is found out that intermediate phases can be characterized as ones with negative Euler characteristic. Our result suggests the existence of these kinds of phases in addition to the simple "pasta" phases in neutron star crusts.

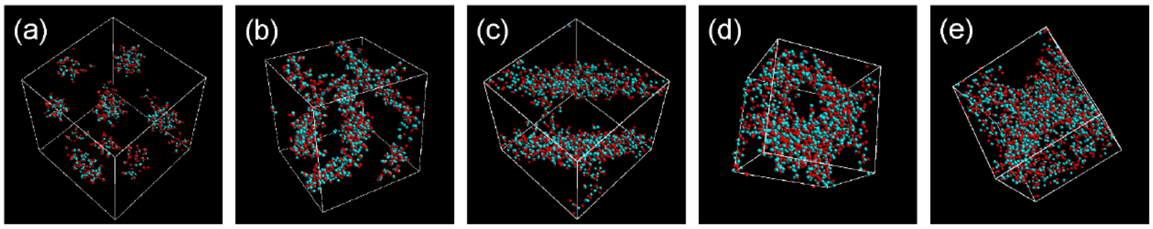

Figure 1: The nucleon distributions of typical phases with simple structures of cold symmetric matter; (a) sphere phase, $0.1\rho_0$; (b) cylinder phase, $0.18\rho_0$; (c) slab phase, $0.4\rho_0$; (d) cylindrical hole phase, $0.5\rho_0$ and (e) spherical hole phase, $0.6\rho_0$ ($\rho_0 = 0.165$ fm^{-3} is the normal nuclear density). The red particles represent protons and green ones represent neutrons.

References

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