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Di-neutron correlations in weakly bound and low density many-nucleon systems

MASAYUKI MATSUO, Niigata University

The correlations in nuclei often lead to spatial clusterizations. In the present talk we shall demonstrate this in connection with the pair correlation. A spatial correlation of the di-neutron type, which has been discussed originally for the two-neutron halo nuclei, may emerge rather generally in a wide class of neutron many-body systems, including the low density nuclear/neutron matters and the medium- mass neutron-rich nuclei containing several weakly bound neutrons. We shall also discuss that the systems with the di-neutron correlation exhibit characteristic modes of excitation. Our analysis is based on the coordinate-space HFB method for the description of the correlated ground state, and the continuum QRPA for the excitation modes. The HFB model predicts that neutron Cooper pairs e.g. in ^{84}Ni, that contains six weakly bound neutrons above the N=50 gap, exhibit strong spatial correlation at short relative distances $< 2-3$fm. The continuum QRPA suggests that the soft dipole excitaition in this nuclei is characterized by a motion of the di-neutrons present in the skin region. The soft di-neutron mode appears also in the octupole multipolarity. In order to put these results in a wider context, we look into the superfluid low-density nuclear/neutron matters. It is shown that the size of the neutron Cooper pair (the coherence length) becomes comparable to or a little shorter than the average inter-neutron distance in a wide interval of densities corresponding to the neutron skin and the halo. We also discuss a possible connection between the strong di-neutron correlation and the BCS-BEC crossover phenomenon.