Probing low-density pairing properties via neutron-rich nuclei

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The nuclear superfluidity, which is one of the fundamental aspects of nuclear equation of state, is predicted (with some uncertainty) to depend strongly on the nucleon density. The s-wave pairing among like nucleons, known very well in stable nuclei, may exhibit a new feature, the crossover[1] between the weak coupling BCS pairing and the Bose-Einstein condensate of strongly coupled pairs, if we look at dilute neutron matter with $\rho/\rho_0 = 10^{-5} - 10^{-1}$[2, 3]. We shall argue in this presentation that neutron-rich nuclei in the medium- and heavy-mass regions will provide us with clues to the intersting pairing properties at low densities.

The spatial di-neutron correlation, predicted not only in light neutron-halo nuclei[4] but also in the meadium- and heavy-mass neutron-rich nuclei[5, 6], is suggestive of the strong coupling pairing at low density. Besides many efforts to seek direct observation of the di-neutron correlation in halo nuclei[7], we think it useful to have indirect but widely applicable probes to the low-density pairing. We propose, as such candidates, two-neutron transfer with monopole and quadrupole mutipolarities feeding the first excited 0^+_2 and 2^+_1 states. Performing a microscopic analysis using the Skyrme-Hartree-Fock-Bogoliubov mean-fields and the continuum quasiparticle random phase approximation for Sn isotopes covering the double-magic ^{132}Sn and beyond, we demonstrate that the pair transfer amplitude is senstive to how the effective pairing interaction behaves at low neutron densities. The most conspicuous is the pair vibrational 0^+_2 state in $^{134\sim}$Sn. The pair transfer strength is anomalously large and the pair transition density is extended to far outside $r \sim 15$fm of the nuclear surface, because of which the sensitivity to the low-density enhancment of the pairing interaction is magnified. We shall also make a comment on a recent argument[8] that the spatial correlation seen [6] in the coherence length (the root mean square radius of the neutron Couper pair) is rather a geometical finite size effect in the single-particle wave functions. We will point out that the enhanced spatial correlation manifests clearly in the probability distribution of the correlated pair at short relative distances $r_{12} <\sim 3$fm, irrespectively of the insensitivity of the coherence length.

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