Di-Neutron Correlation in Ground State of Nuclei near Neutron Drip-Line

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The pairing correlation is important for nuclei near the neutron drip-line as well as in the β-stable nuclei. It is suggested that the neutrons in the halo are correlated and have the short relative distance due to the pairing correlation. It is called the di-neutron correlation. It is interesting to investigate whether the di-neutron correlation appears in the medium-mass neutron-rich nuclei.

We describe the pairing properties in the ground state of nuclei near the neutron drip-line by means of the coordinate space Hartree-Fock-Bogoliubov(HFB) theory. In this calculation, the Woods-Saxon potential is used. We also use the self-consistent HF potential with the Skyrme effective interaction, SLy4[1], with which we obtain the qualitatively same results as the Woods-Saxon case. The detail of our model is described in ref.[2].

In order to examine the spatial structure of the correlated neutron pair in the HFB ground state, we calculate the two-body correlation density, defined as

$$\rho_{corr,q}(\boldsymbol{r}\sigma, \boldsymbol{r}'\sigma') = \langle\Phi_0| \sum_{i\neq j\in q} \delta(\boldsymbol{r}-\boldsymbol{r}_i)\delta(\boldsymbol{r}'-\boldsymbol{r}_j)\delta_{\sigma_i\sigma}\delta_{\sigma_j\sigma'} |\Phi_0\rangle - \rho_q(\boldsymbol{r}\sigma)\rho_q(\boldsymbol{r}'\sigma'),$$

where $|\Phi_0\rangle$ is the HFB ground state. In Fig.1, the two-body correlation densities of ^{84}Ni are plotted on the z-axis. One neutron is fixed at $z = z' = R_{surf}$, where R_{surf} is the half-density radius, 4.8fm. The peak around the fixed neutron($z = z'$) indicates that the two neutrons in the pair are strongly correlated at short relative distances. The di-neutron probability[2] shows that about one half of the neutron which forms the neutron pair distributed within 2-3fm around the fixed neutron.

Fig. 1 also shows that the di-neutron correlation realizes as a superposition of the high-l orbits. If we choose a cut-off angular momentum $l_{cut} = 4$ (up to g-orbit which is the maximum orbital angular momentum of the bound neutron orbits in ^{84}Ni), the di-neutron correlation is weaker than in the case of $l_{cut} = 12$. This feature is understood with the uncertainty relation, $l \sim 1/\theta$, where the short relative distance of the neutron pair implies the small relative angle θ.

We have found that the di-neutron correlation appears in medium-mass nuclei near the neutron drip-line. We speculate that the di-neutron correlation may be general in the superfluid loosely-bound nuclei.

The numerical calculations has done on the NEC SX-5 supercomputer systems at the Research Center for Nuclear Physics, Osaka University.

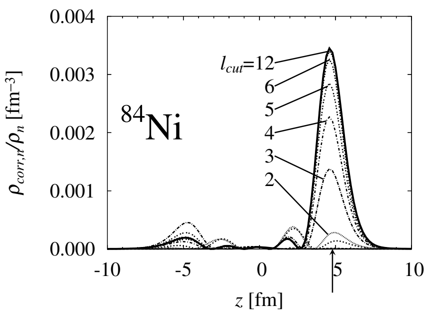

Figure 1: The two-body correlation density of ^{84}Ni. One neutron is fixed at the surface position, $z' = 4.8$fm, indicated by an arrow on the z-axis. The cut-off parameter of the orbital angular momentum l_{cut} is used in the calculation of the two-body correlation density.

References

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