PROPOSAL FOR EXPERIMENT AT RCNP

15/01/2002

TITLE:

Search for Alpha Cluster Condensation in ^{16}O

SPOKESPERSON:

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EXPERIMENTAL GROUP:

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M. Uchida	Kyoto Univ.	D	Y. Yasuda	Kyoto Univ.	D

RUNNING TIME:

Test running time for experiment	4 days
Data runs	2 days

BEAM LINE: WS (WS beam line + Grand Raiden)

BEAM REQUIREMENTS:

Type of particle	^{4}He and ^{6}Li
Beam energy	50–100 MeV/u
Beam intensity	5 enA on target
Energy resolution	$<$ 200 keV (FWHM)
Injection mode	High Resolution Mode
WS transport mode	Dispersive/Achromatic Modes

BUDGET:

Summary of budget request	2,500,000
Experimental expenses	2,000,000
Travel plan	500,000

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SUMMARY OF THE PROPOSAL

Recent theoretical investigations show a possibility of α-particle condensation in low density nuclear matter with $\rho \leq 0.03\ \mathrm{fm}^{-3}$. Röpke *et al.* [**?**] made a variational ansatz for the solution of the in-medium four-body equation. Beyer *et al.* [**?**] solved the Faddeev-Yakubovsky four-body equation for an α-like cluster in nuclear matter. These studies indicate that such α condensation can occur only in the low-density region below a fifth of the saturation density. At higher densities rather a state of ordinary p-n, n-n, or p-p Cooper paring will prevail.

Tohsaki, Horiuchi *et al.* [**?**] proposed a new α cluster wave function in order to investigate α-particle Bose condensed states in finite nuclei. Their wave function was applied to ^{12}C and ^{16}O. The calculation confirmed that the second 0^+ state at E_x=7.65 MeV in ^{12}C is the 3α-cluster condensed state. Furthermore they pointed out that the fifth 0^+ state at E_x=14.0 MeV in ^{16}O could be considered as the 4α-cluster condensed state. These α-cluster condensed states have large root-mean-square (rms) radii of 4.29 and 3.97 fm compared with 2.65 and 2.73 fm for ground states in ^{12}C and ^{16}O, respectively. Large rms values indicate that these 0^+ states correspond to very dilute systems which are only about a fifth of the experimental ground state densities. The fact that α-cluster condensed 0^+ states are of dilute densities is in agreement with nuclear matter calculations where it was shown that a condensate of α-like particles is possible only in matter with $\rho \leq 0.03\ \mathrm{fm}^{-3}$.

It should be noted that the fifth 0^+ state in ^{16}O has been observed experimentally only as a ^{12}C+α resonance formed via the $^{12}\mathrm{C}(\alpha,\gamma)^{16}\mathrm{O}$ reaction [**?**]. This state has not been observed via other reactions, therefore, it is not yet clear whether this 0^+ state really exists or not.

In this Proposal, we propose to search for the 4α-cluster condensed state in ^{16}O via the $^{16}\mathrm{O}(\alpha,\alpha')$ or $^{16}\mathrm{O}(^6\mathrm{Li},^6\mathrm{Li}')$ reaction. After optimizing the probe ((α,α') or $(^6\mathrm{Li},^6\mathrm{Li}')$) and the beam energy (50 MeV/u or 100 MeV/u), we will measure the angular distribution in the angular range of $0^\circ \leq \theta_{\mathrm{lab}} \leq 7^\circ$ in 1° steps for the 4α-cluster condensed state at E_x=14.0 MeV in ^{16}O. The measurement at forward angles will allow a distinct monopole 0^+ assignment.