THE $\Lambda N$ INTERACTION AND STRUCTURES OF THE $^{16-18}$O HYPERNUCLEI

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The shell model without the nuclear centre-of-mass spuriousity is applied to $^{16,17,18}$O isotopes, predicting the bunched and dense hypernuclear energy levels. The $(K^-, \pi^-)$ reaction cross sections are calculated at several angles with the $\theta = 0^\circ$ ones being in good agreement with the experimental data on $^{16}$O and $^{18}$O. The realistic $\Lambda N$ effective interaction derived on the basis of the Nijmegen Model-D is employed and the $\Lambda N J = 0^+$ pairing correlation is found to be repulsive, which is reflected in the $^{18}$O$(K^-, \pi^-)_\Lambda^{18}$O excitation function.

1. INTRODUCTION

In addition to the $p$-shell hypernuclei [1-3], the $sd$-shell ones attract spectroscopic interests as well, because the $(K^-, \pi^-)$ reactions provide the information of the excited states in $^{16}$O [4] and $^{18}$O [5], for example, and because we can therefore study properties of the $\Lambda N$ interaction in these hypernuclear systems in more detail. Furthermore the experimental information will be supplemented in near future through $(\pi^+, K^+)$ reactions, stopped $K^-$ absorption reactions, etc. Thus the shell model analyses of the $^{16,17,18}$O hypernuclei have been made here in relation to the properties of the realistic $\Lambda N$ effective interaction.

2. REPULSIVE PROPERTY OF THE $\Lambda N$ PAIRING CORRELATION

We use the realistic YNG($\Lambda N$) effective interaction [6], which is derived on the basis of the Nijmegen OBE Model-D [7], of the three-range Gaussian form:

\begin{align}
\nu^J_N(r; K_F) &= \sum_{i=1}^{3} \left( a_i + b_i K_F + c_i K_F^2 \right) \exp \left( -\frac{r}{\beta_i} \right) , \\
\beta_i &= 0.5, 0.9, 1.5 \text{ fm}
\end{align}

where the nuclear Fermi momentum $K_F = 1.1 \text{ fm}^{-1}$ is adopted. This effective central interaction can reproduce the observed features of the light $\Lambda$-hypernuclei with proper parameter values [8].

A remarkable property we have found is that the $(J_N^\Lambda J_N^\Lambda) J = 0^+$ pairing correlation is repulsive. Some typical matrix elements within the $sd$-shell are displayed in fig. 1. For comparison we show the corresponding $NN$ matrix elements of $\text{H} - \text{N} - \text{Y}$ force $\nu_{NN}(r)$ which simulates the $G$-matrix derived from the OPEG potential [9]. The $\Lambda N$ positive pairing comes from the fact that the attraction at the outer region of the $\Lambda N$ potential is fairly weak and short-range ($2\pi$-exchange) in contrast to the

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NN case, and hence readily compensated by the repulsive core effect. This balance is seen in the behaviour of the $AN$ reduced matrix element $\langle nl = 0 | v(r) | nl = 0 \rangle$ displayed in fig. 2., where $(nl)$ denotes the relative harmonic oscillator state $N_{rel} = 2n + l$. The increase of $n$ corresponds to the higher $A - N$ relative momentum, or increase of the effect of inner core repulsion. The difference between the $AN$ and $NN$ cases is very clear, since in the former the important contributions are positive except at $n = 0$, while they are negative and large in the latter. It is thus interesting to search for an evidence of the positive $AN$ pairing in the (high-lying) excited states of hypernuclei, e.g., the $[(sd)^1_A (sd)^1_Y]$ two-particle dominant states in $^{18}_A O$.

3. SHELL MODEL FRAMEWORK

We include the core-excited states involving the 1-hole configurations, since the $(K^-, \pi^-)$ reaction populates the “one-neutron-hole states” to produce a $\Lambda$ particle. Thus the $j-j$ coupling shell model spaces for $^{16,17,18}_O O$ with respect to the $^{16}_O O$ closed core are $[(0s, p)_{N}^{-1} j_{N}^{1}]$, $[(0s, p)_{N}^{-1} (sd)_{s}^{1} j_{s}^{1}]$, and $[(sd)_{s}^{1} j_{s}^{1}]$ +