UCRL-18982
Preprint
cy. 2

EFFECTS OF THE OCTUPOLE VIBRATION ON THE REACTIONS $^{207}Pb(t,p)^{209}Pb$ AND $^{209}Pb(p,t)^{207}Pb$

N. K. Glendenning and K. Harada

NOV 25 1969
LIBRARY AND
DOCUMENTS SECTION

September 1969

AEC Contract No. W-7405-eng-48

TWO-WEEK LOAN COPY

This is a Library Circulating Copy which may be borrowed for two weeks. For a personal retention copy, call Tech. Info. Division, Ext. 5545

LAWRENCE RADIATION LABORATORY
UNIVERSITY of CALIFORNIA BERKELEY

UCRL-18982
cy. 2

DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.

EFFECTS OF THE OCTUPOLE VIBRATION ON THE REACTIONS $^{207}Pb(t,p)^{209}Pb$ AND $^{209}Pb(p,t)^{207}Pb$*

N. K. Glendenning and K. Harada†

Lawrence Radiation Laboratory
University of California
Berkeley, California 94720

September 1969

ABSTRACT

The effects of particle-vibration coupling on the reaction $^{207}Pb(t,p)^{209}Pb$ and its inverse reaction are estimated. It is found that the effects are generally small although they are not negligible for some final states.

The purpose of the present note is to estimate the effects of the octupole core polarization on the reaction $^{207}Pb(t,p)^{209}Pb$ and the inverse reaction. Riedel et al.[1] analyzed the reaction $^{207}Pb(t,p)^{209}Pb$ assuming pure configurations both for the target and final nuclei, and compared the calculated cross sections with the experimental results. Their relative cross section to the first excited state ($i_{11/2}$) of ^{209}Pb agrees well with the experiment, but the one to the second excited state ($j_{15/2}$) is smaller than the experiment, i.e. $\sigma_{exp}/\sigma_{theo} \approx 1.4$. The alpha decay phenomenon has a similar characteristic as the two nucleon transfer reaction. The relative alpha intensities from the isomeric state of ^{211}Po was analyzed by Zeh and Mang.[2] The relative decay rate to the $i_{13/2}^{-1}$ state of the daughter nucleus ^{207}Pb calculated by them is very much smaller than the experiment. Recently, Mottelson[3] has discussed pheonomena in which the coupling of a single particle state to the collective octupole vibration in ^{208}Pb plays an important role. According to his lecture, the single neutron $g_{9/2}$, $j_{15/2}$ and $i_{13/2}^{-1}$ states are described as

$$|9/2\rangle = 0.96\,|g_{9/2}\rangle + 0.27\,|(j_{15/2}, 3-)9/2\rangle$$

$$|15/2\rangle = 0.82\,|j_{15/2}\rangle - 0.57\,|(g_{9/2}, 3-)15/2\rangle$$

$$|13/2\rangle = 0.95\,|i_{13/2}^{-1}\rangle - 0.30\,|(f_{7/2}^{-1}, 3-)13/2\rangle$$

If we neglect small admixtures which involves the spin flip, other states are expected to be rather pure single neutron states. In order to see if the disagreements reported in Refs. 1 and 2 are due to the neglect of the octupole core polarization in their calculations, we intend to estimate the effect on the reaction $^{207}Pb(t,p)^{209}Pb$ and its inverse reaction.

For a simplicity, the effect of the inelastic processes in the transfer reactions will be neglected in the present note.

As is well known, the octupole vibrational state is described mainly by a linear combination of many one particle-one hole configurations. Neglecting the blocking effect, we used True's wave function[4] for the 3- state of ^{208}Pb in the present work. If both the target and residual nuclei are expressed by a type of the wave function mentioned above, four kinds of transfer processes are possible. Let us consider ^{209}Pb(p,t)^{207}Pb reaction in which the final nucleus is in 13/2+ state, as an example. In this case, the four processes are described as

$$\text{Process A} = |g_{9/2}\rangle \rightarrow |i_{13/2}^{-1}\rangle$$

$$\text{Process B} = |g_{9/2}\rangle \rightarrow |(f_{7/2}^{-1}, 3-)13/2\rangle$$

$$\text{Process C} = |(j_{15/2}, 3-)9/2\rangle \rightarrow |i_{13/2}^{-1}\rangle$$

$$\text{Process D} = |(j_{15/2}, 3-)9/2\rangle \rightarrow |(f_{7/2}^{-1}, 3-)13/2\rangle$$

and are illustrated in Fig. 1

Structure amplitudes for the two neutron transfer reactions have been calculated based on the harmonic oscillator wave function and tabulated in Ref. 5. We used those values for oscillator constant $\nu = 0.165$, and calculated the projected wave functions which are to be used in the DWBA calculation. Figure 2 shows the projected wave function for the above example with the angular momentum transfer L = 2. Dotted and solid curves represent the projected wave functions with and without the core polarization, respectively. In this case the change of the projected wave function is quite large, but for the most other cases the changes due to the core polarization are very small. To get a rough idea of the change in cross section, we tried

the DWBA calculations, taking the incident particle energies equal to 20 MeV. Optical parameters are taken from Ref. 6 and 7. In Table I, the ratios of the calculated cross sections with and without the core polarization are displayed. Enhancement factors are rather small, because the only particular configurations (particle or hole state is specified) in the 3- state wave function can contribute to the transfer reaction. There are uncertainties connected with the wave functions of the target and residual nuclei, the parameter values of triton and proton optical potentials and the use of a harmonic oscillator wave function. However, we may conclude that changes of the two nucleon transfer reaction cross sections due to the octupole core polarization will be generally within 20%, and they depend on the final states. In the cases for which final states are $j_{15/2}$ and $i_{13/2}^{-1}$ states, the changes of the cross sections are larger compared with other cases. The reason is that some of the new two neutron configurations which are picked up in processes (B) and (C) in Fig. 1 have larger overlap with the triton wave function than the original ones in the type (A). For the $i_{13/2}^{-1}$ final state, the original two neutron configuration is $g_{9/2}\ i_{13/2}$, and one of the new configuration is $f_{7/2}\ p_{3/2}$. The latter has much larger overlap than the former with a triton, and the admixture of $p_{3/2}^{-1}\ g_{9/2}$ configuration in the 3- state wave function is rather large. Finally we could say also that the octupole core polarization acts to reduce the disagreements reported in Ref. 1 and 2.

One of the authors (K.H.) would like to acknowledge the hospitality of the University of California, Lawrence Radiation Laboratory at which he has stayed during the summer of 1969.

REFERENCES AND FOOTNOTES

* Work performed under the auspices of the U. S. Atomic Energy Commission.

† On leave from Japan Atomic Energy Research Institute, Tokai-mura, Japan.

1. C. Riedel, R. A. Broglia, and A. Miranda, Nucl. Phys. A113, 503 (1968).
2. H. D. Zeh and H. J. Mang, Nucl. Phys. 29, 529 (1962).
3. B. R. Mottelson, Proceedings of International Conference on Nuclear Structure, September 1967, Tokyo, page 96; and Nikko Summer School Lectures 1967.
4. W. W. True, Phys. Rev., to be published. We are especially grateful to Professor W. True for making available his unpublished wave function for ^{208}Pb.
5. N. K. Glendenning, Lawrence Radiation Laboratory Report UCRL-18268, June (1968).
6. E. R. Flynn, D. D. Armstrong, J. G. Berry, and A. G. Blair, Los Alamos Scientific Laboratory Report LA-10367.
7. G. R. Satchler, Nucl. Phys. A92, 273 (1967).

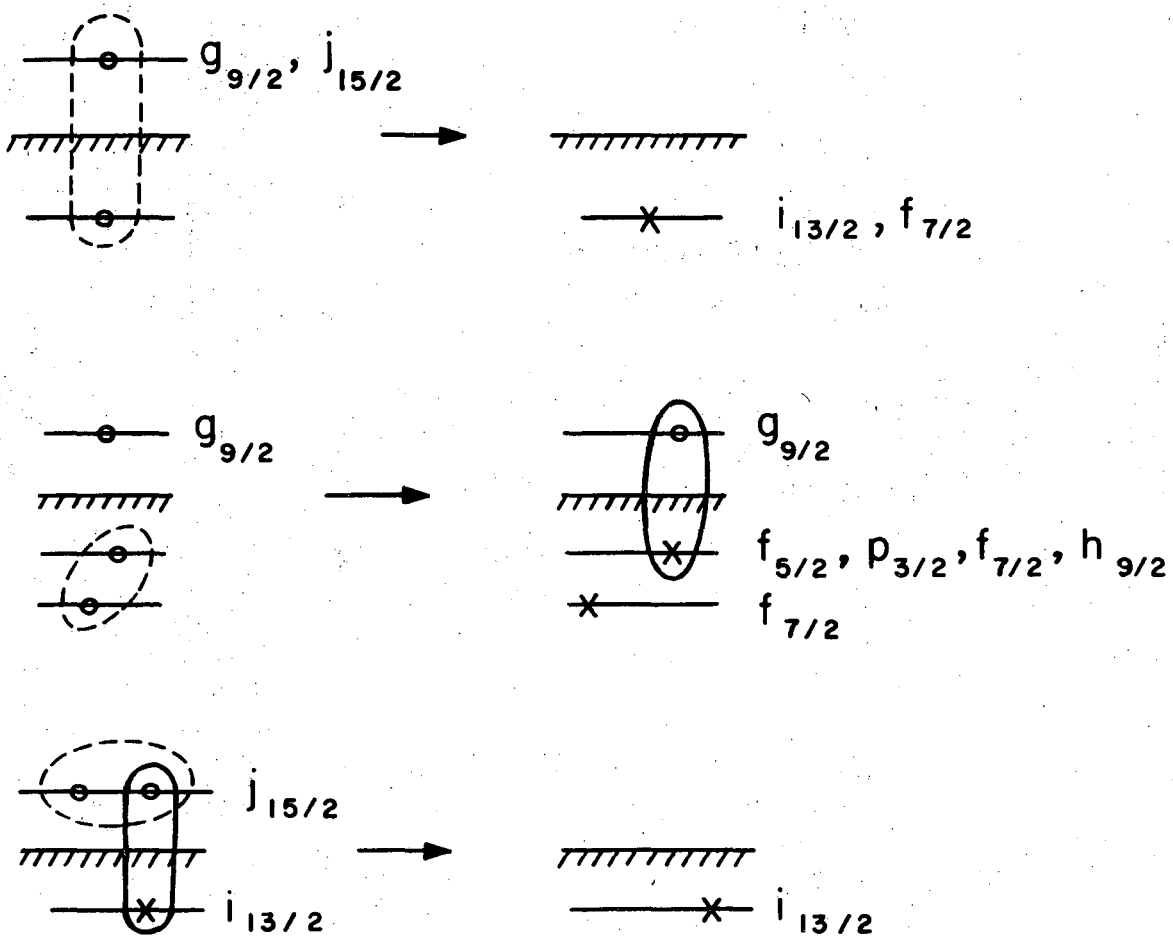
Table I. Ratio of the calculated cross sections with and without the core polarization. Incident energies are taken to be 20 MeV for both reactions.

$^{207}Pb(t,p)^{209}Pb$			$^{209}Pb(p,t)^{207}Pb$		
final state	L	$\frac{\sigma(\text{with c.p.})}{\sigma(\text{without c.p.})}$	final state	L	$\frac{\sigma(\text{with c.p.})}{\sigma(\text{without c.p.})}$
$g_{9/2}$	5	1.01	$p_{1/2}^{-1}$	5	1.01
$i_{11/2}$	5	1.00	$f_{5/2}^{-1}$	3	1.07
$j_{15/2}$	8	1.09		5	1.02
				7	0.98
			$p_{3/2}^{-1}$	3	1.06
				5	1.03
			$i_{13/2}^{-1}$	2	1.17
				4	1.04
				6	0.91
				8	0.83
				10	did not calculate

FIGURE CAPTIONS

Fig. 1. Four contributions to the reaction $^{209}Pb(p,t)^{207}Pb$ in which the final nucleus is in 13/2+ state. The hatched line, the solid circle and the dotted circle represents the Fermi level, a particle-hole configuration in the 3- state wave function and the two neutrons which are to be picked up in the reaction, respectively.

Fig. 2. The projected wave function for $^{209}Pb(p,t)^{207}Pb$ reaction in which the final nucleus is in 13/2+ state. Dotted and solid curves represent the projected wave functions with and without the octupole core polarization, respectively.



XBL699-3728

Fig. 1

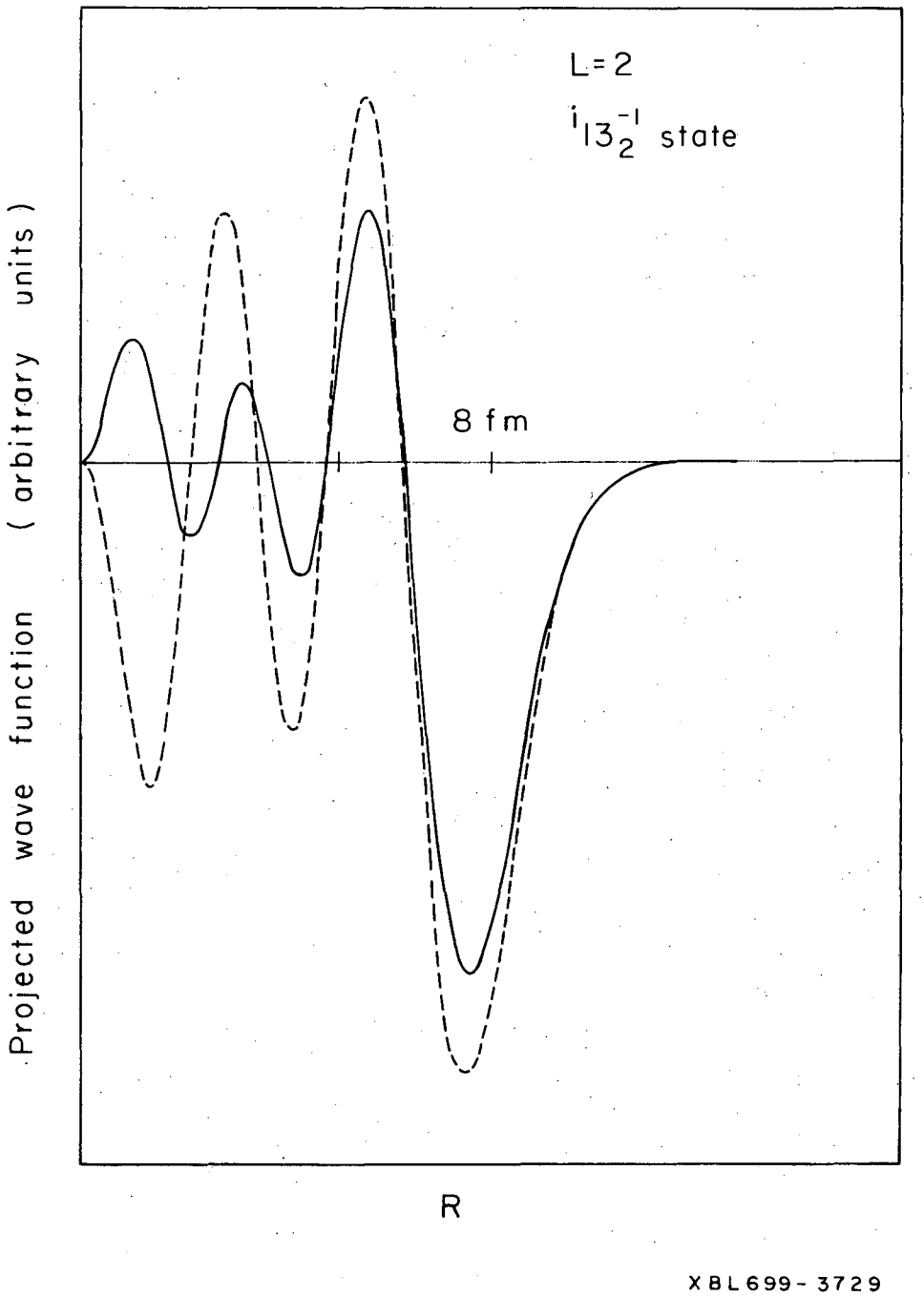

L=2
$^{i}13_{2}^{-1}$ state
8 fm
Projected wave function (arbitrary units)
R
XBL699-3729

Fig. 2

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

TECHNICAL INFORMATION DIVISION
LAWRENCE RADIATION LABORATORY
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA 94720