

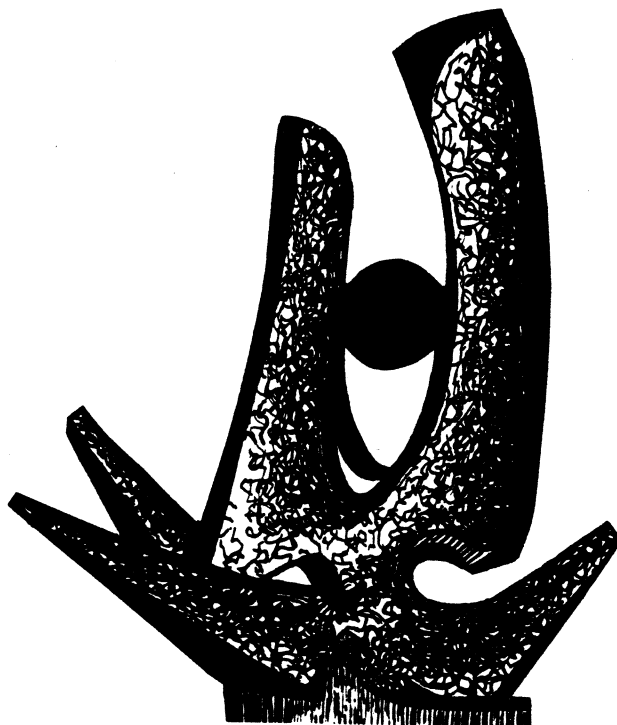
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**A MICROSCOPIC BOSON-VIBRATION COUPLING MODEL
FOR TRANSITION DENSITIES OF COLLECTIVE STATES**

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**A talk presented at the "International
Workshop on Interacting Boson-Boson and
Boson-Fermion Systems" held at Gull Lake,
MI, May 28-30, 1984.**



SEPTEMBER 1984

MSUCL-482

A Microscopic Boson-Vibration Coupling Model
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It is a long-standing problem for nuclear many-body theory to describe transition strengths (more generally, transition densities) of collective states in medium-heavy nuclei within a fully microscopic framework. The interacting boson approximation (IBA) model gives a useful formulae to describe a large number of energy spectra and transition strengths of collective states with few adjustable parameters. However, the IBA model is a macroscopic phenomenological approach for nuclear many-body dynamics so that microscopic justifications have been eagerly looked for. In this direction, recent studies by Otsuka and Scholten [refs. (1) and (2)] made a big progress concerning the microscopic derivation of the parameters of the IBA hamiltonian and transition densities.

As is discussed in refs. (2) and (4), the generalized seniority scheme is a reasonable microscopic theory to study the IBA model parameters in spherical nuclei. We will take the results of the generalized seniority scheme calculations for the IBA transition densities $\alpha(r)$ and $\beta(r)$ which characterize the (s-d) and (d-d) transitions, respectively. In these calculations (most of quasi-particle RPA and shell model calculations), the configuration space is usually restricted within one-major shell around the fermi surface both for protons and neutrons. Therefore, the effect of the configuration space outside the one-major shell should be taken into account in order to evaluate the transition amplitude quantitatively.

Recently, a microscopic model was proposed to study the core polarization effect on the transition and current densities of single particle configurations in the vicinity of the closed-shell nuclei [ref. (3)]. This model consists of two parts. At the first stage, we calculate the single particle wave functions and the strength distributions of the giant resonances by the self-consistent Hartree-Fock + RPA method. Then, we evaluate the core polarization effect on

the electromagnetic transition amplitude by using the particle-vibration coupling model. The effective coupling hamiltonian is determined by a Skyrme-type interaction SG II [ref. (5)] which is also used in the H-F + RPA calculation. This model gives quite satisfactory result for description of the core polarization charges of s-d shell nuclei in comparison with empirical ones. [ref. (6)]

In this contribution, we will discuss a model which takes into account the effect of the higher particle-hole (p-h) excitations on the low-lying collective states by perturbation theory. In this way we can calculate the transition amplitude without introducing effective charges. The perturbed single-particle wave function is given by the formula;

$$|\tilde{\alpha}\rangle = |\alpha\rangle + \sum_{\beta} \sum_{\omega_{\lambda}} \frac{\langle (\beta \times \omega_{\lambda}) \alpha | V_{ph} | \alpha \rangle}{[\epsilon_{\alpha} - (\epsilon_{\beta} + \omega_{\lambda})]} |(\beta \times \omega_{\lambda}) \alpha\rangle \quad (1)$$

where ω is the excitation energy of the giant resonance including both the discrete and continuum state and the interaction V_{ph} is based on a Skyrme-type interaction. The reduced matrix element for the one-body operator is modified to be

$$\langle \tilde{\beta} || \hat{T}_{\lambda} || \tilde{\alpha} \rangle = \langle \beta || \hat{T}_{\lambda} || \alpha \rangle + \sum_{\omega_{\lambda}} [2\omega_{\lambda} / (\epsilon_{\alpha\beta}^2 - \omega_{\lambda}^2)] \langle V_{ph} \rangle \langle \omega_{\lambda} || \hat{T}_{\lambda} || 0 \rangle / (2\lambda + 1)^{1/2} \quad (2)$$

where $\epsilon_{\alpha\beta} = \epsilon_{\alpha} - \epsilon_{\beta}$. On the other hand, the matrix element for the complex many-body wave function can be expressed by,

$$\langle J_f || \hat{T}_{\lambda} || J_i \rangle = \sum_{\alpha, \beta} C_{J_f, J_i}(\alpha, \beta) \langle \alpha || \hat{T}_{\lambda} || \beta \rangle \quad (3)$$

where the states J_f and J_i are provided by the calculation of the generalized seniority scheme model and $C_{J_f, J_i}(\alpha, \beta)$ are the structure factors given by these calculations. The modified transition matrix element for many-body wave functions is given by inserting $\langle \tilde{\alpha} || \hat{T}_{\lambda} || \tilde{\beta} \rangle$ in Eq. (3) instead of $\langle \alpha || \hat{T}_{\lambda} || \beta \rangle$;

$$\langle \tilde{J}_f || \hat{T}_\lambda || \tilde{J}_i \rangle = \sum_{\alpha, \beta} C_{J_f, J_i}(\alpha, \beta) \langle \tilde{\alpha} || \hat{T}_\lambda || \tilde{\beta} \rangle \quad (4)$$

The effect can be regarded as a polarization of the core protons by the valence protons and neutrons through the proton-proton and proton-neutron two-body interaction.

We calculated the proton and neutron core polarization charges in the vicinity of $Z=50$ and $N=64$. First, we solved the RPA response function in coordinate space taking into account the particle escape width for a ^{116}Sn core. The isoscalar giant resonances have two peaks at 5.2 and 13.0 MeV exhausting 5.% and 74.% of the energy-weighted sum rule, while the isovector giant resonance spreads out in the energy-region $E_x=(20-30)$ MeV. We list the isoscalar and isovector core

	α	β	$B(E2)_{s.p.}$	IS	IV
ν	1g7/2	1g7/2	(60.11)	0.504	0.130
	2d5/2	1g7/2	(3.32)	0.703	0.106
	2d3/2	1g7/2	(34.81)	0.670	0.106
	2d5/2	2d5/2	(57.26)	0.520	0.108
	2d3/2	2d5/2	(15.05)	0.517	0.106
	3s1/2	2d5/2	(47.38)	0.518	0.092
	2d3/2	2d3/2	(55.97)	0.513	0.104
	3s1/2	2d3/2	(49.96)	0.515	0.089
	1h11/2	1h11/2	(83.61)	0.574	0.122
	1f5/2	1f5/2	42.62	0.446	0.139
π	2p3/2	1f5/2	5.51	0.664	0.124
	2p1/2	1f5/2	20.83	0.643	0.125
	2p3/2	2p3/2	35.55	0.563	0.134
	2p1/2	2p3/2	35.81	0.562	0.134
	1g9/2	1g9/2	67.31	0.548	0.131
	1g7/2	1g9/2	4.70	0.533	0.129
	2d5/2	1g9/2	37.57	0.706	0.106
	1g7/2	1g7/2	63.93	0.516	0.127
	2d5/2	1g7/2	3.59	0.696	0.102
	2d5/2	2d5/2	61.55	0.506	0.103

Table (1) Isoscalar and isovector E2 core polarization charges of single particle transition in the vicinity of ^{116}Sn . The $B(E2)_{s.p.}$ value is defined by $B(E2)_{s.p.} = |\langle \alpha || \hat{T}_2 || \beta \rangle|^2 / (2j_\alpha + 1)$ with the charges $e(\pi) = e(\nu) = 1$. The proton core polarization charge might be obtained by $\delta e_p = \delta e^{IS} - \delta e^{IV}$ ($\delta e_n = \delta e^{IS} + \delta e^{IV}$).

polarization charges in Table (1). The δe^{IS} value is several times larger than the δe^{IV} value reflecting the fact that the isoscalar giant resonances have larger and lower-energy transition strengths than the isovector ones. Compared to the values of core polarization charges in the SD shell nuclei, the isoscalar δe^{IS} in ^{116}Sn region is somewhat larger because of low-energy giant resonance at $E_x=5.3$ MeV. The δe^{IV} are almost the same in both cases.

As an example of the application of our model, we will discuss 2^+ states in ^{110}Pd . The wave functions J_f and J_i are obtained in two steps. First the generalized seniority scheme is used to calculate the proton and neutron bosons. Then these bosons are combined to construct the wave functions J_f and J_i according to the IBA-II prescription. The IBM calculations with bare charges give the $B(E2)$ -values $445 \text{ e}^2\cdot\text{fm}^4$ for the 2_1^+ state, $25.6 \text{ e}^2\cdot\text{fm}^4$ for the 2_2^+ state and $1.71 \text{ e}^2\cdot\text{fm}^4$ for the 2_3^+ state, while the experimental values are $B(E2)=(9.1 \pm 0.6)*10^3 \text{ e}^2\cdot\text{fm}^4$ (for 2_1^+) and $(134 \pm 24) \text{ e}^2\cdot\text{fm}^4$ (for 2_2^+) [ref. (7)]. The $B(E2)_{\text{exp}}$ for 2_3^+ state is not yet reported. The $B(E2)$ -values are largely increased by the core-polarization effect to be $3.62*10^3 \text{ e}^2\cdot\text{fm}^4$ (for 2_1^+), $189 \text{ e}^2\cdot\text{fm}^4$ (for 2_2^+) and $5.21 \text{ e}^2\cdot\text{fm}^4$ (for 2_3^+). We note that the contribution which arises from the polarization of the core protons by the valence neutrons accounts for about half of the total transition matrix element.

The transition densities and the coulomb form factors of the 2_1^+ state in ^{110}Pd are shown in Fig. (1). Since the transition densities of the giant resonances have strong surface peaks, the core polarization increases the transition density in the surface region by almost a factor of two, but the interior part changes very little. The coulomb form factor is also enhanced almost one-order of magnitude compared to the result without the core polarizations. The positions of three peaks and the minima are well-reproduced by the calculation with the core polarizations. However, the absolute magnitudes of the peaks are still smaller than the experimental ones.

Our microscopic model seems very promising to describe the collective transition strengths in medium-heavy nuclei in both qualitatively and quantitatively. More detailed results will be discussed in a future publication [ref. (9)].

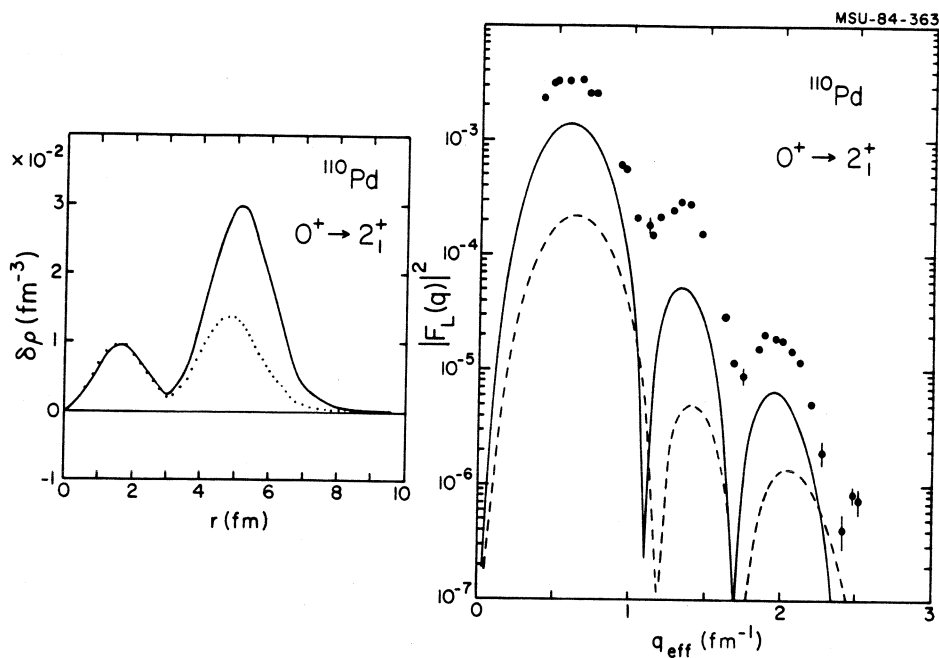


Fig. (1) Transition densities and coulomb form factors of ($0_1^+ \rightarrow 2_1^+$) transition in ^{110}Pd . The dotted and solid curves correspond to the results without and with core polarization effects, respectively. The experimental data are taken from ref. (8).

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