EFFECT TRANSLATIONAL INVARIANCE IN THE GIANT ELECTRIC DIPOL RESONANCE IN ^{154}Sm

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Collective electric dipole excitations (E1) are common phenomena in very different finite fermion systems. They were first discovered in atomic nuclei and characterized as Giant Dipole Resonance (GDR).

Moreover many studies have been performed to investigate the so-called Pygmy Dipole Resonance (PDR), a concentration of electric dipole strength located in region around about 6-10 MeV.

Detailed experimental knowledge about E1 excitations below the GDR is typically limited to the energy region below 4.5 MeV.

High resolution photon scattering experiments (Nuclear Resonance Fluorescence-NRF) have yielded a some of information, especially for deformed nuclei well away from shell closures

In this paper, the QRPA approach has been extended to describe 1^- states in deformed nuclei. The effects of spurious states on the Pygmy dipole resonance (PDR) have been investigated. In this approach has been used Wood- Saxson potantial which broken many symmetries. In case investigating E1 states broken transitional and Galilean invariance.

In models with broken symmetry each excitation has an admixture of the zero-energy spurious state. We study the role of the center of mass-motion spurious state for the deformed ^{154}Sm.

It has been shown that the effects of taking into account the Translation and Galilean invariance of the Hamiltonians in the QRPA, with separation of the zero energy spurious solutions are noticeable in both the low energy density of 1^- states and the PDR.

In constructing the nuclear models one often handless the Hamiltonians with a broken symmetry. The shell model potential when the nucleus is treated as a system of independent particles moving in the common self-consistent potential, is not translation invariant.

$$[H_{sp}, P_{\pm}] \neq 0$$

Here H_{sp} is the single particle hamiltonian, $P_{\pm}$ are the spherical components of the linear momentum for the $J^{\pi} = 1^{-}$ excitations, and $\mu = \pm 1$.

In random phase approximation for the correct description of spin 1^- states the theory must be self consistent, that is, the single-particle (quasi particle) potentials and effective interaction used must be related nuclear forces.

Below we apply the method developed to the problem of separation of the center-of-mass motion and description of properties high energy 1^- states in deformed nuclei.

Now, we start with assumption that there are two types of effective seperable interactions restoring the broken symmetries of the deformed mean field and pairing potential.

- restoring translational invariance of the QRPA Hamiltonian interactions

$$h_0 = \frac{1}{2\gamma} \sum_{\mu} [H_{sp}, P_{\mu}]^{+} [H_{sp}, P_{\mu}]$$

$$\gamma = < 0 \left| [P_{\mu}^{+}, [H_{sp}, P_{\mu}]] \right| 0 >$$

- where Hsqp is the Hamiltonian for the single-quasiparticle motion, is the coupling parameters and determined by the pairing potentials.

restoring Galilean invariance the pairing interaction

$$h_0 = -\frac{1}{2\beta}\sum_{\mu}[U_\Delta, R_\mu]^+[U_\Delta, R_\mu]$$

$$\beta =< 0\left|[R_\mu^+,[U_\Delta, R_\mu]]\right|0 >$$

where $R_\mu = \sum_k^A r_k Y_{lm}(\Theta_k, \Phi_k)$ is proportional to the c.m. co-ordinate of the nucleus and β is determined by the mean field.

The calculations were carried out with a Hamiltonian of the form

$$H = H_{sqp} + h_0 + h_\Delta + W_1$$

where W1 represent the coherent isovector dipole vibrations of protons and neutrons, the centre-of-mass (c.m.) of the nucleus being at rest.

$$W_1 = \frac{3}{2\pi}\chi_1\left(\frac{NZ}{A}\right)^2(\vec{R}_n - \vec{R}_p)^2$$

Here, χ_1 denotes an isovector dipole-dipole coupling constant and $\vec{R}_n$, $\vec{R}_p$ are the c.m. coordinates of the neutron and proton systems, respectively.

In numerical calculations, the experimental value of deformation parameter $\delta =$ 0.27 of the ^{154}Sm were used. The Nilsson single-particle energies are calculated with a defromed Woods-Saxon potential developed by G.Leander.

The resulting B(E1) values, energy-weighted sum rule (EWSR) and non energy-weighted sum rule(NWSR) for either Galilei Invariant or Non Galilei Invariant for the excitation of the 1^- listed in Tab.1.

Galilei Invariant Model						None Galilei Invariant Model					
$I^\pi;K$	E_x (MeV)	$\sum B(E1)$ e^2fm^2	$\sum E_i B(E1)_i$ (e^2fm^2MeV)	EWSR (%)	NEWSR (%)	$I^\pi;K$	E_x (MeV)	$\sum B(E1)$ e^2fm^2	$\sum E_i B(E1)_i$ (e^2fm^2MeV)	EWSR (%)	NEWSR (%)
1^-1	0-9	1.122	9.199	2.68	4.67	1^-1	0-9	1.154	9.456	2.68	4.74
	6-9	1.083	9.071	2.64	4.5		6-9	1.116	9.336	2.65	4.59
	9-20	22.48	324.5	94.7	93		9-20	22.85	334.34	94.9	94
	0-20	23.6	333.7	97.4	98		0-20	24	343.8	97.6	98

Table1. The total B(E1) transition probabilities of ^{154}Sm nuclei as a function of energy

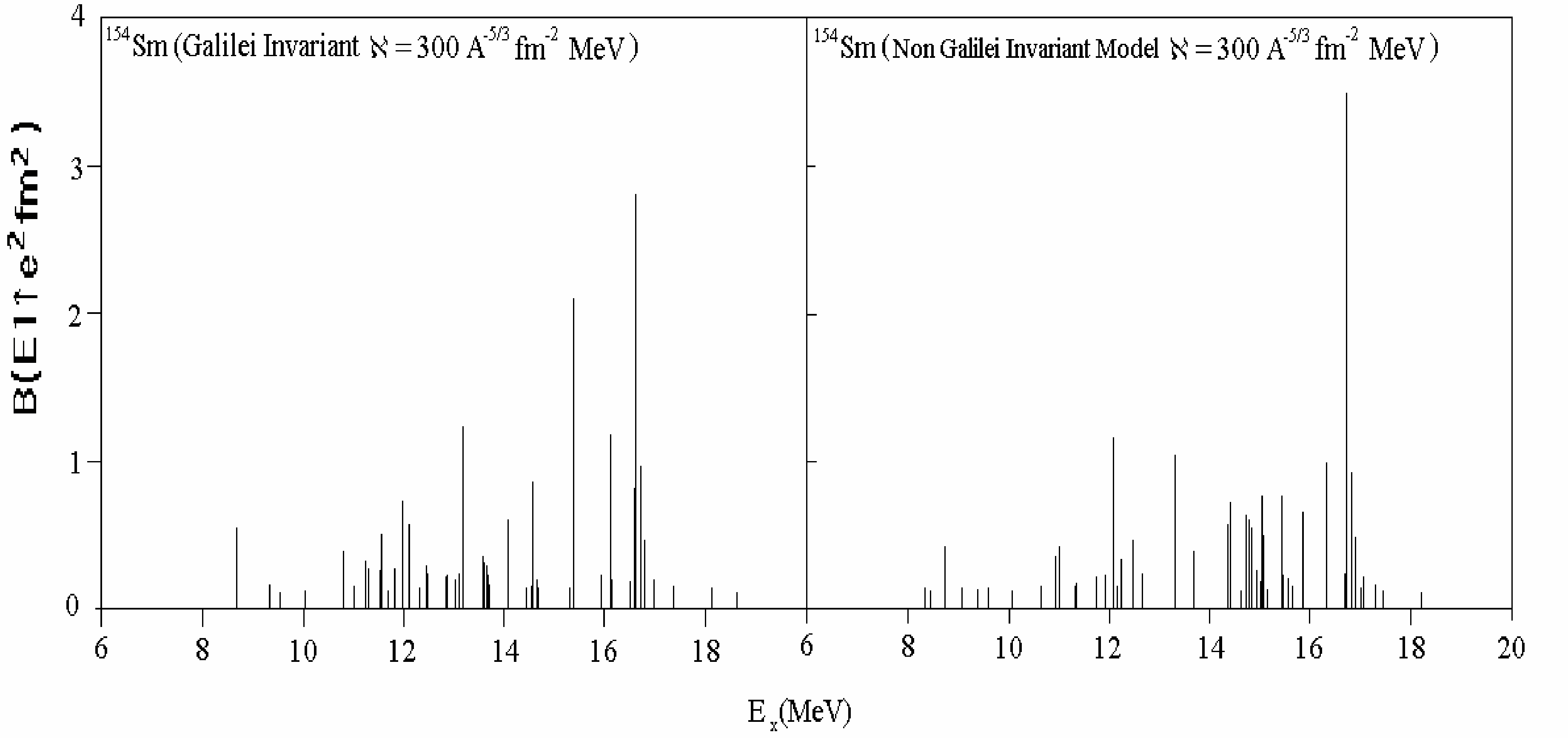
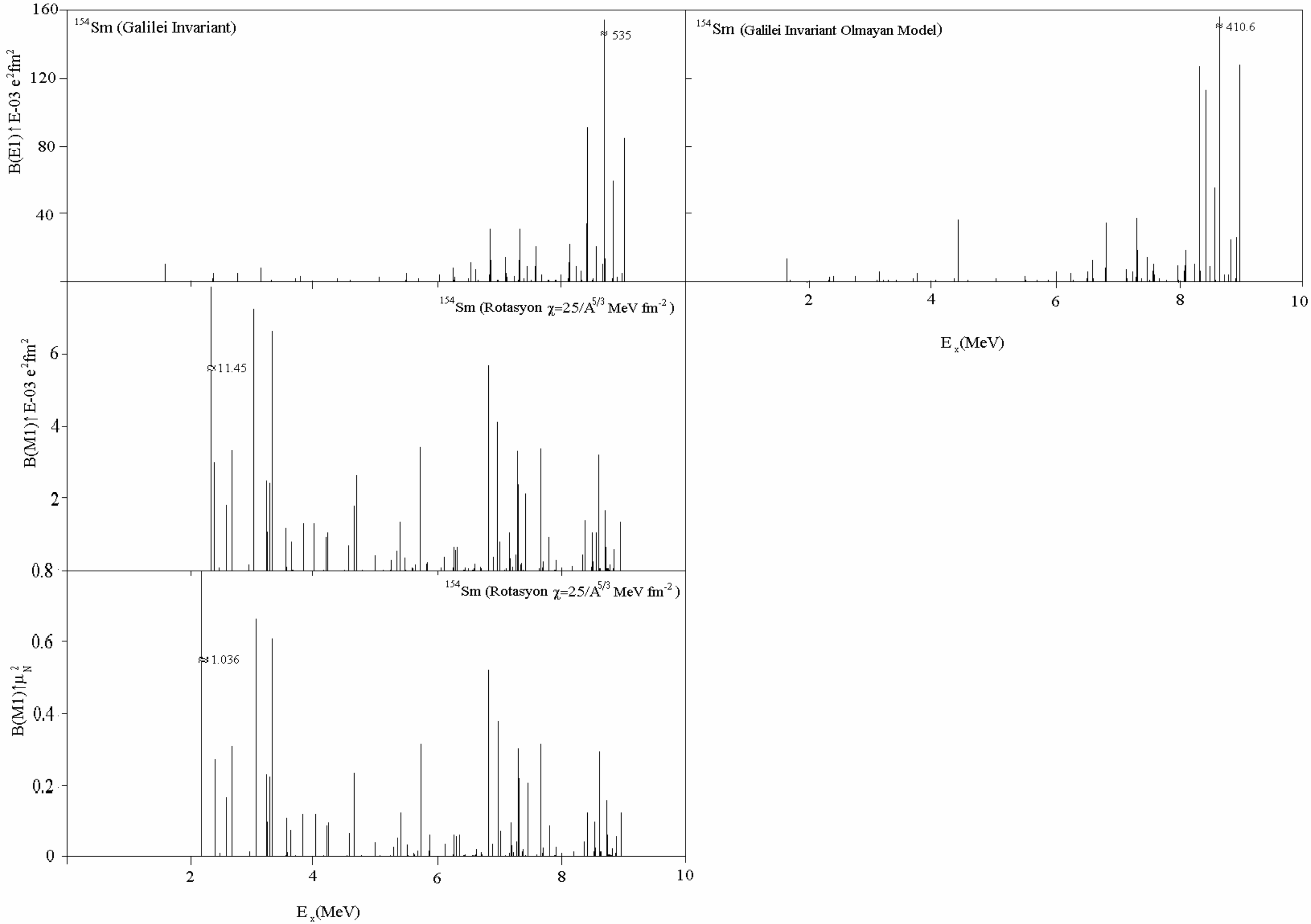


Fig.2 Energy diagram of B(E1) and B(M1) values calculated in translational invariant hamiltonian and non translational invariant hamiltonian for ^{154}Sm nuclei



^{154}Sm (Galilei Invariant)
≈ 535
^{154}Sm (Galilei Invariant Olmayan Model)
≈ 410.6
B(E1)↑ E-03 e^2fm^2
^{154}Sm (Rotasyon χ=25/$A^{5/3}$ MeV fm^{-2})
≈ 11.45
B(M1)↑ E-03 e^2fm^2
^{154}Sm (Rotasyon χ=25/$A^{5/3}$ MeV fm^{-2})
≈ 1.036
B(M1)↑μ_N^2
E_x(MeV)
E_x(MeV)

In models with broken symmetry each excitation has an admixture of the zero-energy spurious state. We study the role of the center of mass-motion spurious state for the deformed ^{154}Sm. Within the translational invariant model the effect of removing spurious state on the E1 strength distribution is stronger than in none invariant QRPA for the states up to neutron binding energy.

We have presented a QRPA approach which allows a selfconsistent calculation of ground state excitations 1^- and 1^+ states after restoration of translational, Galilean and rotational invariance by separable forces. The simultaneous description E1 and M1 transitions permits a direct comparison with (γ,γ') data selective on dipole transitions, but usually lacking parity information.