Continuum quasiparticle linear responce theory using the Skyrme functional

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Continuum and pairing are very important factors to descrive the excitations of both stable and unstable nuclei above threshold excitation energy in the mean field theory. Especially, in unstable nuclei near the neutron drip line, some new-type collective modes are suggested caused by the pairing effect and continuum coupling. In[1], the continuum effect was discussed in terms of the relation between the spacial structure of the quasiparticle wave function and a large B(E2) value in the first 2^+ by using Skyrme-Hartree-Fock-Bogoliubov theory and quasiparticle Randome Phase Approximation(QRPA). We performed continuum QRPA and suggested the dineutron correlation in the soft dipole excitation near neutron drip line nuclei in [2]. The dineutron correlation is characterized by the behaviour of a large amplitude neutron-pair transition density. This behavior comes from a coherent superposition of continuum states.

But we adopt the simple local density-dependent residual force (called often Landau-Migdal approximation) in the previous continuum QRPA. Similar the continuum QRPA is in the same stuation[3]. Consequently the energy-weighted sum rule is broken. For more realistic description of the collective excitations in neutron-rich nuclei, the continuum QRPA should be based on the density functional theory with the Skyrme effective interaction. Especially, velocity dependent terms in the Skyrme functional plays the essential role for the conservation of the energy weighted sum rule.

In the present work, we have constructed for the first time the continuum QRPA theory which incorporates all the kinds of densities (incl. the current, derivative and kinetic energy densities arising from the velocity dependent interactions) existing in the realistic Skyrme functional except the spin-dependent part and the Coulomb term. We demonstrate the achievements by performing numerical analysis for dipole and quadrupole responses in some n-rich medium-mass nuclei including ^{20}O and ^{54}Ca. This new continuum QRPA theory guarantees the energy weighted sum rule (EWSR), to a high accuracy, reaching 95-99% of EWSR including the enhancement factors for the isovector responses (Fig.1). In addition, description of the centroid energy of isovector giant resonances is sizably improved (by a few MeV) over the LM approximation. We have also analyzed the transition densities of both the low-lying states and the giant resonances to see the improvements in the new continuum QRPA theory. Then we found that their behaviors are almost same but there are some little differences between two cQRPA calculation in the low-lying states.

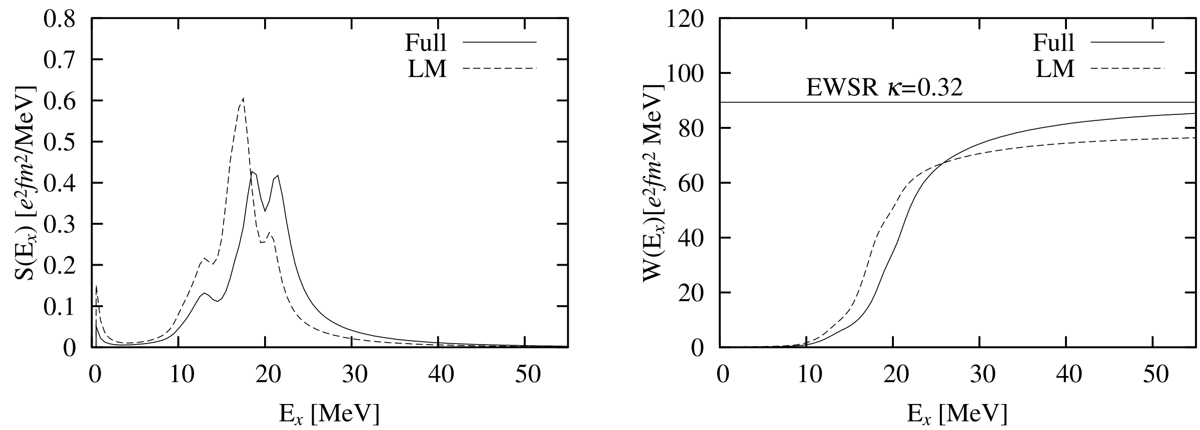

Figure 1: The E1 strength function and the running energy weighted sum in ^{20}O. A comparison is made between the full calc. and the Landau-Migdal approx.

The numerical calculations were performed on the NEC SX-8 supercomputer systems at Rsearch Center for Nuclear Physics, Osaka University.

References

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