**Self-Consistency in Hartree-Fock RPA and Low-Lying States in Nuclei**

Tapas Sil and S. Shlomo

Low-lying collective states are the key features of nuclear excitations and provide important clue on nuclear shell structure [1]. Hartree-Fock (HF) based RPA describes the whole excitation spectrum along with the low-lying states with the small amplitude approximation. For accurate implementation of HF-RPA method, the calculation should be fully self-consistent. One of the essential conditions for self-consistency is to use exactly the same interaction in the HF as well as in the RPA calculations. But, in most of the available HF-RPA calculations are contaminated with the self-consistency violation (SCV) because often for the numerical difficulties, some part of interaction used in HF, such as spin-orbit and Coulomb, are dropped out in the RPA [2]. In Fig. 1, we plot the strength function S(E) versus energy E for $^{208}$Pb for fully self-consistent calculation (SC), missing ph spin-orbit interaction(LS) and missing ph Coulomb interaction (CO) for L=2 and 3. It is seen from the figure that for both of the modes, the energy of the low-lying state increases for the LS cases (0.58 MeV and 0.26 MeV for L=2,3 respectively) where it decreases for the CO cases (0.10 MeV and 0.20 MeV respectively). Unlike low-lying states, for the giant resonances the centroid energies are reduced for both the of modes for LS (0.11 MeV and 0.24 MeV) and for CO (0.19 MeV and 0.04 MeV for L=2,3 respectively). It is to be noted that the effects of SCV on low-lying states are of similar order of those for giant resonances but for low-lying states, the shift (~0.5 MeV) is large in comparison to the excitation energy. Therefore, for the study of low-lying states, a fully self-consistent calculation is necessary.

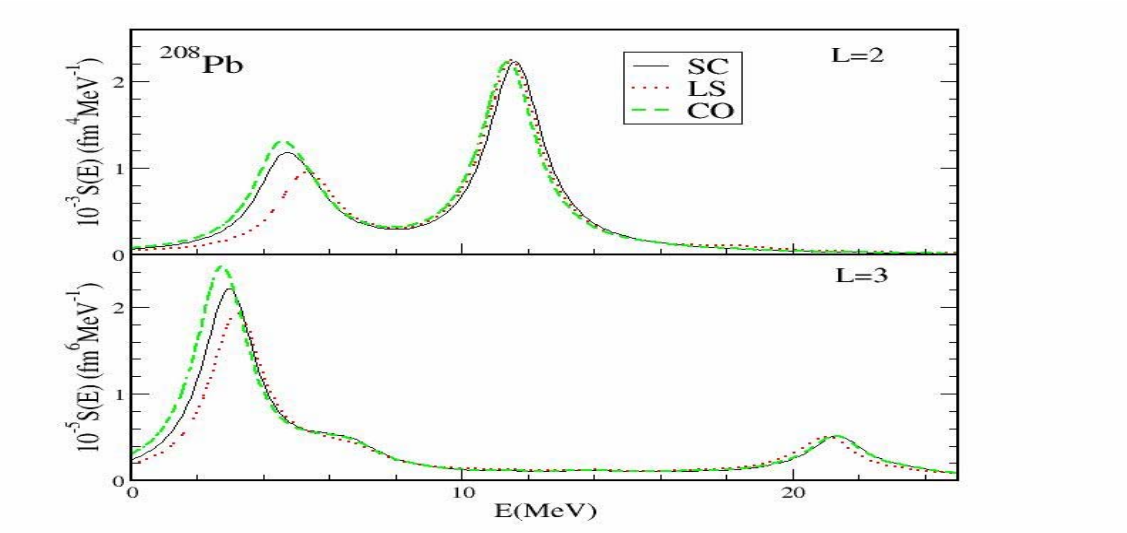


**Figure 1.** Strength function of isoscalar giant resonances calculated with SGII interaction.

[1] A. Bohr and B. R Mottelson, Nuclear Structure (Benjamin, London, 1975) Vol. II.

[2] T. Sil, S. Shlomo, B. K. Agrawal and P.-G. Reinhard, Phys. Rev. C **73**, 034316 (2006).