Self Consistent Random Phase Approximation in a three-level Lipkin model and the Goldstone mode

D. S. Delion
"Horia Hulubei" National Institute of Physics and Nuclear Engineering, Bucharest Măgurele, POB MG-6, Romania

P. Schuck
Institut de Physique Nucléaire, Orsay, 91406 - Orsay CEDEX, France

J. Dukelsky
Instituto de Estructura de la Materia, CSIC, Serrano 123, 28006 Madrid, Spain

We specifically investigate the properties of Self Consistent Random Phase Approximation (SCRPA) with respect to the Goldstone theorem and ensuing conservation laws, the fullfillement of which is one of the outstanding aspects of standard RPA theory [1, 2]. We show that it is possible to restore broken symmetries within the SCRPA applied to the three-level Lipkin model [3–5] We show that SCRPA indeed can be formulated in such a way that it preserves these properties of standard RPA [6]. This is to be considered as a strong advantage over other extensions of RPA [7–11] because SCRPA, though much more demanding numerically than standard RPA, leads to an (nonlinear) equation of the Schrödinger type which seems to be accessible for a numerical solution. The restoration of symmetries within SCRPA is directly linked to the consideration of the so-called "scattering" terms and we discuss their significance in detail. We also show that SCRPA yields much improved solutions which we will compare with the ones obtained from an exact diagonalization. For the two particle case SCRPA even reproduces the exact results. We determine one and two-body densities as very convergent expansions in terms of the generators of the RPA basis [12]. We show that SCRPA excitations correspond to the heads of some rotational bands in the exact spectrum.

PACS numbers: 21.60.Jz, 24.10.Cn
Keywords: Selfconsistent Random Phase Approximation, Three level Lipkin model, Goldstone mode

---

[1] D.J. Rowe, Rev. Mod. Phys. **40**, 153 (1968).
[2] D.J. Rowe, Phys. Rev. **175**, 1283 (1968).
[3] N. Meshkov, Phys. Rev. **C3**, 2214 (1971).
[4] G. Holzwarth and T. Yukawa, Nucl. Phys. **A219**, 125 (1974).
[5] K. Hagino and G.F. Bertsch, Phys. Rev. **C61**, 024307 (2000).
[6] D.S. Delion, P. Schuck, and J. Dukelsky, Phys. Rev. **C72**, 064305 (2005).
[7] K. Hara, Progr. Theor. Phys. **32**, 88 (1964).
[8] J. Toivanen and J. Suhonen, Phys. Rev. Lett. **75**, 410 (1995).
[9] F. Catara, G. Piccitto, M. Sambataro, and N. Van Giai, Phys. Rev. **B54**, 17536 (1996);
F. Catara, M. Grasso, G. Piccitto, and M. Sambataro, Phys. Rev. **B58**, 16070 (1998).
[10] A.A. Raduta et al., Nucl. Phys. **A634**, 497 (1998).
[11] M. Grasso and F. Catara, Phys. Rev. **C63**, 014317 (2001).
[12] B. Feucht, Université J. Fourier de Grenoble, Maîtrise de Physique, Institut de Physique Nucléaire, Juin 2000.