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Collective modes in the generator coordinate method

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Abstract. Using the harmonic version of the generator coordinate method, and Skyrme interaction, the frequencies of the isoscalar breathing and quadrupole modes are related to the relevant incompressibility coefficients. The possibility of extending this to spin modes is also examined. It is found that a spin incompressibility coefficient is negative for a particular set of Skyrme parameter for ^{4}He. Other sets produce low positive values and these in turn could imply a relatively low lying $S = 2$, $T = 1$ state. The replacement of the three-body term by the density-dependent one, suggested by Chang provides a cure for this pathology.

Keywords. Collective modes; generator coordinate method; Skyrme interaction; isoscalar breathing; quadrupole mode; spin mode.

1. Introduction

The generator coordinate method (GCM) (Hill and Wheeler 1953; Griffin and Wheeler 1957) is a very flexible one for the description of collective modes in any many-body system. Being fully quantal it is particularly useful for nuclei (see Wong 1975).

The GCM wave function for a collective mode (CM) is taken as

$$\psi_{\mathrm{GCM}} = \int f(a)\, \Phi(a)\, da, \tag{1}$$

where a is a set of real* collective generator coordinate (GC) and $\Phi(a)$ is a many-body wave function which depends on all the relevant coordinates and on a. The weight function $f(a)$ satisfies the Hill-Wheeler equation

$$\int [H(a', a) - E\, I(a', a)]\, f(a)\, da = 0, \tag{2}$$

where $$\begin{Bmatrix} H(a', a) \\ I(a', a) \end{Bmatrix} = \left\langle \Phi(a') \middle| \begin{Bmatrix} H \\ 1 \end{Bmatrix} \middle| \Phi(a) \right\rangle.$$

The choice of a, in the past have been based on 'educated' guess and here also we take such a course. However we must call attention to some recent work by Reinhard and Goeke (1979) on this question and the path of integration in (1).

*In certain situations it is necessary to allow for complex GC (Brink and Weiguny 1968)