On the Collective Description of Nuclear Surface Oscillation.

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Summary. - A general method for a collective description of a many particle system, which was introduced by Miyazima and the present author and applied to the case of weak coupling surface oscillation of the atomic nuclei, is extended here to the case of strong coupling, and our results are compared with those of other authors.

1. - Introduction.

In recent years, a number of papers have been published (1-11) with a view to unifying the individual particle and the collective particle aspects of atomic nuclei; the authors succeeded in deriving a Hamiltonian, parts of which de-
scribe individual particle motions while other parts describe the surface oscillation (13) together with the coupling term between these two.

The work of Miyazima and the present author (13) was carried out along similar lines, however, a new technique was introduced, using some new redundant co-ordinates, together with an appropriate number of subsidiary conditions, in order to cancel the added degrees of freedom. After performing several canonical transformations a Hamiltonian is obtained, part of which just reproduces Bohr's Hamiltonian (13) in the weak coupling approximation. Among the above mentioned papers, those by NATAF (9), LIPKIN et al. (10), and Villars (11), which came to our attention after our former paper had been submitted for publication, were based on ideas essentially similar to ours, and were applied to the strong coupling case.

Since our method, however, seems to be quite general in its scope and, in some cases, much simpler than others, it might be worthwhile to exemplify its application to the case of strong coupling. The present paper is devoted to this purpose.

Our results are compared, in Sect. 2 and Sect. 3, with those of the above mentioned authors. NATAF (9) and LIPKIN et al. (10) have confined their development to rotational motions, while VILLARS (11) included also vibrational and dilatational motions; in his theory these motions have been considered only in two dimensions, and therefore we have extended our application also to the three-dimensional case including all these types of collective motions. The results are summarized in Sect. 4, while Sect. 5 contains a discussion of the problem.

The basic idea of our method is explained in detail in our former paper (13). However, as the center of mass motion is the simplest example of collective motions, it might be instructive here to illustrate the application of our method to the separation of the center of mass motion from individual particle motions.

For the sake of simplicity, we take the one-dimensional motion and start with the Schrödinger equation for a many particle system

\[ H_0 \psi_0 = E \psi_0, \]

\[ H_0 = -\frac{\hbar^2}{2\mu} \sum_n \nabla_n^2 + V(x) \] 


(*) Here and in the following, potential energy of a particle system is abbreviated as \( V(x) \), or \( V(x, y) \) or \( V(x, y, z) \) in one, two and three dimensional cases, respectively, but we consider it to be a symmetric function of particle coordinates and to depend only on relative distances of the latter.