Integrability Conditions for a Determination of Collective Submanifolds.

1. - Group-Theoretical Aspects.

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Summary. — We study the integrability conditions of a time-dependent Hartree-Bogolubov (TDHB) equation to determine collective submanifolds from the group-theoretical viewpoint. The basic idea lies in the introduction of a sort of Lagrange manner familiar to fluid dynamics to describe collective co-ordinates. This manner enables us to take a one-form $\Omega$ which is linearly composed of a TDHB Hamiltonian and infinitesimal generators induced by collective variable differentials of a $SO_{2N}$ (Bogolubov) canonical transformation. The integrability conditions of our system read $d\Omega - \Omega \wedge \Omega = 0$, which is a fundamental equation to determine the collective submanifolds in the TDHB method. This equation may work well in the large scale beyond a $SO_{2N}$ RPA as the small-amplitude limit, with an appropriate boundary condition.

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1. - Introduction.

One of the most challenging problems in the recent studies of nuclear physics is to give a theory suitable for the global description of collective motions in soft nuclei. As is well known, a time-dependent Hartree-Fock (TDHF) or a time-dependent Hartree-Bogolubov (TDHB) theory is the standard first approximation in the many-body theoretical description of fermion systems. The collective motions due to small fluctuations around static HF/HB mean fields are treated with a random phase approximation (RPA).
An approximate solution of the TDHF/TDHB leads to the RPA solution as the small-amplitude limit. In this sense, the TDHF/TDHB method is a very promising one to construct a microscopic theory of the collective motions. However, when an instability in HF/HB ground states occurs and the fluctuation become large, the RPA treatment of the collective motions meets a serious difficulty. Furthermore, the global solutions of the TDHF/TDHB associated with the collective motions have not been constructed yet. We have never gone beyond the RPA as the small-amplitude limit. Then it has been strongly hoped for an appearance of the TDHF/TDHB theory capable of working well in the large scale beyond the RPA, namely of describing the so-called large-amplitude collective motions.

For the above aim, recently Marumori et al. have proposed a theory of the large-amplitude collective motions by formulating the «maximal-decoupling» condition in a form called «invariance principle of the Schrödinger equation» (1). They have tried to extract a few complex parameters corresponding to the collective degrees of freedom out of a set of full TDHF parameters. On the other hand, Kuriyama and Yamamura have presented a microscopic theory to possibly describe both large-amplitude collective and independent particle motions and their mutual coupling in a consistent way (2). Their theory has been made by extending the spirit of the TDHF method. The fundamental idea of the theory lies in the utilization of a fermion coherent-state representation which forces us to introduce inevitably anticommuting Grassmann numbers. They have successfully obtained constraints governing the collective and the independent particle degrees of freedom by imposing the canonicity conditions. The works of Marumori et al. and Kuriyama-Yamamura suggest us a possibility of applying their basic idea to the group-theoretical many-body theories based on the $SO_{2N}$ (3) and the $SO_{2N+1}$ (4) (the special orthogonal group of $2N$ and $2N + 1$ dimensions) Lie algebra of the fermion operators, respectively ($N$ being the number of single-particle states of the fermions).

The purpose of this paper is to give another version of the $SO_{2N}$ TDHB theory applicable to collective motions in the large scale following the above-mentioned idea. We study integrability conditions of the TDHB equation.

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