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Few-Body Systems

Laudation

Achim Weiguny

The collection of articles in this volume is a tribute to Professor Achim Weiguny on the occasion of his retirement following his 65th birthday. It is dedicated to him in recognition of his important contributions to theoretical physics both as a teacher and a researcher.

Achim Weiguny was born in Bunzlau, Silesia, on June 2nd, 1935. He studied at the University of Marburg and obtained his Diploma in Physics in 1961. Then he moved on to become a research student of Prof. Flügge at the University of Freiburg and was awarded his PhD in Theoretical Physics in 1963. In Freiburg he studied the quantum-mechanical three-body problem and other few-body problems. He was especially interested in Coriolis effects in the few-body problem and his work on the transition to rigid motion in the three-body problem is very highly regarded. Achim received his Habilitation (venia legendi) at the University of Freiburg in 1969 and soon afterwards, in 1970, he was called to the University of Münster as Associate Professor in Theoretical Physics. Two years later he was appointed Full Professor of Theoretical Physics and Director of the Institute of Theoretical Physics in Münster. He established an active research group and many students prepared their diploma and doctoral theses under his scientific guidance.

In 1967/68 Achim spent an academic year in Oxford on a Fellowship supported by the Deutsche Forschungsgemeinschaft and the Royal Society. During that year we had a very fruitful and very enjoyable collaboration exploring various aspects of the Hill-Wheeler generator-coordinate method, a microscopic approach to the nuclear many-body problem, which provides a link with phenomenological collective theories. We studied the connection between the Hill-Wheeler method and the random-phase approximation and together with H. Friedrich and C. W. Wong we gave an application to α-particle models of light nuclei in which the α-particles were built from nucleons with wave functions satisfying the Pauli exclusion principle.

On moving to Münster in 1970 Achim continued his investigations of α-clustering in nuclei in collaboration with H. Friedrich, L. Satapathy, and H. Hüsken.

They used the generator-coordinate method with angular-momentum and parity projection and were able to understand some of the properties of excited bands in light four-body nuclei. They also studied the relative instability of excited states against α-decay and the resulting band cut-off by calculating the angular-momentum-projected energies as a function of the separation between one α-particle and the residual nucleus. The next step was to calculate scattering wave functions, including Coulomb forces, by the Hill-Wheeler method. This was the first of a long series of research projects on reaction theory using the generator-coordinate method, which involved students and other collaborators and which lasted for about 20 years. In a very nice paper Achim and H. R. Fiebig showed that the generator-coordinate method could be used to calculate α-decays of cluster states by defining completely antisymmetrized Gamow states. In collaboration with K. Langanke, J. Leutenantsmeier, and M. Stingl he analyzed antisymmetrization effects in α-particle scattering with respect to the number of nucleons exchanged and showed that all exchange contributions are essential to reproduce the results of a completely antisymmetrized calculation. There were many other collaborations involving H. J. Assenbaum, H. P. Brall, W. Cassing, D. Frekers, Ch. Funck, K. Langanke, and R. Stademann on microscopic approaches to heavy ion reactions, scattering with absorption, resonant structures, transfer reactions, and molecular degrees of freedom. One of the last papers of this series was on an astrophysical application of the generator-coordinate method, a calculation of the *S*-factor for *E*2 capture of α-particles by ^{12}C at astrophysical energies.

In 1980/81 Achim spent a sabbatical year in the USA at the University of California at Los Angeles. He branched out in a new direction with papers on the collective model and on the interacting-boson model. In a series of papers with H. J. Assenbaum he used the generator-coordinate method to relate the interacting-boson model of Arima and Iachello to the collective model of Bohr and Mottelson. In lowest order they obtained the Bohr-Mottelson Hamiltonian in the harmonic approximation. The mapping of the operators of the interacting-boson model onto those of the collective model turned out to be of the Holstein-Primakoff type. The spring of 1985 was spent in Japan, at the University of Tokyo. One of the results of this visit was a paper with Akito Arima on cluster-transfer reactions using the resonating-group method in conjunction with the distorted-wave Born approximation. As a direct consequence of antisymmetry the renormalization of operators in the entrance and exit channels was automatically included.

There was a change of direction in 1987 with the emergence of two quite new research fields. The first was a collaboration with B. Giraud from Saclay on scattering theory within the framework of time-dependent mean-field theory. A number of coworkers, H. Horiuchi, H. Jünemann, S. Kessal, J. Lemm, T. Maruyama, F. Mekideche, M. A. Nagarajan, A. Ohnishi, and A. Wierling were also involved at various stages. A simple model of a collision involving four one-dimensional particles with separable two-body interactions allowed completely analytical solutions. The time-dependent mean-field approximation is nonlinear and has 29 solutions. However, a unique physical branch emerges that is very stable as the strength of the interaction is changed. The mean-field approximation is compared with an exact solution of the four-body problem and is found to be quantitatively as well as qualitatively good for small interaction strengths. Two papers relate the time-dependent mean-field with the generator-coordinate and resonating-group methods. The antisymmetrization of the T-matrix was discussed and it was shown that correct antisymmetrization restores post-prior symmetry.

A series of joint research projects in the field of dynamical symmetries and quantum groups was started in 1989 with S.-J. Wang and his colleagues. One project was on continuous-variable representations of dynamical groups and was related to the generator-coordinate approach to the dynamical-group representations. There were interesting applications to the Wigner D-function and to the representations of Elliott's $SU(3)$. Another was concerned with algebraic dynamics and time-dependent dynamical symmetries with applications to the quantum motion in a Paul trap. The exact solutions for the linear system with $SU(1,1)$ could be obtained using the methods of algebraic dynamics. The quantal-classical correspondence was exhibited clearly. The quantal solutions were determined by those of the corresponding classical equations and a continuous set of classical complex orbits corresponded to just one quantum solution. In addition the adiabatic and non-adiabatic Berry phases were calculated.

Nowadays, there is a growing interest in mathematical models for learning from empirical data. Very recently Achim, working with J. C. Lemm, J. Uhlig, has begun to study the problem of reconstructing a potential from measurements of the particle density in a quantal system at finite temperature. The data consist of a number of measurements of the position of a particle moving in a potential. There are two problems to be overcome. One is the fact that in quantum mechanics the average particle density determines the potential only indirectly. The other is that there are a finite number of measurements of the density at discrete points with experimental errors. Inverse problems like this one are notoriously ill-posed and it is well known that for such type of problems additional a-priori information is required to obtain a unique and stable solution. In the model studied the empirical density is obtained from the relative frequencies of sampled data. The data are used to construct a likelihood function, which is something like an envelope of density. The theory allows the reconstruction of the potential from the likelihood function. The likelihood may be constrained by symmetries such as parity and by a smoothness criterion. Obtaining the likelihood and the potential is a self-consistent procedure, the reconstructed likelihood corresponds to the reconstructed potential and vice-versa. Achim and his co-workers carried out this program for some simple examples and studied the sensitivity of the results to the assumptions about the a-priori information.

The above paragraphs show that Achim is a very active research scientist who has made important contributions to theoretical nuclear physics. In addition to his research and to his work in supervising graduate students he has always been involved with the teaching undergraduates in the department in Münster. He has taken his teaching duties very seriously and his carefully prepared lectures have been appreciated by the students. We wish him many more years of active research, advanced study, and other intellectual enterprises.

David Brink