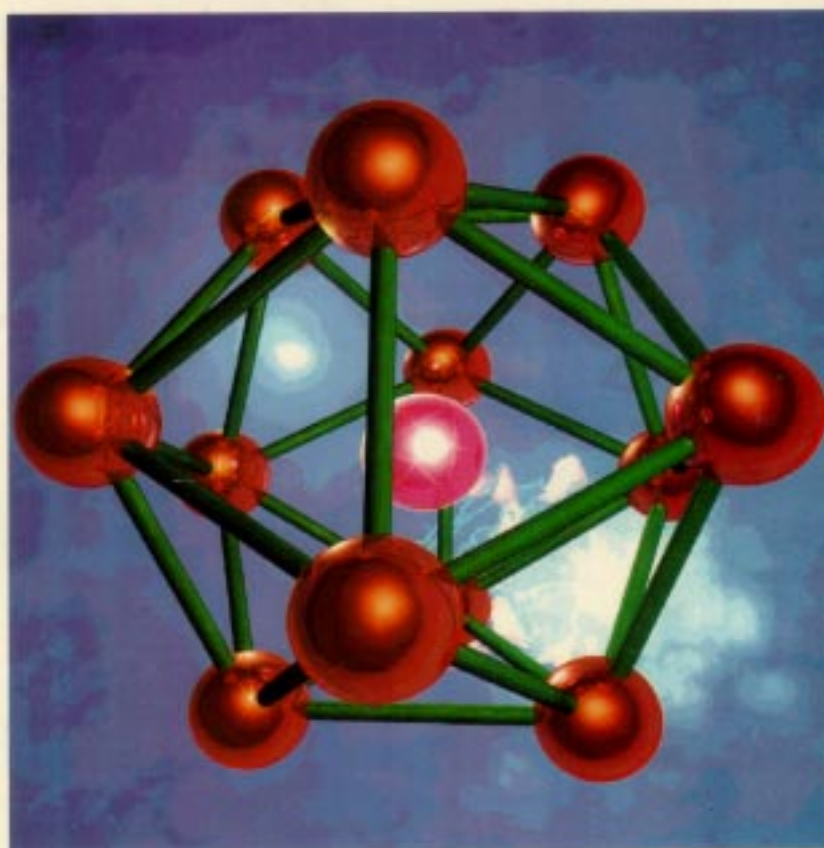


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THEORY OF ATOMIC AND
MOLECULAR CLUSTERS

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Foreword

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(Received 9 February 1994)

Atomic and molecular clusters have drawn vivid interest with the advent of experimental techniques to produce them. Their Physics and Chemistry is extremely rich, offering prospects for a large bouquet of additional unforeseen future technical applications. Within the last years many interesting results concerning thermal, magnetic and electronic properties have been reported. Buckyballs and their relatives with a large variety of surprising features including superconductivity have launched cluster physics to one of the most spectacular fields of physics.

Theoretically, the concepts both from condensed matter and atomic physics can be used, adapted and enlarged by additional degrees of freedom such as shape tensions, discreteness as well as smallness of particle number, i , as well as higher moments of the thermal observables, In addition, as an example of a quantum-mechanical many-body system, that rich instrumentarium could be introduced, treating even clusters with their quantum statistics by Feynman's thermal path integral.

The intention of this volume is to give insight into the present status of theoretical concepts and methods of cluster physics.

These papers have been presented at the International Symposium on the Theory of Atomic and Molecular Clusters at the cozy little harbour-town of Lee, Ostfriesland, in Germany.

The idea there was to bring together the theoreticians active in this field to detail on their newest ideas, just as an oral preprint of this volume. To confront the theoreticians with the status of the experimental results and problems on the meeting each session was opened with a report by an experimentalist. Thus K.G. Standing reported the classic measurements of CsI cluster decay as published in: W. Ens, R. Beavis and K.G. Standing, *Phys. Rev. Lett.* 50 (1983) 27, as well as more recent measurements that will appear in a forthcoming publication; P. Hakanson gave a review on the status of the fast heavy ion cluster impact experiments at Orsay.

The scientific programme greatly improved by the advice of the scientific board; especially the expert continuous engagement of Vlasta Bonačić-Koutechý and Karl Bennemann helped greatly to realize the scientific programme and the meeting as such.

The organization and technical realization was driven to reality by the enthusiastic and enduring engagement of the students of cluster physics of the University of Oldenburg, namely Knut Barghorn, Beate Curdes, Bernd Diekmann, Andreas Dullweber, Olaf Frank, Anja Schute-Manavi, Abha Sood, Heinrich Stamerjohanns, Werner Vogelpohl, Holger Waalkens, Susanne Dohmen for the Logo, Juliane Hilf running the bureaux, and Jacob Curdes, who also edited the book of abstracts, and especially by the local committee colleagues Hans Barth and Peter Borrmann, who took care of the organizational matters and the programme.



Opening address

Engeline Kramer

Lady Mayor, Town of Leer, Ostfriesland, Germany

Received 9 February 1994

Ladies and Gentlemen, I am happy to officially welcome you to Leer. The list of participants shows that some of you had a long journey, which hopefully was not too troublesome.

Our town is proud of having been chosen as your place of conference. In the past days you have had some opportunity to look around our town also on a guided tour. Nevertheless, I would like to give you some more brief information about Leer:

- Around 790 Leer was mentioned in documents for the first time.
- In 1823 the right to be a city was conferred on Leer.
- Our town has about 31.000 inhabitants and covers an area of about 7.000 hectares.
- The city of Leer belongs to the district of Leer with about 140.000 inhabitants and an area of 1.085 km². The district consists of 12 towns and communities, respectively.
- Leer is an independent city, which especially increases the scope of duties to be carried out by the municipal authorities.
- The city's budget is about 150 million deutschmarks per year.
- We are a commercial, shopping, and port-town and have a variety of trade and industry.
- Via the Dortmund-Ems canal the municipal port connects Leer directly with the industrial areas of the federal state of Nordrhein-Westfalen. Via the river Ems and the North Sea the port also represents a connection with the coastal states of the European Community.
- About 1 million tons of goods are transshipped in the port per year.
- Leer has become increasingly attractive to tourists spending short holidays here or visiting us on their city-tours.
- We have the largest area of reconstruction in Niedersachsen. The programme was started in the early seventies. Meanwhile a total of 200 million deutschmarks have been invested from private and public funds.

You have met here in order to exchange ideas and experiences, to attend lectures and discuss scientific subjects. You have chosen Leer for your meeting. This makes us proud and I think it was the intention of the organizers to combine business with pleasure. Past experience has shown that the free hours which participants use for less official conversations and discussions outside the conference rooms in our town are always relaxing and beneficial at the same time. On the basis of private exchange of ideas young participants may benefit from the experiences of senior colleagues and take some valuable advice home.

I am certainly not qualified for expert comments on your complex scientific subjects. Nevertheless, please let me make some remarks on the field of physics from my point of view.

Every field of science, especially physics, consists of two different aspects: on the one hand, there is basic research for improvement of knowledge, on the other hand, industrial applicability for increasing prosperity and comfort. The driving force of the former one is elemental human curiosity, which has always made man ask questions about nature and look for answers. The driving force of the latter one is basically the desire for easing the burden of heavy labour and for a more pleasant life. There has always been basic research and it will continue for ever. Man has been doing research work, because there are so many questions he cannot answer yet. Research as a basis of practical application, however, is a much more problematic field. Especially physics strongly interferes with human society and the question arises: What is our destination?

Growth is increase in population on the one hand, on the other hand, however, which is more dangerous, it means increasing demands of the individual. In the industrial countries this second aspect of growth is bound up with technology and industry, which are dependent on science. Since the atomic bomb the "responsibility of science" has been emphasized. I hope that all scientists are aware of their responsibility. The question of "What is possible?" will more and more turn into "What are we allowed to do?" and finally "What are we to do?"

What we can do is immeasurable. What we are allowed to do is not yet known in detail. Within the group of wrong projects we will find the development of destructive weaponry and also those projects that will finally result in economic and social disaster, although they seem to be advantageous for the moment. The supreme aim should be to teach people what we have to do to make life worth living and keep our earth in good condition.

I hope that you are having a successful congress from which every participant gains in some way. I also hope that you enjoy your sojourn in Leer and that you will take many positive impressions home to your towns.

I know very well that a congress with such an extensive programme is not an easy thing to organize. It has to be thoroughly prepared for a long time. So I want to thank the organizers of this congress, Prof. Dr. Hilf, Mr. Barth, and Mr. Bormann from Oldenburg University for their great efforts and good cooperation with the municipal authorities.

All the best for your congress and I wish you all a safe journey home.



Theory of atomic and molecular clusters

Editor: E.R. Hilf

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Summary

K.H. Bennemann

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This was an extraordinary, interesting conference. Not only many talks were very interesting, but also to learn that one has not to go to Crete or other dream places to attend an important conference on clusters. While still some senior people contributed very well to the success of the conference, here in particular Uzi Landmann deserves credit for his lively discussion, it was very pleasant to realize that the younger generation is very well on the way to take over, to set the tone. For example, the talks by Tománek, Stampfli, Garcia, to mention a few only, were of high quality, excellent, showed that statistical mechanics and solid state theory have discovered cluster physics and chemistry as an interesting research area.

Characteristics of the conference were the nice, friendly atmosphere, like in a good, interesting, intellectual family, and besides that

- (1) many good talks by the younger people,
- (2) very lively discussions (and if necessary with the help of “Freisengeist”) from which one could get more insight into the problems,
- (3) a refreshing, unusually interesting poster session.

The cosy atmosphere of the conference place and of the city of Leer as well as the smooth, fine organization of this conference by Professor Hilf and his coworkers, in particular Daughter Hilf, contributed certainly very well to the success of this meeting. This includes also the wonderful conference dinner with the long (well-meant) “enlightening” speech by the charming Lady Mayor of Leer.

It seems that cluster physics needs more meetings like this. It was very refreshing to have had speakers of quite different temperament, the mixture of young and old, of experimental and theoretical reports and of methods and explanatory theories. The quality of the calculational methods in particular gets better and better. Thus, one can hope for more realistic and reliable treatments of correlations (beyond Hartree–Fock).

There were many good reports and discussions in particular on:

- (a) new methods;
- (b) improvements of calculations, numerical techniques;
- (c) dynamical aspects of various problems (time dependent evolution of cluster properties), excitations;
- (d) many body effects (electronic correlation, fullerenes), and
- (e) cluster collisions (transfer processes).

Important problems (many body problems in particular), like non-linear dynamics, magnetism, new

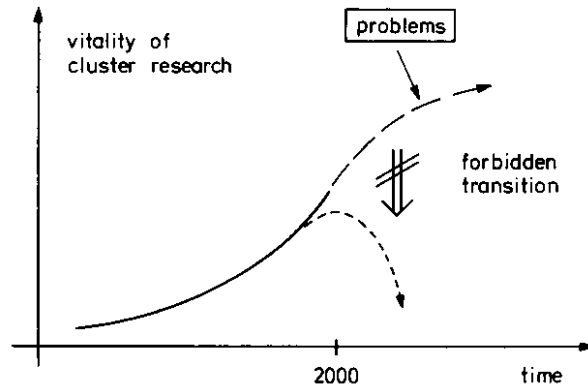


Fig. 1. Perspective of cluster research. New developments should be responsible for the forbidden transition.

calculational methods, the interdisciplinary character of the cluster research and the use of cluster as test material for general problems could keep this research area alive.

In the figure I have illustrated the foreseeable development. Of course, besides the mentioned important problems, very likely new problems will arise, since for sure experimentalists will continue to work, also in order to challenge the theorists.

Finally, let me thank on behalf of all of you Professor Hilf and his friendly coworkers, in particular Borrmann, Barth and daughter Hilf. How well everything was organized I experienced one day during the conference as Professor Hilf left the talks to go to the room of the organisation committee to have coffee with me and his daughter told him: "Papa, go to the talk, we don't need you here", and Papa obeyed. This was maybe typical for the friendly and smooth style of the conference.

I guess now after one week of hard work, serving us and helping us they deserve a bottle of "Friesengeist" (Schnaps) to recharge their batteries again and so I will present this as a farewell- and thank-you-present.