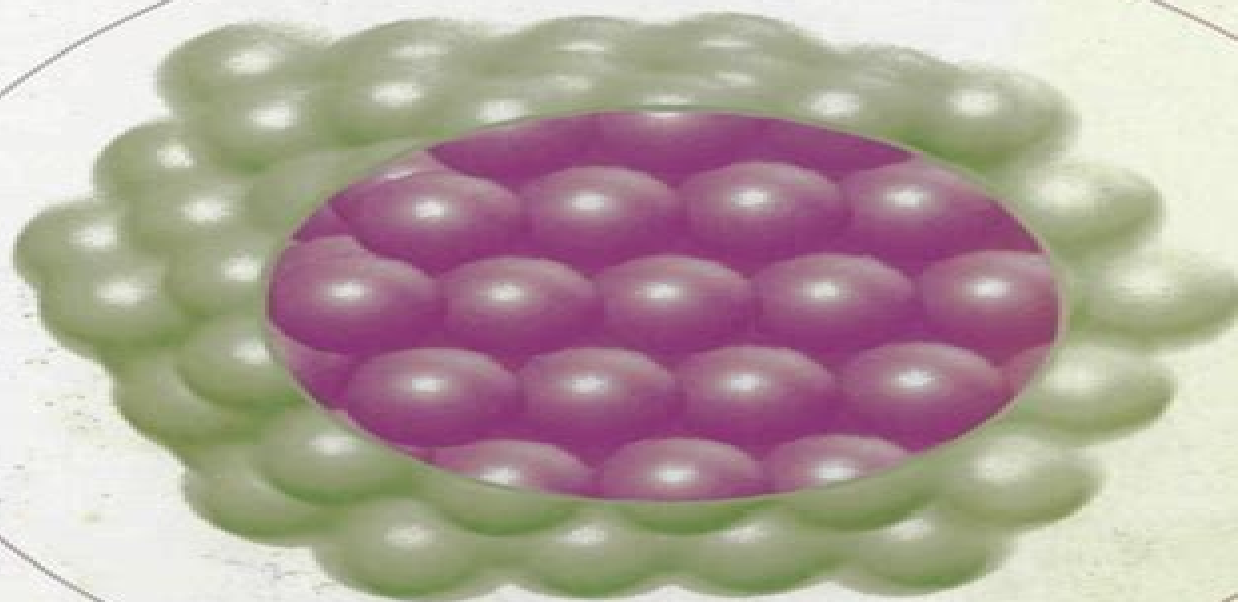


PHYSICS OF CLUSTERS



EDITORS
V D LAKHNO AND G N CHUEV

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Physics Of Clusters

P. Jena



Physics Of Clusters:

Physics and Chemistry of Small Clusters P. Jena, 2013-06-29 Recent advances in experimental techniques now enable researchers to produce in a laboratory clusters of atoms of desired composition from any of the elements of the periodic table. This has created a new area of research into novel materials since clusters cannot be regarded either as a large molecule or as a fragment of the bulk. Both experimental and theoretical studies are revealing unusual properties that are not observed in solid state environments. The structures of micro clusters are found to be significantly distorted from the most symmetric arrangement, some even exhibiting pentagonal symmetry commonly found in icosahedric structures. The unusual stability of certain clusters now described as magic number species shows striking similarities with the nuclear shell structure. The relative stabilities of clusters depend not only on the composition of the clusters but also on their charged states. The studies on spontaneous fragmentation of multiply charged clusters commonly referred to as Coulomb explosion illustrate the role of electronic bonding mechanisms on stability of clusters. The effect of foreign atoms on geometry and stability of clusters and the interaction of gas atoms with clusters are showing promise for an in-depth understanding of chemisorption and catalysis. The magnetic and optical properties are dependent not only on cluster size but also on its geometry. These findings have the potential for aiding industry in the area of micro electronics and catalysis.

Physics Of Clusters Gennady N Chuev, V D Lakhno, 1998-08-25 The monograph is devoted to the relatively new and fast developing field of cluster physics. It is based on talks given at the Cluster Workshops which were held in Pushchino in 1995 and 1996. The reports focus not only on the fundamental physical properties of clusters such as their geometric and electronic structure as well as optical, thermal and magnetic properties but also on a broad spectrum of their potential applications. These include nucleation and growth of small particles, fabrication of new materials with predefined properties, cluster assembled and nanostructures. Some aspects of simulations and calculations of small particles and clusters are also discussed. We hope that our monograph will be of interest to a broad range of readers who will be able to sense the excitement of the talks.

Microcluster Physics Satoru Sugano, 2013-03-08 This book aims at providing graduate students and researchers with fundamental knowledge indispensable for entering the new field of microclusters. Microclusters consisting of 10 to 10 atoms exhibit neither the properties of the corresponding bulk nor those of the corresponding molecule of a few atoms. The microclusters may be considered to form a new phase of materials lying between macroscopic solids and microscopic particles such as atoms and molecules showing both macroscopic and microscopic features. However, research into such a new phase has been left untouched until recent years by the development of the quantum theory of matter. The microscopic features of microclusters were first revealed by observing anomalies of the mass spectrum of a Na cluster beam at specific sizes called magic numbers. Then it was experimentally confirmed that the magic numbers come from the shell structure of valence electrons. Being stimulated by these epoch making findings in metal microclusters and aided by progress of the experimental techniques

producing relatively dense non interacting micro clusters of various sizes in the form of micro cluster beams the research field of microclusters has developed rapidly in these 5 to 7 years The progress is also due to the improvement of computers and computational techniques which have made it possible to perform ab initio calculations of the atomic and electronic structure of smaller microclusters as well as to carry out computer simulations of their dynamics

An Introduction to Cluster Science Phuong Mai Dinh, Paul-Gerhard Reinhard, Eric Suraud, 2013-09-30 Filling the need for a solid textbook this short primer in cluster science is ideal for a one semester lecture for advanced undergraduate students It is based on a series of lectures given by the well established and recognized authors for the past ten years The book covers both the basics of the domain as well as up to date developments It can be divided roughly into two parts The first three chapters introduce basic concepts of cluster science Chapter 1 provides a general introduction complemented by chapter 2 on experimental and chapter 3 on theoretical aspects The second half of the book is devoted to a systematic presentation of free cluster properties and to a thorough discussion of the impact of clusters in other domains of science These explicitly worked out links between cluster physics and other research areas are unique both in terms of fundamental aspects and of applications and cannot be found elsewhere in the literature Also suitable for researchers outside of the field looking for an introduction to cluster science

Clusters of Atoms and Molecules Hellmut Haberland, 2013-11-11 Clusters of Atoms and Molecules I is devoted to theoretical concepts and experimental techniques important in the rapidly expanding field of cluster science Cluster properties are discussed for clusters composed of alkali metals semiconductors transition metals carbon oxides and halides of alkali metals rare gases and neutral molecules The book contains several well integrated treatments all prepared by experts Each contribution starts out as simple as possible and ends with the latest results so that the book can serve as a text for a course an introduction into the field or as a reference book for the expert

Theory of Atomic and Molecular Clusters Julius Jellinek, 2012-12-06 The emergence and spectacularly rapid evolution of the field of atomic and molecular clusters are among the most exciting developments in the recent history of natural sciences The field of clusters expands into the traditional disciplines of physics chemistry materials science and biology yet in many respects it forms a cognition area of its own This book presents a cross section of theoretical approaches and their applications in studies of different cluster systems The contributions are written by experts in the respective areas The systems discussed range from weakly van der Waals bonded through hydrogen and covalently bonded to semiconductor and metallic clusters The theoretical approaches involve high level electronic structure computations more approximate electronic structure treatments use of semiempirical potentials dynamical and statistical analyses and illustrate the utility of both classical and quantum mechanical concepts

Clusters of Atoms and Molecules II Hellmut Haberland, 1994-08-26 Cluster science studies the transition from atomic and molecular physics or chemistry to the science and technology of condensed matter Two main topics from this large field will be emphasized in this second volume of Atomic and Molecular Clusters After an Introduction Chap 2 deals mainly with

molecular clusters how they react to positive or negative charges Sect 2 1 to 2 5 how they decompose and how they can be charged Sect 2 6 and 2 7 and how one can do chemistry with them 2 8 and 2 9 Clusters in contact with a macroscopic medium are treated in Chap 3 It is from this domain that one can expect possible new applications of cluster science The optical spectra of silver clusters in a dielectric medium are discussed in Sect 3 1 Their properties have since long been used unknowingly to stain glass windows Large clusters floating in an ambient pressure gas are called aerosols Sect 3 2 Their properties can be used to monitor air pollution Development of a photographic film is due to supported silver clusters in a liquid environment Sect 3 3 Large semiconductor clusters also called quantum dots have novel optical and electronic properties Sect 3 4 The optical properties of large clusters in general are reviewed in Sect 3 5 and properties of clusters supported on clean surfaces are discussed in Sect 3 6

Contribution of Clusters Physics to Materials Science and Technology Joel Davenas, P.M. Rabette, 2012-12-06 During the last decade there has been an increasing interest in clusters and small particles because of the peculiar properties induced by their large area to volume ratio For that reason small particles are often considered as an intermediate state of matter at the border between atomic or molecular chemistry and physics of the condensed matter The importance of the surface effect can explain the anomalous properties for example the existence of the five fold symmetry observed in different circumstances beams of rare gas clusters gold particles deposited on a substrate However the question of the critical size at which the transition to bulk properties occurs cannot be simply answered since the reply depends on the peculiar property which is studied The importance of the size effect was emphasized in the last International Meetings However the situation remains confused in most cases since the exact role of the cluster environment cannot be clearly elucidated and is a main difficulty except in cluster beam experiments In fact ideally free clusters constitute a laboratory exception In most applications small particles must be supported on a surface or embedded in a matrix in order to be stabilized which obviously shows the role of the environment

Clusters and Small Particles Boris M. Smirnov, 2012-12-06 Small particles in gaseous systems are called clusters aerosols dust particles Aitken particles etc depending on their size the media where they are observed and the field of science in which they are studied Below we call clusters systems of bound atoms or molecules containing from several atoms molecules up to thousands so that their structure can be essential for determining their properties If clusters are like bulk systems we call them small particles The principal peculiarity of clusters is with respect to magic numbers of cluster atoms that correspond to a heightened cluster stability Magic numbers correspond to complete structures of clusters as systems of bound atoms or molecules The values of magic numbers depend on the character of interaction of the cluster's atoms Cluster parameters as a function of the number of cluster atoms n have extrema at the magic numbers of atoms For example a cluster with a magic number of atoms has a higher binding energy and ionization potential than clusters with neighboring numbers of atoms The difference between clusters and small particles is such that parameters of small particles are monotonic functions of the number of their

atoms while for clusters these parameters have local extrema at magic numbers of atoms

Progress in the Physics of Clusters Gennady N. Chuev, Viktor D. Lakhno, A. P. Nefedov, 1999 The findings reported in this book on the methods of cluster measurements will lead to new avenues using nondestructive mass spectrometry and dipole mass isomers Much attention is given to the physics and chemistry of fullerenes and nanotubes including the problems surrounding the formation and growth of nanotubes electron characteristics of fullerenes the influence of solvents simulation of the properties of carbon clusters etc Some unique experimental data on the conversion of aerosols into aerogels with the formation of fractal structures is provided In addition the book covers one of the most interesting subjects of modern physics fractal clusters

Clusters of Atoms and Molecules II Hellmut Haberland, 2011-12-21 Cluster science studies the transition from atomic and molecular physics or chemistry to the science and technology of condensed matter Two main topics from this large field will be emphasized in this second volume of Atomic and Molecular Clusters After an Introduction Chap 2 deals mainly with molecular clusters how they react to positive or negative charges Sect 2 1 to 2 5 how they decompose and how they can be charged Sect 2 6 and 2 7 and how one can do chemistry with them 2 8 and 2 9 Clusters in contact with a macroscopic medium are treated in Chap 3 It is from this domain that one can expect possible new applications of cluster science The optical spectra of silver clusters in a dielectric medium are discussed in Sect 3 1 Their properties have since long been used unknowingly to stain glass windows Large clusters floating in an ambient pressure gas are called aerosols Sect 3 2 Their properties can be used to monitor air pollution Development of a photographic film is due to supported silver clusters in a liquid environment Sect 3 3 Large semiconductor clusters also called quantum dots have novel optical and electronic properties Sect 3 4 The optical properties of large clusters in general are reviewed in Sect 3 5 and properties of clusters supported on clean surfaces are discussed in Sect 3 6

Quantum Phenomena in Clusters and Nanostructures Shiv N. Khanna, Albert W. Castleman, 2014-01-15

Quantum Phenomena in Clusters and Nanostructures Shiv N. Khanna, Albert W. Castleman, 2003-04-08 Clusters and nanoscale materials give rise to properties and behaviour that are governed by size restrictions and hence display features directly attributable to quantum confinement Thus they represent ideal media for observing and studying quantum phenomena This book presents and evaluates some of the latest developments in this area of basic research Each of the chapters focuses on selected aspects of the field and the authors endeavour to display the breadth of the subject by presenting some of the important recent advances that have been made through the use of new experimental techniques and theoretical approaches

Cluster Processes in Gases and Plasmas Boris M. Smirnov, 2009-12-15 This reference on cluster physics in materials science draws upon the author's unrivalled experience in plasma science He covers in detail electromagnetic effects cluster motion and growth as well as aerosols providing the knowledge instrumental for an understanding of nanostructure formation Around 400 case studies enable readers to directly relate the methods to their own individual tasks or projects

Clustering Phenomena in Atoms and Nuclei Marten

Brenner, Tom Lönnroth, F. Bary Malik, 2013-06-29 In these days of specialization it is important to bring together physicists working in diverse areas to exchange and share their ideas and excitement This leads to cross fertilization of ideas and it enriches as in biological systems a specialized field with new strength development and direction derived from another area Although this might be an uncommon thing it is an important step in our understanding of the physical world around us which is after all the main purpose of physics The seed for this conference was really sowed when one of us MB and Mr Manng rd showed some a scattering data at backward angles to FBM one summer about four years ago That occasion led to a long research collaboration between the Abo Akademi physicists and other scientists in several countries The actual idea to explore the possibility of holding a conference however crystallized in the summer of 1989 during a visit of FBM to Abo Akademi The final decision to organize a conference was made after MB visited Profes sor Ben Mottelson in Copenhagen and Professor Anagnostatos in Athens At this point it was recognized that there are similarities as well as differences between clustering phenomena in nuclei and systems consisting of atoms It was therefore conjectured that it could be very stimulating to bring together these groups to exchange their ideas and to learn from each other s fields A conference along these lines we hoped would contribute to an increased mutual understanding

Clusters of Atoms and Molecules Hellmut

Haberland, 2012-01-07 Clusters of Atoms and Molecules I is devoted to theoretical concepts and experimental techniques important in the rapidly expanding field of cluster science Cluster properties are discussed for clusters composed of alkali metals semiconductors transition metals carbon oxides and halides of alkali metals rare gases and neutral molecules The book contains several well integrated treatments all prepared by experts Each contribution starts out as simple as possible and ends with the latest results so that the book can serve as a text for a course an introduction into the field or as a reference book for the expert

Introduction to Cluster Dynamics Paul-Gerhard Reinhard, Eric Suraud, 2008-07-11

Clusters as mesoscopic particles represent an intermediate state of matter between single atoms and solid material The tendency to miniaturise technical objects requires knowledge about systems which contain a small number of atoms or molecules only This is all the more true for dynamical aspects particularly in relation to the quick development of laser technology and femtosecond spectroscopy Here for the first time is a highly qualitative introduction to cluster physics With its emphasis on cluster dynamics this will be vital to everyone involved in this interdisciplinary subject The authors cover the dynamics of clusters on a broad level including recent developments of femtosecond laser spectroscopy on the one hand and time dependent density functional theory calculations on the other

Metal Clusters at Surfaces Karl-Heinz

Meiwes-Broer, 2012-12-06 Numerous experiments and calculations have shown that isolated metal clusters possess many interesting features quite different from those known from surface and solid state physics or from atomic and molecular physics The technological exploitation of these new properties e g in miniature electronic or mechanical components requires the cluster to be brought into an environment such as an encapsulating matrix or a surface Due to the interaction with the

contact medium the properties of the clusters may change or even disappear Thus the physics of cluster on surface systems the main subject of this book is of fundamental importance The book addresses a wide audience from the newcomer to the expert Starting from fundamental concepts of adsorbate surface interactions the modification of electronic properties through electron confinement and concepts of cluster production it elucidates the distinct properties of the new metallic nanostructures

Physics and Chemistry of Small Clusters P Jena, 2014-01-15

Physics and Chemistry of Finite Systems: From Clusters to Crystals Peru Jena, S.N. Khanna, B.K.N. Rao, 2013-11-11

Recent innovations in experimental techniques such as molecular and cluster beam epitaxy supersonic jet expansion matrix isolation and chemical synthesis are increasingly enabling researchers to produce materials by design and with atomic dimension These materials constrained by size shape and symmetry range from clusters containing as few as two atoms to nanoscale materials consisting of thousands of atoms They possess unique structural electronic magnetic and optical properties that depend strongly on their size and geometry The availability of these materials raises many fundamental questions as well as technological possibilities From the academic viewpoint the most pertinent question concerns the evolution of the atomic and electronic structure of the system as it grows from micro clusters to crystals At what stage for example does the cluster look as if it is a fragment of the corresponding crystal How do electrons forming bonds in micro clusters transform to bands in solids How do the size dependent properties change from discrete quantum conditions as in clusters to boundary constrained bulk conditions as in nanoscale materials to bulk conditions insensitive to boundaries How do the criteria of classification have to be changed as one goes from one size domain to another Potential for high technological applications also seem to be endless Clusters of otherwise non magnetic materials exhibit magnetic behavior when constrained by size shape and dimension Nanoscale metal particles exhibit non linear optical properties and increased mechanical strength Similarly materials made from nanoscale ceramic particles possess plastic behavior

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