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Nobel Prize in Physics 1977



Philip Warren Anderson **Sir Nevill Francis Mott** **John Hasbrouck van Vleck**

The Nobel Prize in Physics 1977 was awarded jointly to Philip Warren Anderson, Sir Nevill Francis Mott and John Hasbrouck van Vleck *"for their fundamental theoretical investigations of the electronic structure of magnetic and disordered systems"*.

Information about winners:

Dr **Philip W. Anderson**,

Bell Telephone Laboratories, Murray Hill, New Jersey, USA,

Sir Nevill F. Mott,

Cambridge University, Cambridge, England

John H. van Vleck,

Harvard University, Cambridge, Massachusetts, USA,

RESEARCH INFORMATION:

The three prize-winners are theoreticians within the field of solid state physics - the branch of physics which lies behind essential parts of the current technical development, particularly in electronics. All three have added many new basic concepts to the theory, which have made it possible to understand new experimental results. The distance between fundamental results in basic research and technical applications is as a rule comparatively short in this field. As an example, one can mention that van Vleck's ideas have played a central role for the development of the laser, whereas the technical development of amorphous materials like glass, which is now going on, would be unthinkable without Mott's and Anderson's contributions to the fundamental theory.

van Vleck has been called "the father of modern magnetism". He has developed methods which make it possible to understand how a foreign ion or atom behaves in a crystal. At first the electrons of such a perturbing ton feel the influence of the electric field - the crystal field - which is generated by the atomic nuclei and the electrons of the host crystal. Through its electrons, the perturbing ion can also enter into chemical bonding with its environment which is usually called the ligands. van Vleck was the first to develop the crystal field theory as well as the ligand field theory to describe such phenomena in greater detail. These quantum chemistry methods have now almost become routine tools, particularly within inorganic chemistry with important extensions to molecular biology, medicine and geology.

Another important part of van Vleck's work deals with the Jahn-Teller effect, which is associated with an interaction between the electrons and the positions and mottoes of the atomic nuclei. A perturbing atom in a crystal can sometimes replace a host atom without essential changes in the surrounding lattice. Under certain circumstances the electronic structure of the perturbing atom is so incompatible with the symmetry of the environment that it leads to a local distortion of the lattice. This so-called Jahn-Teller effect was predicted in the 1930's but, only during the last decade, has one essentially through van Vleck's work succeeded in understanding this phenomenon in greater detail and in realizing its experimental importance.

van Vleck was the first to point out the essential importance of electron correlation - the interaction between the motions of the electrons - for the appearance o local magnetic moments, i. e. "mini-magnets" in materials. His former student P.W. Anderson, has further developed these ideas and succeeded in explaining how local magnetic moments can occur in metals, as for instance copper and silver, which in pure form are not magnetic at all.

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These phenomena can be quit complicated - the strength of the "mini-magnets" can, for instance, change abruptly when the concentration of the perturbing ion varies only a few percent. In a simple quantum mechanical model, Anderson has caught all the aspects which seem to be of decisive importance for understanding what happens in such situations

Mott and Anderson have separately given essential contributions to our knowledge of disordered systems. In crystallic materials, the atoms form regular lattices, which greatly facilitate the theoretical treatment. In disordered materials, this regularity is lacking - either so that the components of an alloy are placed at random in the regular lattice positions, or so that there is no lattice whatsoever as for instance in glass. It is exceedingly difficult to treat such materials theoretically. In 1958, Anderson published a paper in which he showed under what conditions an electron in a disordered system can either move through the system as a whole, or be more or less tied to a specific position as a localized electron. It was Mott who several years later called the attention of particularly the expert mental physicists to this paper, which has become one of the cornerstones in our understanding of, among other things, the electric conductivity in disordered systems. Mott and Anderson have in a series of papers created a multitude of new concepts which have turned out to be central for the understanding of disordered materials. Their ideas have to a large extent been experimentally verified and they have in tints way laid the foundation for important technical developments.

The electric properties of crystals are described by the so-called band theory which gives a classification with respect to the conductivity in metals, semiconductors, and insulators. This theory is not universally valid, however, and a famous exception is provided by nickel oxide, which according to band theory ought to be a metallic conductor but in reality is an insulator. Mott has shown how this can be explained by means of a refined theory which takes the electron-electron interaction into account. This led also to the study of the so-called Mott transitions, by which certain metals can become insulators when the electronic density decreases by separating the atoms from each other in some convenient way.

All the prize winners have been active in large domains of physics where they have given highly valuable contributions. This year's prize puts the emphasis - on their work concerning electron-electron interaction and the coupling between the motions of the electrons and the atomic nuclei in magnetic and disordered materials, where they - particularly in the treatment of and the emphasis on localized electronic states - have gone far beyond the conventional theories, with direct importance for experiments and technology.

For more details please visit:

http://www.nobelprize.org/nobel_prizes/physics/laureates/1977/press.html