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E. Mooser, on his sixtieth birthday, June 5, 1985

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On June 5, 1985, Professor Emanuel Mooser celebrates his sixtieth birthday. The conviction has emerged among his near colleagues and coworkers that a special issue of Helvetica Physica Acta should be published at this occasion as a jubilee volume. The contributors to this issue have had to be selected in order to keep the style and the size of the publication in conformity with the editors' policy. Every scientist approached accepted to contribute with an enthusiasm corresponding to E. Mooser's popularity, not only on the scientific level, but also in all his human relationships.

As the son of Emanuel and Margrit Mooser, Emanuel was born on June 5, 1925 in Thun. From this charming little town in Berner Oberland, his father, who was a test pilot moved in 1940 to another historical city, Luzern, world wide known as a resort town, where the already bright student Emanuel Mooser got through his maturity examination. From 1944 to 1949, he was a student in the section for Mathematics and Physics at the Eidgenössische Technische Hochschule in Zürich. The course of his study was partially interrupted by his activity in the Swiss army where he became an artillery officer. Straight after his diploma as a physicist he started to work with Professor Georg Busch in the group which became seven years later the Laboratorium für Festkörperphysik. At that time, the intensively investigated field of solid state physics was actively involved in the description of the semiconductors. Each newly discovered semiconductor constituted an event. In this stimulating scientific atmosphere, Emanuel Mooser started to investigate the magnetic susceptibility of gray tin which could be produced in a powdered and not very pure form. In his thesis 'Die magnetischen Eigenschaften der Halbleiter mit besonderer Berücksichtigung des grauen Zinns', published in 1953, E. Mooser gave a comprehensive review of the various contributions to the magnetic susceptibility in semiconductors, originating from the free carriers and from several types of impurities.

In the early fifties, the science of semiconductors statistics was well established. Several attempts were made in order to solve the problem of the dependence of the Fermi energy upon the semiconductor band parameters. The solution of the integral neutrality condition involved a large amount of numerical or graphical computations. Emanuel Mooser's contribution has been to build an analogic apparatus, with sliding rules, which allowed the determination of the Fermi level for non degenerate free carrier gases, in the conduction and valence bands. This contribution is worth mentioning because it reflects a definite trait of character. As a physicist, he has always been an ingenious and precise experimentalist. His skill in handling mechanics, glass blowing or sample preparation has been of primary importance in numerous original works. But this manual skill results in another achievement in which he became a master. In many occasions you will see Emanuel Mooser with a sheet of paper in the hands, folding and unfolding it until a structure is shaped. After a persistent training in Origami, he developed his own style consisting in folded paper bas-reliefs based on principles not far away from the symmetries encountered in the crystal lattices.

Besides several colleagues like Ch. Enz, O. Vogt, S. Yuan, he first met in Zurich at that time D. K. C. MacDonald whose style later made an impression on him, especially as a research group leader. Actually, his Ph.D. thesis rewarded with a silver medal at the ETH brought him a postdoctoral fellowship at the National Research Council in Ottawa. He had got married with Margrit Hunkeler who took upon herself during their whole life a significant responsibility for most practical aspects in their common life. Shortly after the birth of their daughter, they left for Canada. There started a most creative and significant collaboration with W. B. Pearson. This work led to the publication in 1959 of the so called Mooser–Pearson plots which introduce a new classification of valence compounds based on two atomic parameters, that is

1) the average principal quantum number as a measure of the valence shell of the component atoms and
2) the difference between the electronegativity of anion and cation.

However, the road leading to this comprehensive crystal chemistry began with the careful investigation of the chemical bonds and of the crystal structures in semiconducting compounds. Semiconductivity was recognized to be the result of the presence in a solid, of predominantly covalent bonds. His earliest publication already mentions the generalized 8-N rule governing the filling of the *s* and *p* orbitals by the valence electrons, which was used to predict whether or not a compound is an intrinsic semiconductor.

After two successful years in Canada, E. Mooser came back to the ETH in Zurich as a scientific coworker of Professor Georg Busch. Work on semiconducting compounds continued. With a few younger coworkers, the predicted semiconductivity of some ternary compounds was experimentally substantiated. The developed valence bond treatment of semiconductivity became strengthened. Precursory remarks stressed its wide field of application e.g.: The valence bond description explains semiconductivity in terms of the bonds formed between each atom and its neighbours, in terms of the 'short range order'. The conclusion followed that 'it might lead to the understanding of liquid and amorphous semiconductors'. The work in collaboration with W. B. Pearson did not stop during the Zurich period. After turning down an offer to be appointed professor at the Western Reserve University in Cleveland, he went back in June 1957 for a longer stay at the National Research Council in Ottawa, where as Associate Research Officer, he lead a research group in semiconductor physics. From a survey of the chemical bonding in the then known semiconductors, Mooser and Pearson evolved a criterion generally applicable for predicting semiconductivity among the chemical compounds. Beside the saturation of the valence of the anions by the cations valence electrons, it was advised to take into account

1) the anion-anion and cation-cation bonds occurring in the structure, as well as
2) the non-bonding electrons, in order to enunciate the rules governing the chemical composition of semiconductors.

The systematics of semiconducting structures allowed the separation of the phases derived from a closed-packed-cubic substructure of anions (Fig. 1). On the one hand (low average principal quantum number, that is small size or light atoms and small electronegativity difference) the tetrahedral coordination, on the other hand (high average principal quantum number and large electronegativity difference) the octahedral coordination. This interpretation fits well with the chemical trends usually assigned to the covalent and ionic bonds like more or less directional sp^3 hybridized or p bonds, low or high coordination, loose or dense packing, respectively.

These qualitative and keen considerations played a determining and leading role in distinguishing the class of the semiconductors among solids and in emphasizing the basic properties that are common to all semiconductors. They opened the way to more rigorous theoretical interpretations, and to wide experimental research in new semiconductors. Among the materials, with non bonding orbitals or with cation-cation bonds, the crystals with layered structures hold a

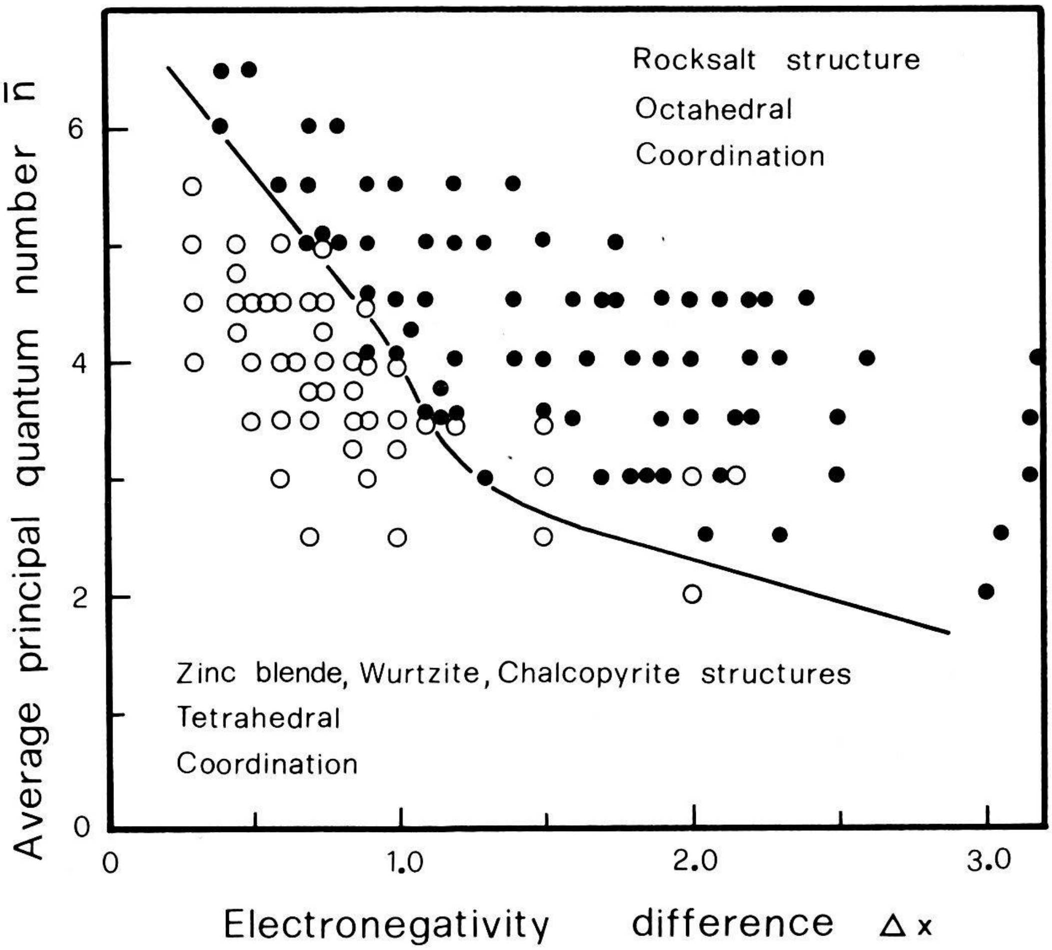

Figure 1
Binary' valence compounds with cubic close-packed anion substructure and tetrahedral and octahedral coordination.

key position. With a couple of younger coworkers, Emanuel Mooser started to investigate more especially the electronic properties of semiconductors with high structural anisotropy. The leading thread of his research started with the synthesis of single crystals of the compounds under examination. It proceeded with the experimental investigation, mainly by optical or electrical measurements and ended with the interpretation substantiated by the most recent theories. The typical example of the studied semiconductors is certainly gallium monoselenide which is a layered polycompound (Ga–Ga bonds within the layers) with an intrinsic energy bandgap of about 2 eV and showing characteristic excitonic features at the fundamental optical absorption edge.

In June 1961, with his wife and two children, he came back to Switzerland. He was appointed director of the physical laboratory at the Cyanamid Research Laboratory in Cologny, Genève. In the company, it was the time of the fat cows. He had the possibility to devote himself entirely to pure basic research. It has been an opportunity to study thoroughly the crystal chemistry of semiconductors, in particular the relations between bonding structure and semiconducting properties. The systematic survey passed beyond the tetrahedrally and octahedrally coordinated semiconductors. The concept of spinpairing in bonds along specific directions became indicative for the magnetic state but also for structural stability and for semiconductivity.

Several research students worked in his laboratory and made their Ph.D. there. He contributed to many teaching schools, in particular in Bristol. His first impact on the physics of layered materials like GaSe or MoS_2 dates from this period. The time was great ... unfortunately too short, Cyanamid closed the Geneva laboratory in 1969. To that event we owe the beginning of E. Mooser's career as a Professor. On January 1st, 1969, he was appointed extraordinary and paradoxically also ordinary professor at the Ecole Polytechnique in Lausanne which had just become Federal at that time. He became the director of the newly founded Laboratory for Applied Physics and started to do research along his line of action, that is including materials research, sophisticated physical experimentation and top level solid state theory. His research group grew up dramatically to reach a total number of forty to fifty members. It has been open to many visitors and to many research students, some of them occupying presently leading positions in the community of solid state physicists. The explosion in publications (numbering over six hundred up to now) gives an insight in the dynamics and in the pertinence of his research group.

Among other topics of research, the study of excitons in wide gap semiconductors with the help of optical techniques has been a leading subject of his scientific interest. The structural anisotropy and the adjacent direct and indirect band gaps in gallium selenide resulted in intricate optical spectra at the fundamental optical absorption edge. The analysis of the spectra and in particular of the influence of the magnetic fields lead to a suitable description of the electronic states in this semiconductor and to an elegant sketch of magneto-optical effects. In the case of lead diodide whose poorly understood excitonic series has been a subject of long controversy, he strongly supported the interpretation of a normal series based on the optical measurement of a new line in the spectrum. The investigations of a series of crystals with anisotropic structures confirmed his expertise in the domain of materials with low dimensional structures. This was put in a concrete form by the publication of the book series Physics and Chemistry of

Materials with Layered Structures for which he efficiently acted as a managing editor.

Within his Institute and besides the research on the physics of semiconductors, Professor Mooser launched a research in biomedical engineering in collaboration with other groups in the two Federal Institutes of Technology and in the University of Lausanne. The common mark of the projects is the development of non invasive techniques allowing the measurement of specific pathological parameters in order to help the physician in his diagnostic or in his control.

His interest has reached, however, far beyond the boundaries of the Lausanne Institute. During twelve years he has been a leading member of the research council of the Swiss National Foundation for Scientific Research where he contributed significantly in defining the direction of the research policy, fighting hard in order to maintain the high scientific level of the research in Switzerland, which is in some ways connected with the available financial support. Lastly, one of his most promising achievements is the laborious build up of the Swiss Foundation for Research in Microtechnology, which should become a tool in carrying out research projects of high scientific level and of acute practical significance in collaboration with Universities, Institutes of Technology and Industries, especially in the strategic field of microelectronics. Devoting most of his time to these more research promotional activities, Professor Mooser became a personality with efficient drive in scientific research in Switzerland to whom several research groups owe their existence.

With the present jubilee issue, the scientific community and his close coworkers would like to express their congratulations to Emanuel Mooser, and to thank him warmly for all his achievements. They also would like to wish him further success and satisfactions for a rich future.