Charles Mauguin

1878-1958

Charles Mauguin, through his research and teaching, took an outstanding part in the development of modern crystallography in France.

He was born in Provins, a small town of Ile de France, where his father was a baker. There he received the elementary education and passed, at the age of 16, the competitive examination of the Normal Teacher's Training College of Melun. He thus started his educational career by teaching young children to read and to count, at the same time, however, he prepared for the entrance examination at the Ecole normale of Saint-Cloud, where he was admitted in 1902, intending himself to become a teacher in a Normal Teacher's Training College. The instruction given there, extended from mathematics to natural sciences, and was especially suitable for his studious mind, eager for knowledge. He was lucky in being noticed by his professor of chemistry, Simon, who also directed the laboratory of organic chemistry of the 'Ecole Normale Supérieure' of Paris. Therefore Charles Mauguin's first steps into Scientific Research was academical work on organic chemistry; this lead him, in 1910, to the degree of Doctor of Sciences. In his thesis 'Bromine sodium amides and their part in the transposition of Hofmann', he was studying the amides $R{\cdot}CO{\cdot}NH_2$ where he substituted sodium bromide for the two hydrogens; these products are unstable and as they release the sodium bromide, they provide isocyanates OCNR which may be considered as resulting from the oxidation of the first amides. He thus discovered a close link between the amides and the ureides which are of major importance in the chemistry of the living cell; he also thought that, through a process of biochemical oxidation, the same reactions could be reproduced. Charles Mauguin soon discontinued the research in organic chemistry, but kept in view the biological aspect of chemistry during his whole life.

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At the same time as he was preparing his thesis, he was attending at the Sorbonne the mathematics classes of Emile Picard, Poincaré, Painlevé, Goursat. But he was particularly struck by the outstanding course of lectures given in 1905 by Pierre Curie on symmetry in physical phenomena. This led him to take a special interest in crystallography, he attented the classes of Fr. Wallerant who was at the head of the laboratory of mineralogy at the Sorbonne. Wallerant made him his assistant and directed him to the study of liquid crystals. The German physicist Otto Lehmann had discovered some organic substances which may possess the same fluidity as real liquids (some are more mobile than water) as well as the birefringence of crystals (several of them are twice as birefringent as calcite). This curious state of matter appears as a turbid phase in a range of temperatures included between those where the isotropic liquid and the solid phase exist. The constitution of this turbid phase was much discussed; some thought it was due to the presence of an insoluble impurity. Mauguin thought that the turbid liquid is constituted by birefringent elements, the orientation of which varies from one point to another, so that it becomes almost opaque in a thick layer. Testing on azoxyanisol and azoxyphenetol which, in the turbid phase, are extremely fluid, he imposed a uniform orientation to the different birefringent elements to make it homogeneous and perfectly transparent. He succeeded in this by acting with agents such as the magnetic field, whose action penetrates through the mass itself of the liquid, or else by applying appropriate surface actions.

The turbid phase of the azoxyanisol, placed between the pole pieces of a magnet, becomes clear almost at once and then resembles optically a very highly birefringent uniaxial crystal, the axis of which is parallel to the direction of the magnetic field. Mauguin achieved a complete optical study of the anisotropic phase and found the classic phenomena of uniaxial crystals, for instance he obtained in the visible spectrum beautifully channelled spectra with several hundred grooves, using a one millimetre thick layer. He thus determined the two indices of refraction. When the current of the electromagnet is cut off, the orientation is lost in a very short time, together with the homogeneity and transparency of the sample.

Contact with solids may force the molecules into a strictly determined orientation; Mauguin showed that a homogeneous layer of azoxyanisol is obtained by simple fusion of the crystals between two plates of glass, provided they are absolutely clean. When observed in the polarizing microscope, the preparation appears as a uniaxial crystal the axis of which is normal to the support. The situation is completely different when the azoxyanisol is melted on a newly cleaved muscovite mica plate. The liquid crystal then takes such an orientation that the optic axis is parallel to the cleavage, namely along a crystallographic direction at about 30° to the symmetry plane. This was at that time (1912) rather unexpected; X-rays have since shown that (010) is a glide-symmetry plane. If the azoxyanisol is melted in a wedge-shaped crevasse obtained by cleavage, the two optical axes in contact with the two surfaces of the wedge, form an angle of 60° with one another. The result is a helicoidal structure which Mauguin studied experimentally in all detail and fully explained theoretically.

This outstanding research was interrupted by the First World War. The results have lost nothing of their interest, and the techniques developed by Mauguin are still used in the research now continuing on these substances which are so important in physicochemistry as well as in biology.

After short periods as Associate Professor, in 1912 at the Faculty of Sciences of Bordeaux, and in 1913 at the Faculty of Nancy, Mauguin came back in 1919 to the Faculty of Sciences of Paris, as Associate Professor under Frederic Wallerant, whose successor as Professor of Mineralogy he was from 1933 to his retirement in 1948.

When he resumed work in a research laboratory after four years of interruption during the war, Mauguin was one of the very few scientists in France who had understood the importance of the discoveries of Laue and the Braggs for the analysis of crystalline structures. Being a chemist, he was immediately aware of their great interest for making accurate statements about the mode of linkage of atoms in the different chemical compounds. He had submitted to the first Solvay Council of Chemistry, in 1922, a report *Electronic Theory of Valence*, where he methodically and clearly set forth work almost unknown in France. He considered X-rays to be the most direct means for finding the nature of the chemical bond. He thereupon followed this new way, built the apparatus, including cameras, and perfected the techniques. He published in 1924 a remarkably well documented book *La structure des cristaux determinée au moyen des rayons X* which played in our country a decisive part in the formation of a new school of crystallographers. His first original publication in this new field is of 1921 and deals with the atomic structure of quartz. In 1923 he published the atomic structure of cinnabar, laid stress on its relationship with galena and showed how the atom of mercury, because it may be approximated by a flattened ellipsoid of revolution, leads to an helicoidal arrangement which gives to cinnabar a strong rotatory power.

In order to stress this interpretation of the rotatory power, he determined the ordering of atoms in calomel, being convinced that in this case an analogy would be found with the structure of rocksalt. This is not so, calomel being a structure of molecules Hg_2Cl_2. He then grappled with the structure of graphite, being unaware that Bernal in London and Mark in Berlin were already studying this problem. Mark was the first to publish his results, but the three authors reached the same conclusions, which did not differ essentially from the result A. W. Hull had given seven years earlier (1917).

In 1926, he published a paper on the use of the reciprocal lattice for the graphical interpretation of Laue and rotation diagrams, which proved to be extremely useful to the X-ray crystallographers.

Mauguin then undertook a fundamental investigation of micas; the result formed the subject of several much quoted publications and numerous papers on silicates were based on them. Mineralogists had always been at a loss to reconcile the extremely diversified chemical composition of micas with their remarkably invariable crystallographic characteristics. This resulted in the distinction of a very large number of mica species merely for chemical reasons. Thus the problem of micas, in the setting of 1925, involved a reconciliation of chemistry and crystallography which, on this subject, were in strong opposition. Mauguin performed the chemical analysis of a great number of micas, and measured their density and lattice constants, the latter with the help of X-rays. This enabled him to determine, purely by experimental means and for each one of the micas, the chemical content of the unit cell. He thus observed that the cell content of non fluoric micas always includes 12 oxygen atoms; for fluoric micas, the sum of oxygens and fluorines is twelve. As for the other chemical constituents, the number of atoms present in the unit cell varies from one mica to another and is mostly fractional, for example 2.12 to 3.69 for silicon, 1.13 to 3.80 for aluminium, etc.... If a fractional number is found, it means that the unit cell is not repeated identically and that X-rays give only the average cell. In such cases oxygen and fluorine which are negative ions and more numerous and bigger than the cations, are determining the structure which is basically the same for every mica.

In a similar way Mauguin studied the problem of chlorites and found that the crystalline fundamental set always includes 18 atoms of oxygen. These results have now become universally accepted and it is not the least merit of Mauguin to have greatly contributed to rendering the chemistry of silicates more understandable.

Mauguin had a strong mathematical background. He spent much of his time on studies of Group Theory and Fourier Transforms. Though he published little on these subjects, his investigations were profitable to his students thanks to seminars and discussions which he held in his laboratory. Still, he published in 1936 in the *Organic Chemistry* of V. Grignard a restatement of the theoretical aspect of the X-ray scattering by a molecule with applications to the study of organic compounds. The same year he also published an important memoir *On the theory of the reflection of X-rays by crystals* where he went back to the theory of Darwin, amplified it and reached general formulas giving the solution to the problem of the reflection of X-rays by a system of parallel reticular planes.

In 1943 he studied the dependence of the sizes and the shapes of the diffraction spots on those of the crystal with a particular reference to crystals of regular octahedral shape.

Charles Mauguin was one of the small group of crystallographers who, under the honorary chairmanship of W. H. Bragg and von Laue, undertook in 1933 to work out International Tables of all the geometrical and physical data apt to facilitate the work of the increasing number of scientists who were busy determining the atomic structures of crystals. He took an active part in the writing of the volume issued in 1935 dealing with the geometrical study of the 230 symmetry groups of Schoenflies-Fedorov. He had already published in 1931, in the *Zeitschrift für Kristallographie*, a report 'Sur le symbolisme des groupes de répétition ou de symétrie des assemblages cristallins'.

The same symbols which appear in this report, slightly modified after collaboration with C. Hermann, are still now in universal use and they have made the name of Mauguin familiar to every crystallographer. It is well known that the main aim of this symbolism is the creation of a direct correspondence between the group of spatial symmetry and the X-ray diagrams.

Having reached the age of retirement in 1948, Mauguin continued up to his last days his life-long habit of studying. Childless, he with Mme Mauguin, who was blind for thirty years, lived a very retired life at the outskirts of Paris, and his time was entirely devoted to study, reading, and the care for his wife. During his last years, he was chiefly interested in atomic physics and chemistry in relation to biology. He was particularly keen on the problem of the origin of life and had assembled on this question a very important documentation. Nevertheless, his last publication which he presented to the Academy of Sciences in March 1952, deals with Astronautics and Relativity and the challenging title is 'Assaulting the time-space'.

He took a keen interest in Botany and specially in mushrooms; he was President of the Mycological Society of France and before Mrs. Mauguin fell ill, one of his great pleasures were walking tours in the mountains and botanising in the woods. During the last years of his life, he gathered a beautiful collection of precious old books about plants.

Mauguin was an easy man to get along with and with his wide erudition, he was held in high esteem both by his students and his colleagues. Though being a very hard worker, he published little, but what much he published are models of clearness and accuracy. I often felt sorry that the results of his deep-probing investigations were not published; but exacting as he was for his students, he was so still more for himself, he would not leave anything unexplained and could not be satisfied with incomplete solutions. This need for clearness is probably his most characteristic feature and made him such a remarkable teacher.

This man, whose bodily needs were rudimentary and whose only luxury was books, was highly preoccupied by the condition and the future of men and by the social responsibility of the scientist. On several occasions he clearly expressed his opinion about the problem of Peace. He was deeply convinced that the material and economic future of mankind depends on scientific progress, and he was somewhat apprehensive of the use that would be made of the discoveries of scientists.

His influence on the growth of our international scientific Unions could have been greater if the infirmity and bad health of Mrs. Mauguin had not prevented him from travelling. He has been on the Advisory Board of *Acta Crystallographica* since it was created in 1947. During the ten last years of his life, he no longer attended the meetings of the French Society of Mineralogy and Crystallography over which he had twice presided, and the only days on which he left his house were Mondays, for attending the meetings of the Academy of Sciences to which he had been elected in 1936. He then used to come right after the meeting to the laboratory of the Sorbonne. There he met some of his former students. He told them of his work and picked up the documents and bibliography that he needed for the problems to which he would give his attention during the week.

He died on 25 April 1958 after having been ill for some weeks, and kept to the last moment his whole lucidity and faith science. Madame Mauguin died five months after him.

J. Wyart

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