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Walter Heitler

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At first sight it may seem strange to find Walter Heitler, who was born and educated in Karlsruhe, Germany, listed among Irish scientists. However, he spent the years 1941-49 at the Dublin Institute for Advanced Studies and shortly after his arrival became an Irish citizen. Although he left the country in 1949 he retained both his citizenship and his links with the country until his death. Indeed his mother and his sister, who taught German at Alexandra College, remained in Ireland until the end of their lives.

Perhaps the most famous of Heitler's contributions to science was the Heitler-London theory of the covalent chemical bond. This theory, which is to be found today in every text-book on chemistry, constituted the final step in explaining the covalent bond in terms of quantum mechanics, and it laid the foundation for the modern theory of organic chemistry. Heitler and London themselves continued to work in that field only for a relatively short time, but their pioneering work was developed by a host of other workers, including Pauling. What Heitler and London found was that the covalent chemical bond was due to an exchange force that originated in the indistinguishability of identical particles. Thus it had no classical analogue. The simplest example of the covalent bond is provided by the hydrogen molecule, which consists of two atoms, not one. According to the Heitler-London Theory this happens because the exchange forces make two H-atoms attract (and repel a third).

Although the chemical bond contribution is the contribution that is best known outside physics, Heitler's contributions within physics were equally profound and much more extensive. Following the work with London he turned his attention to Quantum Electrodynamics, in which field he soon became a leading figure. His first major contribution was the Bethe-Heitler formula for electron-positron production from γ-rays, a formula that is still in use today for arbitrary pair production. A second major contribution was his demonstration (with Bhabha) that cosmic ray cascades could be explained by Quantum Electrodynamics alone, without recourse to nuclear forces, as had previously been supposed. As Jordan remarked in reference to this work

... It was a great merit of Heitler to have provided by his cascade theory a strong barrier against premature speculations: this allowed the quantum-mechanics of the radiation field to have a huge harvest of results, before the real conditions for a fundamentally extended theory became visible.

But perhaps his most important work during this era was the 1938 paper on isotopic spin, in collaboration with Frohlich and Kemmer. This paper extended Heisenberg's theory of isotopic spin from nucleons to mesons, predicted the existence of the neutral pi-meson (which was discovered a decade later) and laid the foundations for the flavour and colour symmetries which are at the heart of the present-day standard models of the non-gravitational interactions. A later contribution was his theory of radiation damping. In the days before the renormalization of Quantum Electrodynamics was introduced, his was the only quantum field theory that could be successfully applied at the phenomenological level and Heitler applied it to the theory of cosmic rays. The importance of the damping theory was appreciated even by the hyper-critical Pauli who wrote

Heitler has given a correspondence scheme...by which he can eliminate in a Lorentz invariant manner the divergences occurring in the treatment of scattering processes. This scheme consists in adding a new rule to the already existing formalism of quantum mechanics. He hopes to obtain thus an approximate theory which would have the same relation to a future quantum mechanics that Bohr's quantization of classical orbits had to quantum mechanics

An unsung contribution (because it does not bear his name) should also be mentioned. This is the so-called Gupta-Bleuler mechanism, which is used to ensure that the probabilities in Quantum Electrodynamics remain positive in spite of the indefiniteness of the Minkowski space-time metric. This mechanism is the fore-runner of the celebrated Higg's and BRST mechanisms used in todays's fundamental interaction (non-abelian gauge) theories. That Heitler was the guiding spirit behind the mechanism can be seen from the fact that Gupta was one of his last post-doctoral fellows in Dublin and Bleuler one of his first in Zurich.

Heitler was not only active in research but was the author of a number of well-known books. His first, called 'The Quantum Theory of Radiation' was first published in 1936 and soon became a standard text-book on Quantum Electrodynamics. Indeed it was the only comprehensive book on the subject until the mid-fifties, with new editions in 1944 and 1954 and five later reprints, the latest being a Dover reprint in 1984. While in Dublin he published a small but delightful monograph on quantum mechanics which has been of great benefit to both physicists and chemists. Later he published a book on Natural Philosophy that will be discussed later.

Heitler was born in Karlsruhe on January 2nd, 1904. After normal schooling he began his studies at the Karlsruhe Technische Hochschule, but, feeling that the instruction there did not adequately cover the subjects in which he was interested, he persuaded his father in 1926 to send him to Berlin, where there was a galaxy of star physicists, including Einstein, Planck and von Laue. He learned a great deal of physics in Berlin, but, realizing that he would not get any help in obtaining a doctorate, he moved one year later to Munich, where he worked with Sommerfeld and Herzfeld, obtaining his doctorate (on concentrated chemical solutions) with the latter. On his completion of the doctorate, Sommerfeld obtained for him a Rockefeller fellowship to visit Copenhagen, with the aim of continuing his work on ions in solution. But the

quantum mechanics of Heisenberg and Schrodinger had just appeared and, realizing its importance, Heitler requested that his fellowship be changed to allow him to work with Schrodinger in Zurich. The request was granted and he arrived there in 1926. In Zurich he had much interaction with Schrodinger, but no direct collaboration. However, it was there that he met London and formulated the theory of the chemical bond. This was at the early age of 23, and had the practical result that Born immediately offered him an assistantship in Gottingen, which he took up in 1928. His program in Gottingen was to study group theory in relation to quantum mechanics and he took advantage of it to study profoundly all the available works on quantum mechanics and quantum field theory, especially those of Heisenberg, Dirac and Born himself. During his second year at Gottingen Heitler and Herzberg were the victims in in one of the many 'missed opportunities' in physics, as follows: Their analysis of the bandspectrum of Nitrogen in 1929 showed that the ^{14}N nucleus obeyed Bose rather than Fermi statistics. This implied that the neutron was a Fermi particle, and hence could not be a composite of a proton and electron, as was generally supposed. But in the late twenties, physicists were extremely reluctant to propose the existence of new particles (recall Pauli's hesitation concerning the neutrino and Dirac's identification of the charge-conjugate of the electron with the proton) and in this climate Heitler and Herzberg did not dare follow their result to its logical conclusion, namely the prediction of the neutron as an elementary particle in its own right. As he has said himself: *Later Herzberg and I were very angry when we realized that we could have predicted the existence of the neutron long before it was discovered experimentally by Chadwick in 1932.*

In spite of the missed opportunity Heitler made good use of his time in Gottingen, where he became Privatdozent in 1929 and developed into a world expert on Quantum Electrodynamics. These were happy times for him, but as both his parents were Jewish and the National Socialists were beginning to emerge, there was always the possibility of his position at the University being terminated. Because of this he made an extended visit to Moscow to see whether, in that event, he could take refuge there. But he was rather disappointed with the conditions in Russia and returned to Gottingen. When the Nazis finally came to power in 1933 he and others (including Nordheim and Wigner) received the expected letters dismissing them from their positions at the University. Luckily there existed at the time an arrangement that permitted young physicists at Gottingen to spend a year at Bristol, and Born arranged for Heitler to avail of that scheme. At the end of his year in Bristol he was offered a position, though not a permanent one.

Neville Mott had just been appointed professor at Bristol and Heitler was able to interact not only with him but with a number of well-known visitors, such as Bhabha, with whom he collaborated on the cascade theory, and other refugees such as Bethe, Kemmer and Frohlich, with whom he collaborated on a variety of topics. The experimental cosmic ray group of Powell and Blackett was already in operation in Bristol so Heitler was also able to keep in close touch with experiment. It was during his time in Bristol that Heitler published most of his work on Quantum Electrodynamics and his early work on cosmic rays. On the outbreak of the war he was interned on the Isle of Man, along with six of his colleagues from Bristol, including his brother Hans. He was released after some time and returned to Bristol. At this time physicists were being

recruited to work on the atomic bomb project but Heitler (along with Kemmer and Frohlich) declined to take part, a decision which later caused a certain rift between him and those who participated in the project. Shortly after his return to Bristol he received from Schrodinger an offer of a permanent position at the recently created Dublin Institute for Advanced Studies. Being attracted by the offer, and being advised that, as a German, he might have difficulty in obtaining a permanent position in England, he accepted. At this time he was engaged to Kathleen Nicholson, a research worker in biological science whom he had met in Bristol, and they married shortly after his arrival in Dublin. Their son Eric was born there in 1946.

During his Dublin years Heitler elaborated on his earlier work with Frohlich and Kemmer, giving for the first time the relations between the cross-sections due to charge-independence (isospin-invariance). But his most important scientific contribution during his Dublin years was the theory of radiation damping mentioned earlier. His research was concerned mainly with the application of this theory and Quantum Electrodynamics in general to Cosmic Ray Physics, which at the time (before the advent of the big accelerators) was the physicists' only access to high energies. Indeed, Heitler and Schrodinger considered the area of cosmic ray physics so important that they urged de Valera to add a School of Cosmic Physics to the Institute of Advanced Studies. This was done in 1947, and the School incorporated also departments of Astrophysics and Geophysics. During his time in Dublin Heitler collaborated both with the experimental physicists associated with the School of Cosmic Physics, such as Walton, Janossy, Nevin and O'Ceallaigh (who had recently discovered the neutral K-meson in Bristol) and with many young local theoreticians, such as Jim Hamilton, James McConnell, Sheila Tinney (nee Power) and Phillip Gormley. He had, of course, also a sequence of foreign post-doctoral fellows, many of whom, such as Walter Thirring, H. Peng, Cecile de Witt (nee Morette) and S. Gupta, have since become international names in their own right. An interesting view of Heitler's impact on the Dublin scene is given by Sir Neville Mott in his Royal Society obituary:

Heitler is remembered in Dublin for the clarity and interest of his lectures; he was always courteous and very helpful to his students. His influence was largely responsible for the modernisation of university courses in Dublin in theoretical physics, and for the establishment of theoretical and experimental research groups which are still functioning today. For the benefit of chemists he gave an introductory course on wave-mechanics and its application to the theory of the chemical bond. This was published as a small book by the Oxford University Press and must have served as the introduction to the subject for many of the less mathematically equipped among those who needed the subject.

Heitler visited the United States soon after the war but was less impressed both with the physics and the general environment than he had been on an earlier, pre-war, visit. He was Director of the School of Theoretical Physics from 1946 until 1949, when he accepted an invitation to become Professor of Theoretical Physics at the University of Zurich. He had hesitated before accepting the position, as he had been happy in Dublin and appreciated living close to the sea. But in the end the prestige of the Zurich position (predecessors included Einstein, von Laue, Debye and Schrodinger), the opportunity to revisit the scene of his earlier successes, the lure of

a German-speaking environment and the opportunity to mountain-climb and ski (at both of which he was very proficient) proved irresistible, and he accepted the offer. In spite of many subsequent invitations, he remained in Zurich for the rest of his life. His most successful work in the fifties, carried out in collaboration with Edmond Arnous from the Institut Henri Poincare in Paris, was concerned with the natural breadth of spectral lines. He also produced an important paper on detailed balance (which was actually the completion of a note in 1925 on Einstein's derivation of the Planck radiation law). However, he found himself rather out of sympathy with the renormalization program of Quantum Electrodynamics. Although renormalization made the predictions of the theory completely reliable, and these agreed with the experiments to an uncanny degree of accuracy, Heitler considered it to be merely a clever mathematical addendum to an already existing physical theory, and was concerned by the fact that it evaded the problems posed by the mass-differences of the elementary particles (in particular the proton-neutron mass difference). He tried (rather unsuccessfully) to remedy this defect in the program using a modified version of his earlier damping theory, and indeed his last public contribution to physics was a talk on the subject at the 1962 Solvay Conference. However, his analysis of the problem was correct in the sense that, although the mass-difference problem is now formulated at the quark, rather than the hadronic, level, it remains unsolved.

Heitler had always a deep interest in Philosophy and Religion, and from the beginning of the sixties he began to concentrate more on these subjects. He had no difficulties with Physics as such and freely acknowledged the great successes of reductionist science since the time of Galileo. Nor did the advent of Quantum Mechanics cause him any problem. From his time in Gottingen he had accepted the Born (now called the Copenhagen) interpretation of Quantum Mechanics, and he had little interest in the objections of Einstein and Schrodinger or in the alternative explanations offered by de Broglie, Bohm and others. However, he felt that, in spite of its great successes, reductionist science would prove incapable of explaining a variety of aspects of Nature, particularly the qualitative and non-local aspects. His opinion was that in many processes, such as biology and evolution, forces other than the known quantitative ones must be at work and that there must exist teleological and non-local laws yet to be discovered. These thoughts were first formulated in a book which was translated into English in 1961 under the title 'Man and Science '. The book proved to be very popular and has been translated into many languages. Afterwards, Heitler elaborated his ideas in a series of articles, and received invitations to lecture on the subject from Universities all over Europe. As he once wryly remarked, *he was now visiting the Philosophical and Theological Departments of Universities where he had once visited the Physics Departments.* He had always had an interest in anthroposophy without accepting it fully and toward the end of his life he became a Christian. He died on November 15th 1981.

Heitler received many honours. He was elected a Member of the Royal Irish Academy in 1943, a Member of the Norwegian Royal Society in 1974, a Fellow of the Royal Society in 1948 and received honorary doctorates from both Dublin universities. He was awarded the Max Planck Medal of the German Physical Society in 1968. In 1970

he became one of the few physicists to receive the Marcel Benoist prize, and in 1979 he was awarded the Gold Medal of the Humboldt Society.