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Nobel Prize in Physics 1948

Patrick Maynard Stuart Blackett

The Nobel Prize in Physics 1948 was awarded to Patrick M.S. Blackett *"for his development of the Wilson cloud chamber method, and his discoveries therewith in the fields of nuclear physics and cosmic radiation"*.

RESEARCH INFORMATION:

According to the statutes of the Nobel Foundation, the Nobel Prize for Physics may be awarded for "discovery or invention in the field of physics". The Royal Swedish Academy of Sciences in awarding this years' prize to Professor P.M.S. Blackett of Manchester, for his development of the Wilson method and his discoveries, made by this method, in nuclear physics and on cosmic radiation, indicates by the very wording of the award, that its decision is motivated on *both* the grounds mentioned in the statutes. Particular weight may perhaps, in this case, be laid on the discoveries made, but these only became possible by Blackett's development of the method and the apparatus.

Experimental research on the different kinds of rays appearing in nuclear physics has always been based to a great extent on the power of an electrically charged atomic particle, when moving at high speed, to *ionize* the gas through which it passes, i.e. to split a number of gas molecules along its path into positive and negative ions. Thus, one is able to

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count the number of particles by means of the Geiger-counter tube; such a counter being a special, very sensitive kind of ionization chamber, in which even a few ions produced by the ray are sufficient to release a short-lived discharge by an avalanche-like process.

But the whole course of the particle appears infinitely more clearly by the method invented by C.T.R. Wilson in 1911 and named after him. The radiation is allowed to enter an expansion-chamber, containing a gas saturated with water vapour. A sudden expansion of the chamber cools the gas, and cloud-drops are then formed instantly around the ions produced along the tracks of the particles. By suitable illumination these tracks can be made to stand out clearly as if they had been described by luminous projectiles. The "Altmeister" of modern nuclear physics, Lord Rutherford, once called the Wilson chamber "the most original and wonderful instrument in scientific history".

But still, the immense value of the Wilson method for research purposes did not become really apparent until the early twenties, and the credit for this changed attitude was largely due to the work of Blackett, who has ever since been the leading man in the development of the method. Before 1932 his work dealt chiefly with the *heavy* particles, appearing in radioactive radiations. In 1925, he obtained the first photographs ever taken of a nuclear disruption, namely the disruption of a nitrogen nucleus by an alpha particle of high velocity; the photographs clarified quite definitely the main features of the process. In this investigation and others from the same period he also verified, by accurate measurements, that the course of a collision between atomic nuclei always follows the classical laws of conservation of momentum and energy, provided the energy value of mass, as given by the theory of relativity, is also taken into account. These two laws, together with the conservation law of electricity, i.e. that positive and negative electricity are always produced together in equal amounts, form a set of three fundamental principles of general validity.

Blackett was soon to give to these principles an unexpectedly rich content by new experimental discoveries. In 1932 namely, he turned his interest to the cosmic rays, which at sea level are mainly vertical. The Wilson cloud chamber had already begun to be used at different places for the study of these rays, but with very low efficiency, as only about every twentieth random photograph showed the track of a cosmic ray. This was due to the fact that the rays are disperse both in space and time, and they must pass through the chamber only about a hundredth of a second before or after the moment of expansion, if they are to give a sharp track. Nevertheless, Anderson had at the time succeeded in obtaining a few photographs, showing the temporary existence of free *positive* electrons. These electrons, on account of their strong tendency to fuse with negative ones, seemed to exist free in a space filled with matter, only as long as they move at a great speed.

Together with his collaborator Occhialini, Blackett now developed an automatic Wilson apparatus, in which the cosmic rays could photograph themselves: the moment of expansion was determined by two Geiger counters, placed one above and the other below the chamber and connected to a quick electrical relay in such a way, that the mechanism of the cloud chamber was released only when *simultaneous* discharges occurred in both counters, i.e. when a cosmic ray had passed through them both and thus in all probability also through the cloud chamber between them. In this way the efficiency of the Wilson chamber was multiplied many times over, and the method became of extreme importance in cosmic ray research.

Immediately after completing this apparatus, Blackett and Occhialini discovered, in cosmic radiation, positive and negative electrons appearing in *pairs*; their tracks were deflected in opposite directions by a superposed magnetic field and they seemed to start from some common origin, often situated in the wall of the chamber. Sometimes such tracks appeared in great numbers, whole "gerbes", on the same photographic plate, demonstrating the existence in the cosmic radiation of veritable "showers" of positive and negative electrons. Shortly afterwards they established, in collaboration with Chadwick, that electron pairs are also produced by hard gamma rays, i.e. by the radiation of ultrashort wavelength emitted by certain radioactive substances; here the energy relations could be studied more closely than in the case of cosmic rays.

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I shall try to give an idea of the great importance of these experimental results, even beyond the fact that they established irrefutably the existence of positive electrons. The discovery of the *pair* creation of electrons led, on the theoretical side, to the acceptance of two fundamental radiation processes of a reverse nature, which may be called *transmutation of light into matter* (represented by electron pairs) *and vice versa*. These processes take place within the framework of the three fundamental principles, just mentioned, regarding the conservation of momentum, energy and electricity: a quantum of light passing close to an atomic nucleus, may thus be transformed into a pair of electrons; but this is possible only if its energy at least equals the sum of the energy values of the two electronic masses. Since the rest mass of each electron corresponds to $1/2$ million electron volts, the light must possess a frequency at least corresponding to 1 million electron volts. If there is an excess of energy (i.e. if the frequency of the light is still higher), this excess will appear as the kinetic energy of the two electrons created. Reversely, the meeting of two slow electrons, opposite in sign, results in their fusion and *annihilation* as material particles; in this process two light quanta, each of $1/2$ million electron volts, are formed; these fly out from the point of encounter in opposite directions, so that the total momentum remains about zero (for even light possesses a momentum directed along the ray).

Blackett and Occhialini immediately drew these conclusions from their experiments and were guided in so doing by the earlier mathematical electron theory elaborated by Dirac on the quantum basis. The existence of the "annihilation radiation" was shortly afterwards established experimentally by Thibaud and Joliot.

These fascinating variations in the appearance of energy, which sometimes manifests itself as light, sometimes as matter, have stimulated the distinguished French physicist Auger to exclaim enthusiastically, in a monograph on cosmic radiation: "Who has said that there is no poetry in modern, exact and complicated science? Consider only the twin-birth of two quick and lively electrons of both kinds when an overenergetic light quantum brushes too closely against an atom of matter! And think of their death together when, tired out and slow, they meet once again and fuse, sending out into space as their last breath two identical grains of light, which fly off carrying their souls of energy!" (As a memory aid Auger's metaphor is excellent; its poetical value is perhaps open to dispute.)

In the late thirties, Blackett continued his researches on the cosmic radiation and, using a still further improved Wilson apparatus, made extensive accurate measurements concerning the momentum distribution, absorbability, etc. of this radiation. By means of a new optical method he was able to measure extremely feeble curvature of the tracks, corresponding to electronic energies up to 20 milliard electron volts.

Professor Blackett. In recognition of your outstanding contributions to science, The Royal Swedish Academy of Sciences has awarded to you this year's Nobel Prize for Physics for your development of the Wilson method and your discoveries, made by this method, in nuclear physics and on cosmic radiation.

In my speech, I have tried to sketch a few, and only a few, of your achievements and, more particularly, to give an idea of the fundamental importance of the discovery of pair creation. To me has been granted the privilege of conferring upon you the congratulations of the Academy and of inviting you now to receive your Nobel Prize from the hands of His Royal Highness the Crown Prince.

__For more details please visit:__

http://www.nobelprize.org/nobel_prizes/physics/laureates/1948/press.html