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C.T.R. Wilson and the Nobel Prize in Physics

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Abstract: C.T.R. Wilson (1869 – 1959), in 1927 shared the Physics Nobel Prize with A.H. Compton. Documents regarding C.T.R. Wilson's nomination for the Nobel Prize were obtained from the archive of the Nobel Foundation. Results of their analysis are given in the present communication.

Keywords: C.T.R. Wilson; D.M. Bose; A.H. Compton, Nobel Prize in Physics

1. Introduction

The Scottish physicist Charles Thomson Rees Wilson (1869–1959), constructed an apparatus to produce clouds under laboratory conditions. In 1911, Wilson took the first photograph of ionized particles, and proved that the cloud chamber was suitable for the investigations of radioactivity and atomic structure [1]. There are a number of articles on Wilson's life and science [2]. However, none of them deals with his nomination for the prestigious Nobel Prize. The present article fulfils the gap.

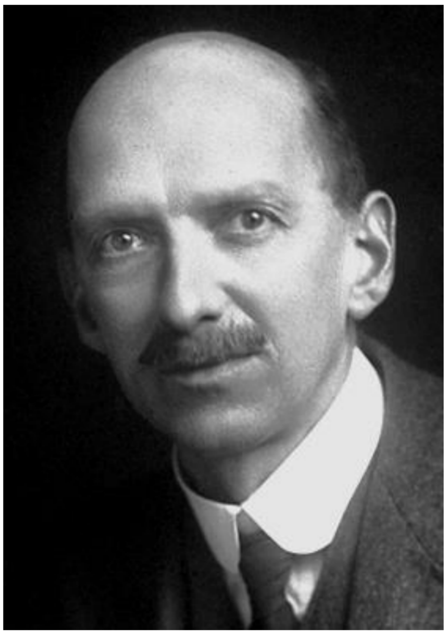

Fig. 1: C.T.R. Wilson *[Credit: Wiki – Public domain]*

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To start with a short review of the work of the Indian physicist D.M. Bose, who improved Wilson's cloud chamber to study radioactive radiation, is given. It shows that between 1914 and 1919, he made similar observations, for which C.T.R. Wilson was awarded the Nobel Prize.

2. D.M. Bose and cloud chamber research work in Europe and Kolkata

D.M. Bose's life and work are discussed by S.C. Roy and R. Singh in different articles and books [3]. The following summary is taken from them.

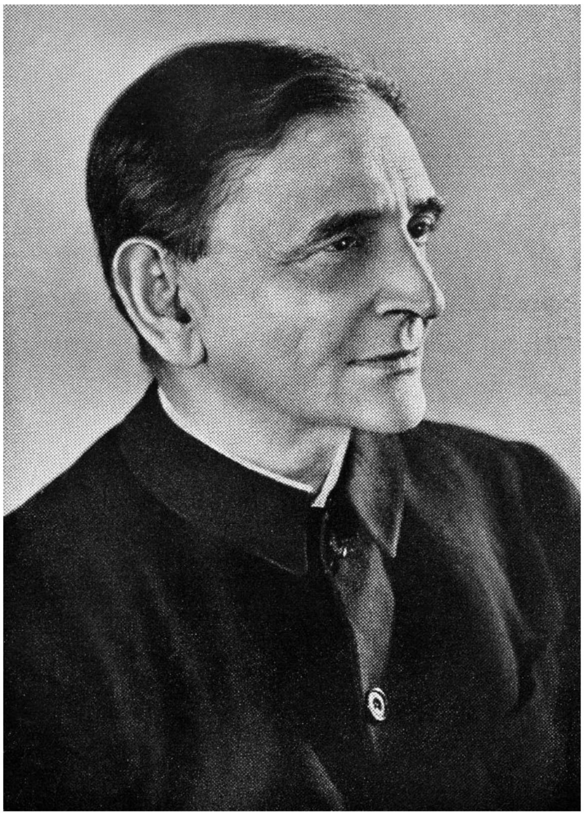

Fig. 2: D.M. Bose *[Credit: Bose Institute]*

In 1907, D.M. Bose joined Christ's College, Cambridge. In the laboratory of J. J. Thomson, he studied the nature of the condensed nuclei produced by incandescent platinum wire in glass bulb saturated with water vapours. Bose obtained A.R.C.S. Diploma and B.Sc. (first class) in Physics, from the Royal College of Science, London. After staying for a short time in Calcutta, young D.M. Bose as a research scholar went to Berlin for higher studied. In Berlin, his research guide was, E. Regener, who in the "Naturwissenschaften" emphasized the importance of Wilson's cloud chamber [4].

In Berlin, Bose improved Wilson's cloud chamber. He replaced some of the brass parts by glass. For instance, the piston was substituted by a glass valve of large cross-section.With the improved expansion chamber, Bose showed: (i) the existence of H-particles, which come into play after the collision of α-particles with hydrogen atoms,

(ii) made the path of the colliding and deflecting α- and β particles visible and (iii) observed the ionisation traces of gamma radiation in hydrogen [5].

In 1919 Bose returned back to India. He was the first person, who constructed Wilson cloud chamber at the University of Calcutta. With S.K. Ghosh he wrote: "On the photographing the ionization tracks of the rest atoms of radioactive elements." They photographed the tracks of the "rest atoms", and confirmed the shape of ionisation tracks of rest atoms as predicted by L. Wertenstein [6]. They also studied tracks of α-particles in helium. "Besides the long range recoil helium atoms, we have obtained a few photographs in which are shown the ionisation tracks of all the constituent parts of a helium atom, namely, of the nucleus and the two bound electrons", wrote the authors [7].

D.M. Bose in a letter of May 10, 1923, wrote to the Nobel Laureate E. Rutherford, that his explanation for the curved tracks of slow β-particles is more or less as suggested by A.H. Compton. Further, he told Rutherford that in Berlin:

> "I had obtained α-particle tracks of similar type also. I thought that such discontinuities of tracks were due to the rapid alternation of charge of the ionizing particles – a phenomenon whose possibility had been pointed out by (L.) Flamm. But Prof. Regener was of opinion that they were rather due to the fluctuation in the distribution of water vapours along the tracks." (D.M. Bose to E. Rutherford, May 10, 1923).

In his letter, Bose sent some photographs of observations, and wrote: "I have also obtained one case in which a single electron is ejected from the point where a helium nucleus has started its track."

Shortly after the discoveries by A.H. Compton and C.T.R. Wilson (detail below), E. Regener published the detailed summary of Bose's thesis "Study of the passage of α- and β-particles through gases" [8].

The Austrian Marietta Blau acclaimed Bose to be the first scientist who observed H-particles with cloud chamber. This brought her to the idea to visualize cosmic rays with emulsion [9]. K.W.F. Kohlrausch gave Bose credit to be the first person to study beta particles with cloud chamber [10]. T. Alper acknowledged to H.A. Bumstead, C.T.R. Wilson and Bose for making the γ radiation visible with cloud chamber [11].

3. C.T.R. Wilson –Scientific work and nomination for the Nobel Prize

Main part of Wilson's work on the behaviour of ions as condensation nuclei was carried out between 1895 and 1900. As is evident from his list of publications, between 1901 and 1908, he mainly concentrated on atmospheric electricity and condensation phenomena [12]. In 1910, he constructed a new type of expansion chamber in order to observe the tracks of individual α- and β-particles. The results produced with it were not satisfactory [13]. In 1923, the cloud chamber was improved. He made investigations on X-rays and β-particles. He was able to observe individual quanta of radiation, i.e., under suitable conditions identified electrons ejected by an atom. With that he proved A.H. Compton's view that "a single electron may be effective in scattering a quantum of radiation and that in so doing it receives the whole momentum of the quantum" [14]. In the case of nitrogen, Wilson quantitatively confirmed Rutherford's theory of nuclear deflection, which predicted a definite amount of charge of deflecting nucleus [15].

On Jan. 7, 1915, R.J. Strutt (Lord Rayleigh) wrote a letter to the Nobel Committee and nominated Wilson "for his researches on the condensation of water vapours on gaseous ions (which have led to the methods in use for measuring the ionise charge,) and on the track of the ionising rays from radioactive bodies." In his second letter of Jan. 5, 1915, Lord Rayleigh submitted copies of Wilson's important papers. NC did not take notice of Strutt's nomination.The Physics Nobel Prize was awarded to W.H. Bragg and his son W.L. Bragg, who, in 1912, discovered that the structure of crystals could be determined by X-rays.In 1918, Edward B. Poulton, Oxford,nominated William Crookes and C.T.R. Wilson for a shared prize [16]. Between 1919 and 1923, Wilson was not proposed.

In 1923, A.H. Compton, U.S.A., showed that when X- rays are scattered by electrons, due to inelastic collisions, there is an increase in the wavelength of the rays. During the process, a part of the energy is transferred to the recoiling electrons. With the experiment, he proved the quantum nature of radiation [17]. C.T.R. Wilson with the improved cloud chamber reconfirmed Compton's results. He also proved that his chamber was "able to deal with individual quanta of radiation, in the sense that the track of the electron ejected from the atom which emits the quantum of radiation and that of the electron ejected from the atom which absorbs the radiation may under suitable conditions be identified" [18].

For the Physics Nobel Prize for the year 1924, Wilson was nominated by his countrymen Hugh F. Newall, E. Rutherford, and J.J. Thomson. On Dec. 17, 1923, H.F. Newall wrote to the Nobel Committee that already in 1911, C.T.R. Wilson discovered a method to make the ionised particles visible. In the following years he improved the apparatus to observe the atomic disintegration. Newall stated:

> "At a time when the indirect methods had perhaps yielded their harvest of results, this impressive procedure came to provide immediate confirmation and extension, and to push direct scrutiny of the history of the individual flying electron or ion into new developments. The photographic records of their life histories and interactions have ever since been indispensable to research in this domain." (H.F. Newall to the Nobel Committee, Dec. 17, 1923).

After telling the importance of Wilson's work in the field of meteorology and cosmic rays, he stated that Wilson's

> "recent papers condense the results of many years work on the effects of X-rays and on the activities exhibited along the tracks of α-rays and β-rays, both directly and in relation to the study of the characteristic radiations of elementary substances under the action of X-rays; they will be a valuable mine for future investigators in atomic science." (H.F. Newall to the Nobel Committee, Dec. 17, 1923).

E. Rutherford and J.J. Thomson in a joint letter emphasized Wilson's work in the field of meteorology. They wrote that Wilson's tracking method:

> "...is based on his own discovery, made many years ago, that ions produced in gases act as condensation nuclei under certain conditions. Photographs of these trails show in a vivid and concrete way the processes occurring in the passage of

ionizing radiations through gases." (J.J. Thomson, E. Rutherford to the Nobel Committee, Dec. 4, 1923).

They were also of the opinion that Wilson's photographic method had not only confirmed the general correctness of the existing ionisation and scattering theories, but also hinted that we are still far from understanding the complicated processes that occur due to the interaction of radiation like X-rays and a gas.

For the year 1924, the Nobel Prize was reserved as none of the nominees was seen as candidate, who deserves the Prize.

For the Nobel Prize for the year 1925, the Director of Radium Institute in Vienna, Stefan Meyer proposed Swede Manne Siegbahn and C.T.R. Wilson for the Nobel Prize (S. Meyer to the Nobel Committee, Dec. 29, 1924). Other persons who nominated M. Siegbahn were M. von Laue and E.P. Jordan [19].

The reserved prize from the year 1924 was awarded, in 1925, to the Manne Siegbahn "for his discoveries and research in the field of X-ray spectroscopy" [20]. The prize for the year 1925 was awarded jointly to James Franck and Gustav L. Hertz "for their discovery of the laws governing the impact of an electron upon an atom" [21].

Before we proceed further with the case of Wilson, it will be worthwhile to say a few words about A.H. Compton's nomination, who shared the Nobel Prize with Wilson.

4. A.H. Compton's nomination

In 1923, A.H. Compton showed that when X- rays are scattered by electrons; due to inelastic collisions, there is an increase in the wavelength of the rays. During the process, a part of the energy is transferred to the recoiling electrons [22].

The first time, A.H. Compton was nominated, for the prize for the year 1925, by Henry G. Gale from Chicago. A year later, R.A. Millikan, A. Einstein, W. Wien, C. Fabry, and W.L. Bragg proposed Compton [23]. In 1927, E.P. Jordan, M. von Laue, H.F. Osborn, M. Planck, C.D. Walcott and W. Wien proposed Compton for the unshared prize. M. Born and J. Franck were of the opinion that either Compton alone should get the award, or it should be divided between W. Gerlach and O. Stern. R. Pohl proposed that Compton and C. Ramsauer should share the prize [24].

Wilson's nominators were the following Nobel Laureates: Jean Perrin from France, J.J. Thomson, and E. Rutherford from U.K [25]. The French physicist J. Perrin in a letter of Jan. 26, 1926, to the Nobel Committee gave credit to Wilson for establishing a technique, with which the trajectories of the individual alpha- and beta particles can be made visible. He stated that Wilson's method can be used to understand the mechanics of ionisation of gases by X-rays.This mechanism was studied in detail in the laboratory of P. Auger, France. In U.K., Blackett's work in Rutherford's laboratory proved that the same method allows us, to study the genesis of atoms from its individual parts, under the influence of shooting alpha particles. (J. Perrin to the Nobel Committee, Jan. 26, 1926).

J.J. Thomson's letter, written on Jan. 26, 1927, was rather short. He emphasised that Wilson's method is the most direct and in some cases the only method to investigate the properties of the X-rays, α- and β particles. It had helped much for the progress of modern physics.

E. Rutherford was determined to put Wilson's case more strongly. On Jan. 27, 1927, he wrote three and half pages long "Statement of claims of Professor C.T.R. Wilson FRS." Therein he stated:

> "I think all physicists would agree that his pioneer work on the conditions of formation of nuclei in dust free moist air is of the highest originality and merit. The subsequent development of this discovery to show the tracks of individual alpha and beta particles and the effects produced by the passage of X-rays and other ionizing radiations through a gas, was a masterly piece of work carried out with the technical perfection and refinement so characteristic of Professor Wilson's researches."

In order to emphasize the affect of Wilson's method on the contemporary research Rutherford observed in the "Statement of claims …":

> "The experiments of Wilson himself and later of A.H. Compton, (W.) Bothe, (J.M.) Nuttall and (E.J.) Williams and others have shown that the scattering of quantum is accompanied by the motion of the electron involved, and that this is in the direction and magnitude to be expected on the theory. It would have been difficult to obtain such information by any other method - data which are essential for the verification of the theory."

In "Statement of claim …", Rutherford called Wilson's cloud chamber method as the "Experimentum crucis" for the modern Physics. After naming Wilson's method as the most powerful tool to attack and solve the fundamental problems, he referred to his nominator's work in the field of meteorology and added, "All of this work is characterized not only by great originality and experimental skill, but the results are interpreted with judgement and vision."

The Nobel Committee asked its expert to prepare a supplementary report on Wilson's scientific work (details below).

5. Evaluation of Wilson's work by the expert M. Siegbahn

The Nobel Committee asked Manne Siegbahn to evaluate Wilson's achievements. In order to keep the length of article appropriate, only some of the highlights of the Report of Expert, dated Aug. 9, 1927, (original is Swedish) are given below.

> "As stated in the previous report (i.e., year 1924) Wilson's method makes it possible to study in details the phenomena that are related to the collisions of α-particles in gas molecules. Also the method has been used to visualise a number of properties of radiation related to its quantum nature."

> "Using cloud chamber, (P.) Auger studied the secondary betaparticles, which come into existence due to the interaction of gas atoms and X-ray. Auger has shown that Wilson's method is an excellent substitute to the other techniques, and in some particular cases it can be used to get more direct information, than had been possible by other methods."

> "Wilson's method is complimentary to Scintillation and Geiger's methods used for the study of nucleus and α-particle collision, and the path of particle traversed by it. The observations regarding collision of nucleus and α-particles, in which the photon is ejected from a nuclei (a rare phenomenon as observed by Rutherford) was made by Paul M.S. Blackett, and W.D. Harkins and (H.A.) Shadduck (…) using Wilson's method."
>
> "In the end it must be stated that Wilson's method is also applicable for the study of Compton effect. Although the effect is assured by spectroscopic measurements, yet the measurement of velocity and direction of electrons with the help of Wilson's method are of great value to explain this phenomenon."

The opinion of the Nobel Committee about Wilson's achievements is given in the following section.

6. Opinion of the Nobel Committee

The Report to the Nobel Committee, dated Sept. 30, 1927 (henceforth RNC, original in Swedish) shows that for the year 1927, 20 nominators proposed 34 nominees. The Committee reported that Wilson, who since 1924 was nominated, this time had been supported by the three Nobel Laureates. The Nobel Committee opined:

> "From this supplemented inquiry it is clear through the investigations made by Auger at the laboratory of Perrin, that Wilson's method is a most valuable complement to other methods. In certain cases his method gives more pertinent information than is possible by other methods. The method has been applied in several research projects, among other the study of the Compton effect. Although this effect was verified through spectroscopy after the first demonstration through ionisation methods, the demonstrations by Wilson have been of great value for the clarification of the phenomenon."

The general overall view of the Committee was:

> "On the whole the method has shown to be a most valuable contribution to the experimental methods of radioactivity and related subjects. The full significance has been revealed only in recent time, and the committee members consider the importance so great as to warrant the Nobel Prize in physics."

The NC proposed to the Swedish Academy of Sciences that: "the 1927 price in physics should be shared in equal parts between Prof. A.H. Compton, Chicago, for his discovery of the effect named after him, and Prof. C.T.R. Wilson, Cambridge, for his method of making the paths of electrically charged particles visible by condensation of vapour." The Swedish Academy of Sciences, which is the final authority to decide on the Prize, also gave its adjudication as proposed by the Committee.

7. Conclusions

D.M. Bose learned to construct and work with the cloud chamber in the U.K. and Germany. Based on the knowledge, he constructed the instruments at the University of Calcutta. Bose's case shows the transfer of technology and methodology from one country to other.

European scientists, such as, K.W.F. Kohlrausch, T. Alper, M. Blau, and E. Regener appreciated Bose's work. They even gave credit to Bose being the first in observing some effect. However, none of the Europeans nominated Bose for the Nobel Prize. Bose had no chance to win the Nobel Prize, because "no one can receive the prize in a given year without being nominated for that year" [26]. However, the fact remains that D.M. Bose along with S.K. Mitra were the first two Indian physicists, who were asked by the Nobel Committee to send proposals. In a joint letter, they nominated M.N. Saha. Details of Saha's nomination and the opinion of the Nobel Committee are explored elsewhere [27].

C.T.R. Wilson was often nominated for the Nobel Prize, but he was ignored. In 1927 NC or rather the Swedish Academy gave decision in his favour, because the full significance of Wilson's cloud chamber was revealed only after 1926.

The number of A.H. Compton's nominators was much higher than C.T.R. Wilson, still the NC proposed for a shared Nobel Prize. This suggests that the number of nominations is irrelevant as far as the decision of the NC is concerned.

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