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Max Planck: His Story of Winning the Nobel Prize in Physics

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Abstract

The Nobel Prize is a most coveted and one of the best-known academic honours in the world. During 19th century, Germany, France, and UK were leaders in science and most of the Nobel Prizes were shared amongst their scientists. The contents of my essay are based on the account given by Rajinder Singh and Björn Martens in their recently published book in Germany, "Inside Story of Max Planck and the Nobel Prize Award". The book reveals the complications and intricacies of winning the Nobel Prize. Max Planck is acknowledged as the Father of Quantum Physics. His revolutionary ideas were not accepted till experimental verification of Photoelectric Effect by Einstein. He got 74 nominations, including one from Albert Einstein, for Nobel Prize between 1907 and 1918 before he was awarded the Nobel Prize in 1919. The story reveals that getting nominated is not so difficult but there are many hurdles to be crossed for achieving the award. Max Planck made several discoveries and gave a new definition of Second Law of thermodynamics which became basis of his famous law of black body radiation, known as Planck's law. SN Bose's derivation of Planck's law is considered as the best explanation using Bose-Einstein statistics. Planck's ideas influenced the development of Theoretical Physics in Germany and later in the whole world.

Keywords: Max Planck, Radiation, Quanta, Planck Constant, Nobel Prize

INTRODUCTION

Max Karl Ernst Ludwig Planck (Max Planck) was born in Kiel, Germany on April 23, 1858. After passing high school examination, Planck, who was considered hard-working and talented, was enrolled at the University of Munich to study mathematics and natural sciences. He studied for three years at the University of Munich, one of the top universities in Prussia, Germany. He was tutored by the well-known mathematicians Gustav Bauer and Ludwig Seidel. He learnt physics from equally eminent Professors of his time, such as Hermann von Helmholtz and Gustav Kirchoff in Berlin University. He got his Doctorate from Munich University in 1879 for his work on thermodynamics. At the age of 22, in 1880, he received 'habilitation' from Munich and qualified for teaching as a lecturer in the university [1, 2].

Max Planck started his research work in thermodynamics. He gave a new definition of Second Law of thermodynamics based on Entropy. Later, he developed a new theory of black body radiation using entropy and Boltzmann constant which became famous as Planck's law of radiation. He was appointed Professor of Theoretical Physics in university of Berlin. Soon after, he was nominated as a member of Prussian Academy of Sciences. In Berlin, he published two books in German language, "Das Prinzip der Erhaltung der Energie" (The Principle of Conservation of Energy) in 1887, and "Über irreversible Strahlungsvorgänge" (On Irreversible Radiation Processes), in 1897. These books established his reputation as a scientist and teacher of Physics in Germany.

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His journey towards Nobel Prize starts in university of Munich and ends in university of Berlin. He got the Nobel Prize in Physics in 1919 retrospectively for 1918 "in recognition of the services he rendered to the advancement of Physics by his discovery of energy quanta." Let us explore the adventurous story of his Nobel Prize which he richly deserved but had to wait for 12 years due to wranglings of the Nobel Committee or the intransigence of Royal Swedish Academy of Sciences, which is the final arbiter for awarding the Nobel Prize.

Achievements for which Max Planck was nominated for the Nobel Prize

We sum up the achievements of Max Planck for which he was nominated for the Nobel Prize over a period of 12 years from 1907 to 1919.

Planck radiation law [3]: Based on the molecular kinetic observations, in 1896 Wilhelm Wien gave the equation for spectral energy distribution for a black body.

In 1899, experimental physicists, Otto Lummer and Ernst Pringsheim, observed systematic deviation between their experimental results and Wien displacement law, in the case of short wavelengths. They doubted the correctness of the law. Later, in the case of long wavelengths, they found that the Wien displacement law did not have general validity. Planck also believed that Wien's law has no theoretical base. From the theory of electromagnetic radiation, he derived a correct version of Wien's law, which is known as Planck's law of radiation. It states that electromagnetic radiation from heated bodies is not emitted as a continuous flow but is made up of discrete units or quanta of energy, the size of which involves a fundamental physical constant (Planck's constant). H. Rubens and F. Kurlbaum believed Planck's formula was most useful due to its simplicity.

Energy quantum and Planck constant [4-6]: To explain the experimental results, Planck introduced the concept of "Energy element" (ε) proportional to the vibration-number (ν), i.e., $\varepsilon = h \nu$, where 'h' is a universal constant (later came to be known as Planck constant). His calculated value for h was 6.55×10^{-27} ergs x second. Planck published an article in the journal "Annalen der Physik" on Jan. 9, 1901, in which he introduced the term "Elementarquanta" (elementary quantum) in matter and electricity. From his calculations, he found that the elementary quantum of electricity, that is, electron has the value 4.69×10^{-10} esu. He found his value very close to the value determined by J.J. Thomson (6.5×10^{-10}). The idea of Planck constant, and energy quantum lead to the quantum theory (now known as 'old quantum theory') which was a harbinger of revolutionary changes in the concepts of classical physics. Theoretical Physics got a 'quantum jump' in Germany after the discovery of Planck's law and Heisenberg's Quantum Mechanics and Schrodinger's Wave Mechanics.

The first Solvay Conference [7] was held in 1911 in Brussels, Belgium where all the topmost scientists were invited. The subject for discussion was: 'The theory of radiation and quanta' and it provided a platform to make Planck's energy quanta known outside German speaking area. Many comments for and against the quantum hypothesis of Planck were received. Einstein [8] wrote to a friend that in Brussels, the failure of the quantum theory was lamented, without a remedy being found. Still, conference was a success-by positively changing attitudes towards the quantum concept and emphasizing the central importance of this concept for future physical research. Max Born [9] wrote: "According to Planck hypothesis absorption was a continuous while emission discontinuous phenomenon involving discrete quanta. But this strange hypothesis seemed to him the only way out of the dilemma between quantum effects and electro-magnetic theory."

Nominations of Max Planck for Nobel Prize

Max Planck got a record number of nominations from 74 nominators of many different countries of Europe and America during 1907 to 1918 [10, 11]. In 1910, one of the longest nominations was from F. Hasenöhrl of Austria. He nominated Planck for his work in the field of theory of heat radiation which contains several new ideas. Their general validity and universal character give useful results for the entire physics. He wrote that as the idea is quite strange, and we are not used to it, thus, the hypothesis of 'energy quanta' had been criticised.

In the second proposal for the year 1910, E. Riecke of Germany stated that Planck's influence on experimental and theoretical research was profound. The award of the Nobel Prize would appear to the proposer, entirely justified. Philipp Lenard, the Nobel Prize winner of the year 1905, opined that as L. Boltzmann has expired, according to his opinion for the important discovery of the radiation laws of black body radiation, the Nobel Prize be awarded to M. Planck.

I believe the Nobel Committee was not convinced due to lackadaisical attitude of nominators. The nominators believed, the theory in the present form is not perfect. They observed: "Max Planck is aware and continues to improve the theory. The "quanta" hypothesis has already passed successfully through many discussions. It is more and more gaining ground. Its great fruitfulness has been shown in the successful application to the theory of the specific heat as described by A. Einstein and others".

Successes and Failures of Max Planck Quantum Theory

The successful application of Planck quantum theory is illustrated as follows:

i. *Explanation of the photo-electric effect by Albert Einstein.*
ii. *Decrease in specific heat capacity of diamond at low temperature.*
iii. *James Franck and Gustav Hertz observed that the energy an electron needs to possess, to ionize a mercury atom, is of the order of a quantum.*
iv. *W. Wien showed that the X-rays also can trigger electron emission. This assumption has been brilliantly confirmed.*
v. *The conduction of electricity through metal is explained by electron theory as a flow of electrons through metal. Attempts to set up empirical formulae for conduction resistance, adhering to the Planckian radiation formula, with certain assumptions, agrees remarkably well with experiment.*
vi. *N. Bohr applied quantum theory to explain the lines of hydrogen spectrum.*

Despite all these successful applications of Planck quantum theory, there were some gaps which remained to be fulfilled. In 1910, Planck set up a new idea. In the second Planck radiation theory it is assumed that a resonator absorbs energy continuously but on the other hand emits energy as a whole multiple of energy quantum. One consequence of this assumption is that a resonator at the absolute zero point is not deprived of all energy, but has a "zero-point energy", independent of temperature. This concept of zero-point energy is a new idea of quantum physics, which is foreign to classical physics.

In 1914, the report of G. Granqvist of Sweden concludes: "Nevertheless, with the focus on the inconsistencies of Planck's quantum hypothesis, it remarks, on the one hand the theory is not perfect as other theories in physics, but at the same time Planck radiation law and Planck constant given in the theory play important role for studying different areas of physics". Based on Expert's report, the Nobel committee also concluded in its report, despite numerous confirmations Planck's work is not yet as complete to be rewarded with a Nobel Prize.

Award of Nobel Prize to Max Planck in 1919

In 1916, H. Rubens, Germany, wrote to the Nobel Committee, that from electrodynamic, thermodynamic and probability theory, Planck gave a radiation law, which is named after him. For the derivation of the law, he found it necessary to introduce a universal constant. This is to be seen as the starting point of the modern quantum theory. It is one of the greatest achievements of the modern physics, even of science [12]. W. Wien, Germany, nominated Planck for his work on radiation theory and for installing the quantum theory. He argued, Planck's work has become important for the development of physics [13].

The greatest living legend in science, Albert Einstein of Germany, also wrote his letter, which reached the Nobel Committee on Oct. 18, 1918. In the letter, he nominated Planck for his

achievements in the field of heat radiation, and specially for his work "on the law of energy distribution in normal spectrum" and "on the elementary quanta of matter and the electricity". Einstein opined that with them Max Planck made possible, not only to determine the exact and absolute size of atom; but also laid the foundation for the quantum theory. W.C. Röntgen, who was awarded the first Physics Nobel Prize, in a very short letter nominated Planck for his work on quantum theory [14].

Even though the committee acknowledged Planck's work in 1918, however, it did not find the quantum theory worthy of the Nobel Prize, due to contradictions within the theory. In fact, for the year 1918 none of the proposed candidate was seen as worthy of the Prize. Thus, the prize was reserved.

The Nobel Committee in its report of Sept. 15, 1919, first notes that since 1907 Planck had received the most nominations over the years from the most competent nominees of all the 1919 candidates. In 1919, among these notables were A. Einstein, M. Born, M. von Laue, and W. Wien. The report refers to the discussion about Planck's candidacy in 1908, and the unanimous opinion of the Nobel Committee members, and declined of the proposal by the Swedish Academy [15]. The Nobel Committee considered Planck's discoveries on a par with the classical theories. It even implicitly described Planck as a pioneer of science, and discoverer of the elementary quanta subsequently proposed for the 1918 prize.

Ultimately, after so much wait, 74 nominations, including some from the greatest living Scientists of the world, and a bit of frustration, Max Planck, one of the greatest scientists of Germany and father of Quantum Theory. was awarded the Nobel Prize reserved for 2018 in 2019. It may be of interest for Indian and global readers of this article that lacunas in original derivation of Planck's theory of black body radiation were removed by SN Bose in 1924, who applied Einstein's light-quantum to derive Planck's radiation law. It is unfortunate that Bose missed the Nobel Prize in Physics.

CONCLUSIONS

Max Planck made a speculation to introduce quantum idea for radiation emission by black bodies to explain discrepancies of Wien's law which proved to be successful for derivation of his Planck's law of thermal radiation. However, he was not successful in his attempt to get Nobel Prize despite 74 nominations, including those by topmost physicists, namely, Albert Einstein and Max Born. Ultimately, he was awarded the Nobel Prize when applications of his quantum hypothesis became evident in several areas of Physics.

Nobel Prize in Theoretical Physics is generally awarded after verification of theory by experiments. Explanation of the photo-electric effect by Albert Einstein proved to be a cornerstone for establishment of Planck's quantum hypothesis on firm footing. It was applied to explain specific heat of solids by A. Einstein and the lines of hydrogen spectrum by Neils Bohr. Planck's contribution to Physics is paramount comparable to any other scientist of that era. He is, without an iota of doubt, founder of Quantum Physics. These days, his theory is called "old quantum theory".

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