

# Religious and Philosophical Grounds of Max Planck's Physics<sup>1</sup>

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## Abstract

Until a few months before his death, Planck claimed he was not a believer and, most of all, he did not believe in a personal God, like the Christian one; at the same time, however, he defined himself as deeply religious.

Even if Planck is famous as a great physicist, he is equally well known for the philosophical thinking which animated his scientific research, in particular a few metaphysical principles which seemed to drive his new discoveries within the modern physics framework. There are many extra-scientific issues in Planck vision: the strong belief that science needs metaphysical foundations; his consistent work as a “truth seeker”, following the idea that science can really unveil some aspect of the truth; the confidence that does exist an order of nature, particularly shown by some fundamental constant, like the quantum of action  $h$ ; finally, the possibility to find a unique explanation of the physical phenomena, in line with the search for a Theory of Everything.

Even if Planck himself was at first reluctant in accepting the quantum theory, as soon as he convinced himself on the reality of  $h$ , he was absolutely ready to contribute to dismantle classical physics, because he thought that the final goal of science is to look for truth. In this paper I try to show that his thinking moved more from philosophy and religion to science than *vice-versa*, nevertheless this direction didn't affect negatively his fundamental contributions to the advance of scientific knowledge.

**Keywords:** faith, metaphysics, truth, religion, horizon of science

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## 1 MAX PLANCK: A SHORT BIOGRAPHY AND EXTRA-ORDINARY DISCOVERY

Max Karl Ernest Ludwig Planck (Kiel 1858 – Göttingen 1947) comes from a family of jurists and protestant pastors, which in 1867 shifted to Munich. Planck attended classical studies, but a brilliant physics professor made him interested in this subject. At the University of Berlin, he attended the lectures of Kirchhoff and Von Helmholtz, with whom he improved his know-how and in 1879 defended his thesis in thermodynamics and the reversibility of phenomena. The results were not very encouraging at first, since von Helmholtz did not read the thesis and Kirchhoff disagreed with him; moreover, some of Planck's findings have been already published by the US physicist Gibbs. Later on, however, acknowledgments came: his ideas were crucial for a thermodynamics textbook on which generations of physicists studied; moreover, when Kirchhoff passed away, in 1889, Planck took his place being just 31 years old.

Planck liked fundamental and general problems, and therefore dedicated himself to the study of blackbody radiation, finding a solution in agreement with the experiments performed in that period. He discovered a relation between energy and frequency of radiation, assuming that the energy emission is not continuous, but quantized. In 1900, in the Berlin Physics Seminar, he discussed the famous blackbody equation, where for the first time appears the  $h$  constant, also known as "quantum of action". This fundamental discovery, opening a new chapter in physics – quantum physics –, appeared in two numbers of *Annalen der Physik* between 1900 and 1901, as two

papers, *Ueber irreversible Strahlungsvorgänge* (*On irreversible radiative processes*) and *Ueber das Gesetz der Energieverteilung im Normalspectrum* (*On the law of distribution of energy in the normal spectrum*). The German scientist was very uncertain whether going ahead with this research or not, since it was clearly against the main vision of classical physics. Planck had therefore to convince himself not only that his theory was valid and correct, but also that it truly fitted with the physical reality, being much more than an interpretative formula, just functional and conventional. A milestone in this path were Boltzmann's ideas on the link between entropy and probability, developed around 1898, which helped Planck define his own theory. It was a major breakthrough, so innovative that – notwithstanding several experimental confirmations and the Nobel Prize in Physics awarded to him in 1918 for this very reason – Planck himself for many years tried to find a more traditional solution, but he failed, as himself recalled afterwards, in his *Scientific Autobiography*:

My futile attempts to fit the elementary quantum of action somehow into classical theory continued for a numbers of years and they cost me a great deal of effort [...]. I now knew for a fact that the elementary quantum of action played a far more significant part in physics than I had originally been inclined to suspect (Planck, 1949, pp. 44-45)

Perhaps his own reluctance delayed the approval of the scientific community, but when it finally arrived, it became possible to link together scientific branches which until then were very far apart.

## 2 THE SCIENTIST WITH A WIDEN PHILOSOPHICAL VIEW

Planck became a famous scientist, worldwide known for his fundamental discoveries in the field of quantum physics, but his philosophical thinking was equally important, as it appears from all his works. It founds and permeates his whole activity as a scientist, and in particular a few metaphysical principles which seem to drive and, sometimes, to interfere with his researches and discoveries within the new developing physics. His serious interest and deep study on the relationship among science, metaphysics and religion appeared evident in 1930 with the publication of *Science and faith*. Some years later, in 1937, he began to hold a series of conferences on religion and science (*Religion und Naturwissenschaft*) in the Baltic regions lasting till his death in 1947.

There are many extra-scientific elements which push for a deeper study of Planck's thinking: his sound belief, against Mach and Positivism, that

science need metaphysical assumptions and that the human being cannot limit himself to a mere phenomenal research, without any perspective or reference which could explain the meaning and provide a representation of the world; his serious and consistent work as a *truth seeker*, believing that science could *really* unveil some aspects of reality (realism); the confidence that there is an order in nature, organized in the laws of nature (particularly proved by the existence of fundamental constants, such as the  $h$  discovered by himself); finally, the idea that it is possible to identify a common foundation of all different physical phenomena, in agreement with the search for a theory of everything, unifying the forces acting in physics.

The interest and commitment always supporting Planck's research were a consequence of his wider ambition in reaching a comprehensive and global vision, a unified worldview (*Weltanschauung*), able to harmonize and blend the different sciences in a coherent picture. For this reason, physics and mathematics were not to be taken aside, but to be linked and connected with other branches of knowledge. Planck himself said that he could even have become an historian or a classical philologist, since it was the understanding of facts, their origins and causes, which mainly attracted him. This makes clearer the relevance of the discovery of *quantum*: it touched in fact the very foundation of physics and therefore a vision of nature with relations and consequences not only in other empirical sciences, but also on the philosophical and, more specifically, metaphysical level.

Anyway, Planck was quite reluctant in accepting the quantum theory – since it seemed to contradict the simplicity and the deterministic order granted by mechanism and bring disorder and uncertainty in the explanation of phenomena – labelled as the “most reluctant revolutionary of any time” by L. Pearce Williams (1970). But, as soon as he understood that to explain a phenomenon such as the *black-body* radiation he had to accept and uphold his discovery of the quantum of action  $h$ , even if it meant to dismantle the classical physics, his assent was definitive, because the goal of science is to understand the truth, namely explain nature as it is. In studying Planck's philosophical-religious vision a couple of questions arose: first of all, it is not clear from his writings (there are conflicting sentences) whether the development of his reflection, both personal and scientific, was from philosophy to physics or *vice versa*; second, it has to be understood the real influence of the Christian faith on him and, more generally, in which way the scientist considered the relation between science and religion.

### 3 THE MANIFEST IMAGINE AND THE SCIENTIFIC IMAGINE OF THE WORLD. SCIENTIFIC INVESTIGATION IS INVESTIGATION TOWARDS THE ABSOLUTE

The success of Planck was possibly due not only to his smartness nor to the circumstances and the historic-cultural and scientific framework in which he lived, but rather to the principles and the vision which inspired and drove his choice and his activity as a scientist. Otherwise, he would have hardly reached so outstanding results in physics. As Planck wrote in his *Scientific Autobiography*:

My original decision to devote myself to science was a direct result of the discovery which has never ceased to fill me with enthusiasm since my early youth – the comprehension of the far from obvious fact that the laws of human reasoning coincide with the laws governing the sequences of the impressions we receive from the world about us; that, therefore, pure reasoning can enable man to gain an insight into the mechanism of the latter. In this connection, it is of paramount importance that the outside world is something independent from man, something absolute, and the quest for the laws which apply to this absolute appeared to me as the most sublime scientific pursuit in life. (Planck 1949, p. 13)

Moreover, the discoveries of the German physicist are therefore due not only to his serious and deep scientific activity, but to a way of thinking so to say philosophical or, more precisely, metaphysical, since he suggests the idea to read nature from an extra-scientific point of view. It is not by chance that in his essay *Black-Body Theory and the Quantum Discontinuity* (1978) Thomas Kuhn wrote that, as far as the Planck contribution to physics, one can speak – with few other cases in the history of science, as for example the Copernican astronomical revolution in the XVI-XVII centuries – of a conceptual revolution or, with a statement even more typical of the American science historian, of a change of *paradigm*. That means a complete new vision and a different approach in looking not only at the physical nature, but also at the whole framework: technology and industrial development, economy and politics, historical, sociological, cultural and educational aspects, up to philosophy and literature. Now, after more than one century from Planck's discoveries, we can say without any doubt that he has been one of the most important revolutionaries in the whole history of science, together with Newton and Einstein.

## 4 MAX PLANCK'S SCIENTIFIC REALISM ANTE LITTERAM

We may think that Planck adopted, in an implicit or unconsciously way, a position as a “scientific realist”: the external reality does exist – independently from the human being, his various representations and his different ways of learning – and the material physical world can be understood: it is intelligible because it is organized by the laws which rule it. Hence, these laws have a correspondence – almost harmonic – with what human sensitivity and rationality (logic) can elaborate, building up scientific investigation.

It is quite clear that his “faith” in the capability to find the laws of nature is one of the reasons which led Planck to research and study for such a long time the foundations and, in the meanwhile, to welcome with great reluctance his own finding, since it seemed not to be coherent with the traditional physical framework. The goal of Planck was to understand the *true physical meaning*: it was not enough to have a description or an interpretation of a phenomenon, he rather wanted to develop a theory which could really give an explanation and unveil the *intrinsic* nature of the investigated object. In his Nobel Prize Address *The Origin and the development of the Quantum Theory* the German scientist explains his scientific attitude when studying blackbody's radiation:

If, however, the radiation formula should be shown to be absolute exact, it would possess only a limited value, in the sense that it is a fortunate guess at an interpolation formula. Therefore, since it was first enunciated, I have been trying to give it a real physical meaning, and this problem led me to consider the relation between entropy and probability, along the lines of Boltzmann's ideas. After a few weeks of the most strenuous work of my life, the darkness lifted and an unexpected vista began to appear. (Planck 1960, p. 106)

Planck was absolutely sure that physical laws were not merely possible scientific description – *i.e.* epistemic – without any reference to the reality under investigation, or ontological value. Science must suppose that nature is ordered by laws, otherwise science would be “without foundation”, not reliable, exposed to any possible change or failure.

How do we discover the individual laws of Physics, and what is their nature? It should be remarked, to begin with, that we have no right to assume that any physical law exists, or if they have existed up to now, that they will continue to exist in a similar manner in the future. It is perfectly conceivable that one fine day Nature should cause an unexpected event to occur

which would baffle us all; and if this were to happen we would be powerless to make any objection, even if the result would be that, in spite of our endeavors, we should fail to introduce order into the resulting confusion. In such an event, the only course open to science would be to declare itself bankrupt. For this reason, science is compelled to begin by the general assumption that a general rule of law dominates throughout Nature (Planck, Johnston 1931, p. 58).

This is a further element useful to understand how the discovery of quantum was difficult to be accepted and how fundamental was for the scientist to understand whether it was a law of nature or just the result of a scientific elaboration.

## 5 THE CRITICS TO A CONCEPT OF SCIENCE “WITHOUT ASSUMPTIONS”

Following this view, Planck himself was fully convinced that a scientist who would study and work in his field without a vision of the world or of nature which he was investigating would not exist. Planck defined his position more precisely: science is an autonomous knowledge and as such must be free and independent from extra-scientific visions (philosophical, religious, political or ideological ones of any kind) which could somehow lead or bound it in its development, but, at the same time, science as a human activity cannot be totally “aseptic” and devoid of ideas, assumptions, finality, and so on. As he explains in *The meaning and limits of exact science*:

No phrase has ever engendered more misunderstanding and confusion in the world of scholars than the expression, “*Science without Presuppositions*”. It was coined originally by Theodor Mommsen, and was meant to express that scientific analysis and research must steer clear of every preconceived opinion. But it could not be, nor was it, intended to mean that scientific research need no presuppositions at all. Scientific thought must link itself to something, and the big question is *where* (Planck 1949, p. 82)

Thus, according to Planck, it seems that science, to be what it is having a proper path and reaching specific results, necessarily needs assumptions and at least some principles giving it a direction in such a way to go ahead and elaborate hypotheses, experiments, theories, and so on. Planck himself was a kind of scientist who addressed his research on the basis of his vision of the world, of nature and of science, without which he could never have been able to elaborate the theories and make the discoveries he left to us. A further clarification on the thesis which rules out the possibility of a

“science without assumptions” and considers mandatory to go beyond the experimental data alone, to build up a scientific knowledge with the essential the personal contribution of each scientist, is given by Planck in *Science and Faith* as follows:

Every branch of science must have an empirical foundation: but it is equally true that the essence of science does not consist in this raw material but in the manner in which it is used. The material always is incomplete: it consists of a number of parts which however numerous are discrete. [...] The material must therefore be completed, and this must be done by filling the gaps; and this in turn is done by means of associations of ideas are not the work of the understanding but the offspring of the investigator’s imagination — an activity which may be described as faith or, more cautiously, as a working hypothesis (Planck 1963, p. 121)

This approach to science as a human activity, generated and permeated with ideas, values, principles and finalities is quite similar to the claims made several decades later by the philosopher of science Michael Polanyi (1891–1976) — in his masterpiece *Personal Knowledge* (Polanyi 1956) regarding tacit/explicit knowledge — and by the whole movement which starting from Popper develops a reflection on science, looking at it in the perspective of human knowledge which cannot leave aside assumptions and influences of metaphysical, anthropological, ethical and social origin.

Such a vision is confirmed in an even more explicit way by Planck’s essay *Physics and World Philosophy*, where he stated that:

Every science has its roots in life and that similarly physics can never be completely separated from its student: every student, after all, is a personality equipped with a set of intellectual and ethical properties. Hence the general philosophy of the student will always have some influence on his scientific work, while conversely the results of his studies cannot but exert some influence on his general philosophy (Planck 1963, p. 10).

In *Where Is Science Going?*, the German scientist is even more clear-cut:

To sum up, empiricism is unassailable on the fundamental ground of a pure logic; and its conclusions are equally impregnable. But if we look at it purely from a viewpoint of knowledge it leads into a blind alley, which is called solipsism. In order to escape from this *impasse* there is no other way open but to jump the wall at some part of it, and preferably at the beginning. This can be done only by introducing, once at for all, a metaphysical hypothesis which has nothing to do with the immediate experience of sense-perceptions or the conclusions logically drawn from them (Planck 1981, p. 128)



It is so absolutely clear that Planck had an idea of the world, of knowledge and of science totally “open” and inclined to support a unity of knowledge (Tanzella-Nitti 2002 ) which, at that time, contributed to develop an original perspective, shared by other famous scientists, like Albert Einstein (Jammer 2002). Since the second half of the twentieth century, this perspective has been discussed by historians, philosophers and theologians, and is right now at the center of the present-day debate. The relevance of Planck's work was not just to have provided a new theory, which opposed itself to previous ones, but rather to have developed a new framework not only for science, but for philosophy and culture as well.

## 6 LIMITS AND MEANING OF SCIENCE TILL THE IMPENETRABLE HORIZON

Planck does not limit his reflection on science just to philosophy, as many scientists did in the past and still do at present. In *The meaning and limits of science*, from the human and immanent level rises to the metaphysical and transcendent one, asking some of the “final” questions, aimed at reaching the foundation and overcoming science itself and its value:

But why all this enormous labor, demanding the best efforts of countless soldiers of science during their entire lives? Is the ultimate result — which, as we have seen, in its individual details always drifts away from the immediately given facts of life — truly worth this costly effort? These questions would indeed be justified if the meaning of exact science were limited to a certain gratification of man's instinctive yearning for knowledge and insight. But its significance goes considerably deeper. The roots of exact science feed in the soil of human life. (Planck 1949, p. 112).

Science is therefore a manifestation of the spirit and of the human desire to understand, to go beyond the phenomenal and the material, looking for the root causes, the principles which establish and govern nature and life and give sense and meaning to human activities. The following Planck's statement opens the horizon to infinity and impenetrable:

And he whom good fortune has permitted to co-operate in the erection of the edifice of exact science, will find his satisfaction and inner happiness, with our great poet Goethe, in the knowledge that he has explored the explorable and quietly venerates the inexplorable (Planck 1949, pp. 119-120).

Planck seems to approach even to the “mystical” outcome of the *Tractatus logico-philosophicus* by L. Wittgenstein who in proposition 7 writes that “whereof one cannot speak, thereof one must be silent”. Philosophy, and in this case science as well, do not exhaust the thirst which inspires and pushes human finding investigation, whichever form it takes, but at most, if fully successful in its proper field of study, could lead in front of the mystery and of the impassable boundary that the human being cannot overcome due to his limited cognitive abilities: this finish line, however, does not leave man disappointed or without a valuable knowledge; on the contrary, reaching it does mean becoming aware of what is possible to understand and until which extent he can go. This is not the defeat of science, a surrender to limits or obstacles, but, after a long journey, the achievement of the “threshold” of science, where it is possible to acknowledge the greatness of human mind and, at the same time, the richness and immensity of the reality, which the human being is part of.

Thus, natural science exhibits a rational world order to which nature and mankind are subject, but a world order the inner essence of which is and remains unknowable to us, since only our sense data (which can never be completely excluded) supply evidence for it. Nevertheless, the truly prolific results of natural scientific research justify the conclusion that continuing efforts will at least bringing us progressively nearer to the unattainable goal, and they strengthen our inner hope for a constant advancement of our insight into the ways of the omnipotent Reason which rules over Nature (Planck 1949, pp. 181-182).

Science thus brings us to the threshold of the ego and there leaves us to ourselves. Here it resigns us to the care of other hands. In the conduct of our own lives the causal principle is of little help; for by the iron law of logical consistency we are excluded from laying the causal foundations of our own future or foreseeing that future as definitely resulting from the present (Planck 1981, p. 167).

Science enhances the moral value of life, because it furthers a love of truth and reverence — love of truth displaying itself in the constant endeavor to arrive at a more exact knowledge of the world of mind and matter around us, and reverence, because every advance in knowledge brings us face to face with the mystery of our own being (Planck 1981, p. 169).

## 7 FAITH AS THE FOUNDATION AND THE HORIZON OF SCIENCE

In the last years of his long career, Planck comes to a sort of cosmivision, which put together science, philosophy and faith, which the Nobel Prize

openly supports in a series of conferences on *Religion und Naturwissenschaft*, and in writing essays such as *Science and Faith*:

Anybody who has been seriously engaged in scientific work of any kind realizes that over the entrance to the gates of the temple of science are written the words: Ye must have faith. It is a quality which the scientist cannot dispense with (Planck, 1981, p. 214).

Science cannot solve the ultimate mystery of nature. And that is because, in the last analysis, we ourselves are part of nature and therefore part of the mystery that we are trying to solve. (Planck, 1981, p. 217)

No matter where and how far we look, nowhere do we find a contradiction between religion and natural science. On the contrary, we find a complete concordance in the very points of decisive importance. Religion and natural science do not exclude each other, as many contemporaries of ours would believe or fear. They mutually supplement and condition each other. The most immediate proof of the compatibility of religion and natural science, even under the most thorough critical scrutiny, is the historical fact that the very greatest natural scientists of all times — men such as Kepler, Newton, Leibniz — were permeated by a most profound religious attitude. (Planck 1949, pp. 185-6)

It is worth wondering which kind of faith Planck refers to: whether a faith as a scientist, namely coming from the confidence that reality is intelligible and the human and rational knowledge is effective, or a supernatural faith, fruit of a “deism” or of a transcendental religious faith in the Christian God. It seems that Planck referred both to a faith as an ordering principle and to an ordering/regulating God, rather than to the God of Christian revelation, as it seems to emerge from what he wrote in the essay *Science and Faith*:

The chaos of individual masses cannot be wrought into a cosmos without some harmonizing force and, similarly, the disjointed data of experience can never furnish a veritable science without the intelligent interference of a spirit actuated by faith. (Planck 1963, p. 122)

Faith is the power which gives their real effectiveness to the individual data of science. We may even go a step further and claim that a prophetic faith in the deeper harmony can render valuable services at the earliest stage — the stage of gathering the data. The faith points the way and sharpens the senses. [...]. An experimenter who pursues his work in the laboratory and scrutinizes his results, frequently finds the progress of this work facilitated — more especially when he comes to distinguish essentials from unessentials — if he possesses a more or less deliberate intellectual attitude which

guides his investigations and serves to interpret the results. (Planck 1963, p. 124)

Such a position towards religion is confirmed by the fact that, a few months before his death (1947), in a letter to W. H. Kick (18 June 1947), Planck, who came from a family of Lutheran pastors, denies having ever converted to Catholicism, even if being deeply religious (Herneck 1984). The physicist says he does not believe in a “personal God, even less in the Christian God”.

At the same time, he defined himself deeply religious, sustaining that the religious dimension is not just perfectly compatible with the scientific one, but rather complementary: science and faith, even if – or just since – make use of different methods, have to be placed side by side in driving the search for the truth and leading the progress, without any kind of problems or obstacles:

There is no better way to comprehend this properly than to continue one’s efforts to obtain a progressively more profound insight into the nature and problems of the natural sciences, on one hand, and of religious faith on the other. It will then appear with ever increasing clarity that even though the methods are different – for science operates predominantly with the intellect, religion predominantly with sentiment – the significance of the work and the direction of progress are nonetheless absolutely identical (Planck 1949, p. 187).

Moreover, Planck says that science and religion can cooperate to fight some of the philosophical and cultural trends – perhaps more frequent today than at his times – which favored throughout the XX century the rise of a progressive distrust in reason and a skepticism towards any true, reinvigorating ideologies and dogmatisms, from one side, and calling back different kinds of spirituality close to paganism and of oriental origin, on the other hand:

Religion and natural science are fighting a joint battle in an incessant, never relaxing crusade against scepticism and against dogmatism, against disbelief and against superstition, and the rallying cry in this crusade has always been, and always will be: *On to God!* (Planck 1949, p. 187)

This vision seems to recall what will be affirmed on several occasions by some scientists, like the already mentioned Einstein in his essay *Science and Religion* (1941), and by some documents of the Magisterium of the Church, *i.e.* the *Gaudium et Spes* (1996), and the letter by John Paul II to Father G. Coyne (1988), where we read:

Science can purify religion from error and superstition; religion can purify science from idolatry and false absolutes. Each can draw the other into a wider world, a world in which both can flourish.

Leaving aside the question whether Planck developed a mature religious faith and, before the end of his life, became a believer in the God of Christian revelation, it is certain that the philosophical and religious vision which inspired him from the very beginning of his career has been crucial in defining and steering his scientific research, making him say that it is always possible and necessary to base any activity on human values which give direction and sense to every situation:

There is a fixed point and a secure possession which even the least of us can call his own at all times; an inalienable treasure which guarantees to thinking and feeling men their highest happiness, since it assures their peace of mind, and thus has an eternal value. This possession is a pure mind and good will. These afford secure holding ground in the storms of life [...] They are the essential of every genuine science and they are equally a sure standard by which to measure the ethical value of every individual (Planck 1963, p. 39).

For all these reasons, Max Planck should be considered as one of the highest examples of the natural link between science and a whole “world-view”; as much as this vision is explicit and descends from a conscious reflection, the dialogue among science, philosophy and faith, could give rise to a fruitful and effective relation.

## 8 PLANCK'S META-PHYSICS AND OPEN ISSUES

At the conclusion of this brief study, it is possible to make a first attempt to frame the philosophical perspective of Planck's thought. Some elements are to be considered because they were clearly expressed by the German scientist in the various papers he wrote:

- a) first of all, a strong belief, that science must rely on metaphysical assumptions, against Mach and positivism view;
- b) Planck's idea that the human being cannot limit himself to a merely phenomenal study of nature, without any perspective or reference to explain its meaning and provide a picture of the world;
- c) the serious and consistent work as a “truth seeker”: science can explain some aspects of the reality (realism) while only the reality can guarantee the truth of scientific theories;

- d) the confidence that there is an order in nature, organized by the laws of nature (and based in particular on fundamental constants, like  $h$ );
- e) the intuition that it is possible to find the foundation which provides a single explanation of any physical phenomenon, in agreement with the search for a theory of everything which unifies the forces acting in physics.

Beyond these points, there still exist many open issues, which surely deserve a deeper analysis, that demonstrate the importance and the richness of the thought of the German scientist. For example, the type of scientific realism that Planck adopts, without referring explicitly to some philosophical views or some author. Planck's intellectual approach and scientific achievements cause the collapse of the system then in force and the birth of a new "paradigma": a new discovery, the problems with the dominant theory, the attempt to find an agreement to fit the new element, till to the forced change of the entire frame because the reality asks for a new theory explaining the new features that cannot be denied or considered only as an interpretation.

Moreover, Planck's personal story and religious faith remain in the background *vis à vis* his scientific belief in the intelligibility of reality, in the capabilities of science and the unity of knowledge, as briefly discussed in the present paper. Possibly, social and political events and family adventures faced by Planck prevented him from a 'traditional' religious conversion, which could have helped him unify his philosophical and scientific vision with the religious one. Anyway, references and hints to this specific dimension are so many and deep both in his original scientific writings and in the continuous production in the '30s that it is possible to glimpse the depth of his thought, and to rank Planck in the same, small group of scientists — such as Galilei, Newton, Maxwell and Einstein — who, starting from science, left us a vision of the world — we could say a *Weltanschauung* — as complete and comprehensive as possible.

Finally, in his book not by chance entitled *Where is Science Going?*, Planck wrote:

And so we arrive at a point where science acknowledge the boundary beyond which it may not pass, while it points to those farther regions which lie outside the sphere of its activities. [...] We started on a territory of a special science and have dealt with a series of problems that are of a purely physical character; but these have lead us from the world of mere sense-perception to the real metaphysical world. [...] It is a land of mystery. It is a world whose nature cannot be comprehended by our human powers of mental conception; but we can perceive its harmony and beauty as

we struggle towards an understanding of it. And here on the threshold of this metaphysical world we have been brought face to face with the highest question of all, that of the freedom of the human will. It is a question which each one must meditate upon for himself if he thinks at all seriously on what the meaning of this life may be. (Planck 1981, p. 105–106).

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#### NOTES

1. This short paper is dedicated to the memory of a colleague and prof. Lodovico Galleni (1947), passed away on November 29, 2016, in Pisa (Italy). Prof. Galleni was a passionate and tireless promoter of the dialogue between science and religion and, even if he was not a Planck's scholar, he would have certainly shared this view and the interdisciplinary approach of Planck, which is today an essential ingredient in the relationships among philosophy, faith and science.

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