PROBLEMOS

Problemos
ISSN: 1392-1126
ISSN: 2424-6158
redakcija.problemos@fsf.vu.lt
Vilniaus Universitetas
Lituania

Mandelstam – Planck Polemics and its Representation in the Soviet Scientific Literature: Ideological Metamorphoses

Pechenkin, Alexander

Mandelstam – Planck Polemics and its Representation in the Soviet Scientific Literature: Ideological Metamorphoses
Problemos, vol. 99, 2021
Vilniaus Universitetas, Lituania
Disponible en: https://www.redalyc.org/articulo.oa?id=694573981008
DOI: https://doi.org/10.15388/Problemos.99.8

Articles

Mandelstam – Planck Polemics and its Representation in the Soviet Scientific Literature: Ideological Metamorphoses

Mandelštamo ir Plancko polemika bei jos recepcija sovietinėje mokslo literatūroje: ideologinės metamorfozės

Alexander Pechenkin a_pechenk@yahoo.com
Lomonosov Moscow State University, Federación de Rusia
https://orcid.org/0000-0002-0099-8785

Problemos, vol. 99, 2021

Vilniaus Universitetas, Lituania

Recepción: 12 Enero 2021
Aprobación: 05 Marzo 2021

DOI: https://doi.org/10.15388/Problemos.99.8

Redalyc: https://www.redalyc.org/articulo.oa?id=694573981008

Abstract: The L. I. Mandelstam - M. Planck polemics concerning the theory of dispersion (1907-1908) are taken under consideration. Mandelstam attacked Planck's theory published in 1904. Planck reacted by publishing a short reply in 1907. Mandelstam was not satisfied and published a paper where he provided a more detailed calculation (1908). Planck criticized his approach again (1908). Mandelstam published two more papers, but Planck did not react to these publications.From a historical point of view it is interesting that in the Soviet scientific literature, Mandelstam's position was almost unanimously considered to be correct and powerful. The situation changed after the collapse of the Soviet Union. Russian physicists came to treat Planck's position as the correct one. In this connection, the problem of scientific objectivity arises. The author emphasizes the ideological context of the scientific interpretation of facts. The phenomena of progressivism and introjection are taken under consideration.

Keywords: optics, dispersion, polemics, State ideology, the ideological engine.

Summary: Straipsnyje aptariama L. Mandelštamo ir M. Plancko polemika dėl dispersijos teorijos (1907–1908). Mandelštamas viešai kritikavo 1904 m. publikuotą Plancko teoriją. Planckas į tai sureagavo paskelbdamas trumpą atsaką 1907 m. Mandelštamas nebuvo patenkintas ir 1908 m. publikavo detalesnius skaičiavimus. Planckas dar kartą sukritikavo jo požiūrį 1908 m. Tada Mandelštamas publikavo dar du straipsnius, tačiau Planckas į šias publikacijas nesureagavo. Istoriniu požiūriu įdomu, kad sovietinėje mokslinėje literatūroje Mandelštamo pozicija buvo beveik vieningai pripažinta teisinga ir neginčijama. Situacija pasikeitė žlugus Sovietų Sąjungai. Rusų fizikai ėmė traktuoti Plancko poziciją kaip teisingą. Šiuo atžvilgiu iškilo mokslinio objektyvumo problema. Autorius pabrėžia faktų mokslinės interpretacijos ideologinį kontekstą. Atsižvelgiama į progresyvizmo fenomeną ir introjekciją.

Keywords: optika, dispersija, polemika, valstybės ideologija, ideologinis mechanizmas.

Introduction

The present paper consists of two parts: historical and philosophical. In turn, the historical part consists of three divisions: 1) the Mandelstam-Planck polemics dedicated to the problem of dispersion, which occurred in 1907 (context and quotations); 2) the treatment of this polemics in Soviet writings about Mandelstam (in his scientific biography written by his friends and coworkers, in biographical essays written later by Mandelstam's disciples, in the reviews of the problem of dispersion written in Soviet scientific journals, books, and textbooks; 3) the

treatment of Mandelstam-Planck polemics by Russian scientists at the beginning of the 21st century.

The philosophical section takes the problem of scientific objectivity into account. This problem has been amply elucidated in the philosophical literature. We shall however consider the influence of state ideology on the scientific interpretation of theoretical discussions. We shall emphasize the implicit introjection (non-themed spontaneous drawing of ideological terminology) of the ideological language into both the scientific reviews and the textbooks.

A considerable part of the present paper is presented in the author's book (Pechenkin 2019). However, the logical structure of this paper differs from the corresponding chapters of the book, most of the text has been rewritten, and the author's book does not contain a philosophical discussion of the problem of scientific objectivity.

1. Who was L. I. Mandelstam?

1.1. Mandelstam in Strasbourg

Max Planck (1958–1947) needs no introduction to the reader. Let me concentrate on the biography of Mandelstam. Leonid Isaakovich Mandelstam (1879–1944) graduated from the Strasbourg University (Kaiser Wilhelm Universität Straßburg) in 1902 and started to work as an auxiliary assistant at the Strasbourg Institute of Physics, which was merged into the faculty of mathematics and natural science. His career was rather successful: in 1904 Mandelstam became Second Assistant and in 1906, First Assistant. He kept this position until his departure for Russia (June 1914). In 1913 Mandelstam was appointed to deliver the lectures on applied physics. In 1907 Mandelstam became Privatdocent, in 1913 Mandelstam received the title of Professor. True, this was just a title: he could be addressed as Professor, his career potential became higher, but for the rest, he did not differ from Privatdocent.

Mandelstam started his research under Professor Ferdinand Braun who was Director of the Institute of Physics. Braun was one of the pioneers of radio technology and radiophysics. In 1909 he shared the Nobel Prize with Marconi for his "contribution to the development of wireless telegraphy".

Mandelstam's degree work was dedicated to the indirect method of frequency measurements (more precisely, to measurements of the period of capacitor discharge). Mandelstam's subsequent research (which he conducted together with Brandes, the second assistant at the Institute of Physics) was directly dedicated to the development of Ferdinand Braun's ideas. This was the idea of loose coupling, which resulted from Braun's 1902 experiments. What is "loose coupling"? This is a coupling between an antenna and a closed circuit in the Braun transmitter and receiver. The force of coupling is proportional to the coefficient of mutual inductance of the corresponding coils. In the case of strong coupling of primary and

secondary circuits, the system works as a single whole. In the case of loose coupling, the back-action of the secondary circuit on the primary is small. It permits weak dumping of forced oscillations in the secondary circuit.

In his 1909 Nobel Lecture Braun elucidated the problem of loose coupling by referring to his cooperation with Mandelstam and Brandes.

In 1904 Mandelstam published the article entitled "On the theory of F. Braun's transmitter: Coupling and Coherency". In this article, Mandelstam proposed a unified theory of different modifications of the Braun transmitter.

In 1904 Mandelstam began to cooperate with N. D. Papalexy, who, like Mandelstam, arrived in Strasbourg from Odessa and graduated from Strasbourg University in that year. "1904 was the year of our first collaborative work in the field of oscillations and radio, which continued in Strasbourg and Moscow until recently," Papalexy wrote in his biography of Mandelstam. "This work was dedicated to the method of obtaining phase lagging, but identical in shape, oscillations, which formed the basis of experiments on the directional radio-telegraphy and radio interference" (Mandelstam. Vol 1: 9).

1.2. Mandelstam in Russia and the Soviet Union

In 1914 Mandelstam and Papalexy returned to Russia. In the present author's book, the first ten years of Mandelstam's life in Russia (and after 1917 in Soviet Russia) are characterized as the "years of pilgrimage." From December 1915 to September 1918 Mandelstam worked as a consultant at the Siemens and Halske radiotelegraph plant in Petrograd (this plant was taken over by the Russian Government). From 1918 to 1922 Mandelstam lived in Odessa and taught physics at the Odessa Polytechnical Institute. From 1922 to 1924 Mandelstam was a scientific consultant at the Central Radio Laboratory in Moscow (in 1924 this laboratory moved to St. Petersburg).

A new stage in Mandelstam's life started in 1925. Mandelstam became a Professor of Theoretical Physics at Moscow State University. He also became Full Member of the Physics Institute at Moscow State University (in 1929 the Schools (Faculties) system was restored in Moscow State University and Mandelstam became Professor of the Physics School). Mandelstam delivered a wide range of courses (the list of the most important courses follows): 1925/26 –lectures on the theory of oscillations, 1925/26 a seminar on topics in optics and electrodynamics, 1925/26 a seminar on the field theory, 1927/ 28 a seminar on statistical physics, 1928/29 a seminar on the special theory of relativity, 1930/31 and 1931/32 lectures on the theory of oscillations, 1932/33 – lectures on selected topics in optics (paradoxes), 1933/34 – a seminar on the foundations of the theory of relativity, 1936/37 – a seminar on dispersion and adsorption, 1937/38 a seminar on some chapters of the theory of oscillations, 1938/39 lectures on the foundations of quantum mechanics.

As a researcher, Mandelstam concentrated on optics in 1925-30. Here his main result (together with his friend and co-worker G. S. Landsberg)

was the combinational scattering of light. "The effect can be summarized as follows," – wrote one of Mandelstam's former students, G. Gorelik, in his textbook (Gorelik 1950: 604), –

> [t]he spectrum of the scattered light contains, in addition to the Rayleigh scattering at the frequencies of the existing light, additional lines which which lie on long-wavelengths and short-wavelengths of each spectral line of the exciting light. These satellites (the "Stokes" satellites on the long wavelength and "anti-Stokes" satellites on the short wavelength side) are characterized by the intermolecular or lattice vibrations, which are sometimes also manifested in infrared absorption spectra.

When addressing the First All-Union Conference on Oscillations, Mandelstam used radio-engineering terminology in his explanation of his discovery made together with Landsberg. "In its essential features, the spectrum of scattered light reproduces the spectrum of the modulated transmitter…Speaking schematically, we have here nothing else than the modulation of an incident wave by the natural oscillations of the molecule and molecular aggregates. It is clear then that, as the spectrum of a telephone transmitter carries all our talk, the spectrum of the scattered light carries what a molecule speaks about itself. By studying this spectrum you study the structure of a molecule." (Mandelstam Vol.3: 60).

Mandelstam's aphorism on the "conversation of a molecule" became very popular among physicists.

Mandelstam also wrote papers concerning a wide scope of problems in physics (radiophysics, the theory of oscillations, optics, and quantum mechanics). Some of his papers were written by him together with his disciples. However, Mandelstam's most remarkable contribution was a cycle of his courses which he delivered at Moscow State University. In Mandelstam's "Complete Works," two volumes (the fourth and fifth volumes) have been constructed on the base of his students' records of his lectures and seminars and Mandelstam's own drafts.

Mandelstam received very important prizes: the Lenin prize (1931), Mendeleev prize (1936), and Stalin prize (1942). Mandelstam was decorated with the highest Soviet honours: The Order of the Red Banner of Labor (1940) and The Order of Lenin (1944).

In 1928 Mandelstam was elected as a corresponding member of the USSR Academy of Sciences; in 1929 he was elected as a full member (an Academician).

Soviet science was organized hierarchically (like science in Russia now): corresponding members and academicians enjoyed higher wages and a number of privileges (more comfortable State apartments, free and advanced medical treatment, etc.).

1.3. The Nobel Prize story

As stated earlier, after becoming Professor of Moscow State University Mandelstam concentrated on optics. He conducted research together with his coworker and friend G. S. Landsberg (who was one of the

scientists who initiated the invitation of Mandelstam to teach at Moscow State University).

The combinational scattering of light was a discovery of the Nobel Prize level. Mandelstam and Landsberg conducted experimental and theoretical research in scattering of light by crystals and Mandelstam and Lansberg were close to winning the Nobel Prize. The Indian physicist Raman received the Nobel Prize for his research concerning the scattering of light in liquids, for the discovery of what was called the Raman Effect.

The episode with the Nobel Prize was painfully treated by Soviet scientists and historians of science. For example, Landsberg's disciple and coworker I. Fabelinsky pointed out that "any research carried out by Landsberg and Mandelstam was very careful and thorough, guided by a clear understanding of the effect under study; they did not rush to publish their results" (Fabelinsky 1982: 124). Raman promptly published a report of his discovery on March 31, 1928. The Russian scientists, unfortunately, were in no hurry to report their discovery of the effect. News of their discovery reached print only in July.

I. E. Tamm pointed out the political aspect of the Nobel Committee's decision (Tamm 1965: 3)

In the Russian scientific literature, the term "Raman effect" was avoided. Instead, the term "The Combinational Scattering of Light" was used. However, starting with 1990s the worldwide accepted terminology has been legitimated in Russia.

The paper written by R. Singh and F. Riess restores the chain of events from the original documents. Raman was nominated by a number of physicists: among them, physicists as great as N. Bohr and E. Rutherford. Raman was known among Swedish physicists.

Mandelstam and Landsberg were nominated by O. D. Chvolson, the Russian prominent physicist, the author of the five-volume course on physics. Raman was also nominated by Chvolson.

Mandelstam was also nominated by his friend Papalexy (Landsberg for unknown reasons had not been nominated by Papalexy).

2. Mandelstam's Early Research in Optics

In 1907, in Strasbourg, Mandelstam started to publish on optics. In doing research in optics, he was being trained as a theoretician. In his first paper "*Űber optish homogene und trűbe Medien*" ("On optically homogeneous and turbid mediums") Lord Rayleigh's famous theory of the blue colour of the sky was criticized. Four papers dedicated to the criticism of Planck's theory of dispersion followed (1907–1908). In 1911 Mandelstam's paper "On Abbe's theory of microscopic images" appeared. This paper was followed by the paper "On application of integral equations to the theory of optical images" (1912). There is an acknowledgment in which the author thanks R. von Mises for consultations in this paper. Von Mises was a specialist in mathematical physics. He was invited to Strasbourg University as *Außerordentlicher* Professor of Applied Mathematics and arrived in Strasbourg in 1909.

A new stage in Mandelstam's research in optics is represented by his paper "*Über die Rauchigkeit freier Flűssigkeitsoberflächen*" ("On the roughness of free surfaces of liquids") developing the statistical approach of both M. Smoluchovski and A. Einstein on the interconnection of the scattering of light and the fluctuations of the density of a scattering medium (1913).

2.1. Mandelstam's "On Optically Homogeneous and Turbid Mediums"

The problem of light scattering in the terrestrial atmosphere was first considered by Lord Rayleigh at the end of the 19th century (1871-1899). He assumed that molecules scatter incoherently because they participate in thermal motion. This allows a summation to be made over the intensities of scattering by individual oscillators.

In contrast to Lord Rayleigh, Mandelstam believed that the molecular motion in the atmosphere did not make it an inhomogeneous medium which is able to scatter light. As all "small volumes of space" (approx. equal to λ^3, where λ is the length of a light wave) contain the same number of molecules, waves emitted by them are coherent, *contra* Lord Rayleigh – the motion of molecules in small volumes does not make any difference. As corresponding fields are summed, scattering does not arise. The waves which radiate are mutually suppressed; we are left only with the waves which propagate in the direction of the incident wave.

Rayleigh explained the blue color of the sky referring to the dependence of scattering on the wavelength of the scattered light. Short wave light (namely, blue light) is scattered more than, say, red light, which is a long wave. According to Mandelstam, Rayleigh's conception of the atmosphere does not allow us to treat it as an optically heterogeneous medium. The atmosphere is an optically homogeneous medium and it does not scatter light. According to Mandelstam it is worth looking for the explanation of the blue color of the sky by referring to foreign particles suspended in the atmosphere.

What does Mandelstam himself write about Rayleigh's theory?

> In his theory of turbid media Rayleigh assumed the random motion of particles. His argumentation is approximately the following: if a plane wave falls on motionless particles, they start to oscillate with a constant phase shift. At some point P, depending on the direction and distance, a certain interferential picture arises. Thus, we do not need to summarize the intensities (proportional to square of amplitudes of field strengths) produced by every single particle near the point P, we need to summarize the field strengths themselves. If particles are in movement, they will no longer have constant phase shifts. The field strengths at the point P do not have constant phase shifts, either (apart from the case when the direction to P and a line connecting the particles coincides with the direction of the wave propagation). As the wavelength is small, the phase shift runs over all possible values even over a short time. In this case, it is possible to sum up the intensities.
>
> This is valid for a few particles. If we have many particles, then, I think, it does not make any difference whether an interferential pattern in the point P is produced by two particular particles or two spatial areas which are small with respect to wavelength and equal to each other with respect to a number of particles constituting them. However, an optically homogeneous medium can always be

> divided into such space areas because this is the definition of homogeneity. Thus we conclude that an optically homogeneous medium cannot be turbid irrespective of whether the particles are at rest or in motion. I consider it inadmissible to apply the Rayleigh theory of turbid media to the atmosphere. Air should be treated as an optically homogeneous medium since a cube, the edge of which equals to the wavelength of sodium light, contains 5·106 molecules, which Rayleigh considers to be scattering particles (Mandelstam Vol. 1: 116).

2.2. The Mandelstam Criticism of Planck's Theory

In the biography of Mandelstam (this biography opens the first volume of Mandelstam's "Complete Works"), the description of the Mandelstam–Planck polemic subsequently followed the exposition of Mandelstam's article dedicated to Lord Rayleigh's theory.

Mandelstam's biographers write:

> Mandelstam's papers "On the theory of dispersion" are closely connected with this article. They are dedicated to the discussion of the possibility of explaining the attenuation of light by referring to light scattering. M. Planck proposed such an explanation in his theory of dispersion. However Mandelstam showed that Planck's theory was not able to explain the attenuation of the transmitted wave. Mandelstam conducted the calculations which showed that the essence of the problem consisted in a distinction between the damping of isolated oscillators and the damping of the oscillators constituting a medium (Mandelstam Vol. 1: 15).

This historical excursion was finished in an amusing way. Planck's postcard is cited in the biography of Mandelstam. In this postcard, Planck agrees with Mandelstam and writes that he made a corresponding correction. Here, there is a lack of coordination. Mandelstam's article "On the theory of dispersion" dedicated to the criticism of Planck's theory was published in 1907. Planck's postcard is dated by 1904. Probably, it was Planck's reaction to some unpublished statement of Mandelstam.

Let us turn to Mandelstam's writings. As was noted, in 1907 Mandelstam took under criticism the famous theory of the blue color of the sky put forward by Lord Rayleigh at the end of the nineteenth century. In the same 1907 Mandelstam published an article "On the theory of dispersion" (*Physikalische Zeitschrift*, 1907) which criticized Max Planck's theory. Planck rejected Mandelstam's criticism in a short note published in *Physikalische Zeitschrift* in the same year. Mandelstam reacted by publishing the article where he developed his criticism (*Physikalische Zeitschrift*, 1908). Planck again rejected Mandelstam's criticism (*Physikalische Zeitscrift*, 1908). Mandelstam insisted in an article (*Physikalische Zeitscrift*, 1908) which had not already received Planck's reply.

What was the point of the Mandelstam–Planck controversy? In his article on the theory of dispersion, Mandelstam argued that under Planck's assumption and contrary to Planck "a wave attenuation resulting from dispersion should not be anticipated" (Mandelstam Vol. 1: 125). Like Planck, Mandelstam treated molecules scattering light as elementary oscillators (resonators). Planck, however, showed that the attenuation of a transmitted light wave in the absence of dissipation resulted from its

scattering. This is connected with radiative damping which results from the deceleration of oscillator oscillations caused by its intrinsic radiation field.

Planck adopted Rayleigh's presupposition that the light scattering in the terrestrial atmosphere proceeds incoherently. Mandelstam's discussion differed from that of Planck. Mandelstam called Planck's approach quasistatic. Taking under consideration the interaction of oscillators in small volumes, Mandelstam supposed that damping resulting from the radiation of oscillators was compensated by the radiation action of the other oscillators in the small volume. The Mandelstam-Planck polemics proceeded in the language of mathematical physics. Here we shall omit mathematical details.

Let us turn to Mandelstam's visual presentation, which he provided in his second paper (Mandelstam Vol. 1: 170):

> The main result of Mr. Planck's theory can be presented as follows. If a light wave is transmitted through an optically homogeneous medium, a part of the energy is scattered by the elementary oscillators. The scattered energy equals to the sum of energies which were emitted by the oscillations of each oscillator in accordance with its oscillations and by means of its radiation as if this oscillator was alone in the field. As a result, we have the attenuation which can be interpreted as an absorption.

Mandelstam (Vol. 1: 169) proceeded from the assumption that

> by the part of the force which results in the damping of an oscillating electron, this electron acts not only on itself but also on each charge which is located at a distance which is small with respect to the wavelength. This is physically obvious. Let us have two oscillators which are located within the wavelength distance. Let us give them identical but oppositely directed moments. Let them oscillate without any additional supply of energy. In this case, damping which results from radiation should be small as compared with the damping of oscillations of a single oscillator, the damping resulting from its radiation. This means that the dissipative part of the force which an electron acts on itself is compensated by a corresponding part of the force which acts on this electron due to another electron.

In the article written in reply to Planck's counter-criticism, Mandelstam wrote (Vol. 1: 170–171):

Mr. Planck predetermined optical homogeneity. He also admitted that the oscillator sizes are vanishingly small as compared with their mutual distances. Mathematically this means that the damping of oscillators results from the term:

$$\frac{2}{3\tilde{n}^3}\frac{\partial^3 p}{\partial t^3}$$

which appears in the equation of oscillations of an electromagnetic oscillator which is under the action of the external field.

I have shown that the term

$$\frac{2}{3\tilde{n}^3}\frac{\partial^3 p}{\partial t^3}$$

has only appeared due to Mr. Planck's mistake and under a correct calculation it has not appeared.

2.3. Planck's Reply. Polemics

In the same 1907, Planck replied to Mandelstam's criticism by publishing a short essay in *Physikalische Zeitschrift*. Planck emphasized that he does not agree with the cancelation of the item containing the third derivation since the "different oscillators have different (phase shifted) moments" (Planck 1907: 214):

> I can not consider Mandelstam's calculations as correct and also correct in the first approximation, namely because in them the momentum of the resonator p is taken as a function of time only, whereas the momentum p also depends on a space coordinate of the resonator.

In the second article on dispersion (1908), Mandelstam recounted the field of oscillators in another method and again concluded "that the space average electric field does not contain the item

$$\frac{2}{3\tilde{n}^3}\frac{\partial^3 p}{\partial t^3}$$

This takes place irrespective of whether the other oscillators have the same momentum" (Vol. 1: 168). And further: "Within a range small with respect to the wavelength, the field of an oscillating electron contains the constant item

$$\frac{2}{3\tilde{n}^3}\frac{\partial^3 p}{\partial t^3}$$

Thus this item does not appear in the equation connecting the field in the area of an oscillating electron with its momentum" (ibid.: 169).

> Planck reacted by the essay in which he stated that he did not understand the essence of Mandelstam's recalculation. According to Plank, what is correct in Mandelstam's article is well known, and what Mandelstam puts forward as a novelty is not understandable. "Mr. Mandelstam's model is so oblique and obscure that I cannot hope to be as successful in my meditations as I was by taking the preceding more simple model" (Planck, 1908: 282). Planck also wrote:
>
> All the principal controversy about whether it is possible to explain the scattering of light in the dispersion medium by referring to the elementary oscillators which provide dispersion, as far I understand, comes to the following.

> When higher order terms are taken into account, actually there is no scattering. This corresponds the situation that identical oscillators adjoining each other constitute the medium which can be treated as absolutely homogeneous.

Mandelstam also sharply reacted (Vol. 1: 171):

Mr. Planck objected that his equations are valid in spite of my objections. One only needs take into consideration, Mr. Planck wrote, that different oscillators have different out of phase moments. This means that the term

$$\frac{2}{3\tilde{n}^3}\frac{\partial^3 p}{\partial t^3}$$

should again appear in the equations. Mr. Planck has only designed his calculations. I have conducted this calculation by proceeding from Mr. Planck's project and I again came to my result. Besides this calculation, Mr. Planck's objections are falsified by my discussion which showed that the equations of oscillator oscillations that don't contain

$$\frac{2}{3\tilde{n}^3}\frac{\partial^3 p}{\partial t^3}$$

can be deduced in such a form which shows that the moment of other oscillations do not play a part. I do not understand the criticism directed against it by Mr. Planck.

2.4. R. Gans and H. Happel are Involved in Controversy

As was said, Planck had not published anything in reply to Mandelstam's third article on dispersion. However, Gans and Happel article "*Zur Optik kolloidaler Metallosungen*" appeared in 1909. In this article, one section was dedicated to the Mandelstam–Planck polemics. This section was entitled „The relation between the electric field strength and electromagnetic oscillatory state of metallic particles. Mandeltam's objections against Planck's theory".

Gans and Happel supported Planck's result. True, they took into consideration Mandelstam's first paper only. Gans and Happel counted that Mandelstam made a mistake when he "assumed that on average the .. oscillators are contained in some sphere irrespective whether this sphere is arbitrary chosen or whether it is the sphere in the centrum of which an oscillator is located" (Gans, Happel 1909: 291).

Gans and Happel write:

We shall show,", "that in the latter case M1 + 1, oscillators are contained in the sphere. Therefore, M1 oscillators are contained in it when the oscillator which was located in the centrum of the sphere has

been removed. As a result, the controversial term in the difference $\Xi 1 - \Xi$ disappears and Planck's result is valid" (ibidem).

Neither Mandelstam, nor his disciples who wrote his biography, reacted to the comment of Gans and Happel. It should also be noted that Gans–Happel's article had no considerable resonance in the literature.

Paul Ehrenfest (1880–1933), who lived in Russia then, wrote several letters to Mandelstam (24.5.1911, 2.6.1911, 22.9.1911, 5.1.1912, 8.11.1912). These letters were published in the book dedicated to Mandelstam's anniversary (Akademik 1979).

Ehrenfest was concerned with the Mandelstam–Planck polemics and Gans–Happel's criticism of Mandelstam's critics of Planck's theory (Akademik 1979: 55). Ehrenfest sympathized with Mandelstam's position, but he had some doubts about it. Mandelstam's replies to Ehrenfest are not known to the present author.

3. The Mandelstam-Planck Controversy from the Point of View of Soviet Physicists

In describing Mandelstam's criticism of Lord Rayleigh and the Mandelstam-Planck polemics, Papalexy unequivocally is on the side of his friend and coauthor. Landsberg took a similar position. As a matter of fact, the above quotations of Mandelstam's biography belong to Landsberg: they are literally reproduced in his paper published (Akademik 1979). It is interesting that in his textbook "Optics" Landsberg formulated his position in another way (Landsberg 1976: 518):

> «Radiation is the cause of the dissipation of energy accumulated by the oscillator, as a result of which its oscillation amplitude reaches a certain limit, and does not tend to infinity. This reason is indicated by M. Plank and called the attenuation due to radiation. It does not cause the transformation of this radiant energy into other forms of energy, but only causes the scattering of this radiant energy in all directions. Thus, the energy of a plane wave propagating in the original direction decreases.
>
> However, as L. I. Mandelstam showed, attenuation, due to scattering, is fully manifested only for an isolated oscillator. Due to the interference of secondary waves scattered by various oscillators of the medium, the attenuation of the incident wave can be largely compensated».

Landsberg's discussion of the Mandelstam-Plank controversy is present in (Fabelinsky 1968). Fabelinsky was Landsberg's student and they started to compose the book "The molecular scattering of light" together. Landsberg's death in 1957 left Fabelinsky to write this book alone.

Almost everybody who wrote about the modern history of optics followed Papalexy and Landsberg. M. A. Volkenstein in his popular books (1972: 14), S. Gorelik in his classic textbook (1950: 604), Ia. G. Dorfman in his Mandelstam biography (in the "Dictionary of Scientific Biography"), D. V. Sivukhin (2006: 517-528), D. I. Trubetskov in his book on oscillations and waves (2003) went along this line.

Yu. L. Klimontovich's excursion into the Mandelstam–Planck polemics can be treated as an exception. Together with his scientific adviser V. S. Fursov, Yu. L. Klimontovich published an article on a close subject. Klimontovich referred to H. Lorentz' article "On the question of light scattering by molecules" (1910), according to Klimontovich, Lorentz "reconciled" Mandelstam and Planck by showing that their results are valid for two limiting cases (Klimontovich 1996: 66). It should be noted that the reconciliation about which Klimontovich writes arises as a result of his reconstruction of historical events. In his 1910 article, Lorentz made no mention of the Mandelstam–Planck polemics.

3.1. Mandelstam-Planck Polemics is Represented in Soviet Literature

Above we cited authoritative books on physics. However, the Mandelstam-Planck polemics were taken into consideration in the Soviet scientific-popular literature. In these publications, the glorification of Mandelstam sometimes takes anecdotal forms. For example, in the book about "outstanding figures in natural science and technology" we find the following passage:

> Suffice it to say that after the publication of L. I.Mandelstam's work, the famous physicist M. Planck, who was then at the zenith of fame, came up with a theory of the propagation of light in matter, in which he made a mistake, incorrectly considering the interaction of individual oscillators. It took several remarks by L. I. Mandelstam to clarify the errors of the venerable author of the theory of quanta" (Essays... 1948: 5).

Here, every word is not true. It was Mandelstam, not Planck, who criticized the already published works, and it was not Mandelstam who explained Planck's mistakes, but, on the contrary, Planck showed his mistakes to Mandelstam.

A more accurate story with the polemic between Mandelstam and Planck is presented in the book by P. S. Kudryavtsev "History of Physics" (1971, Vol. 4). However, Kudryavtsev also pointed to Planck's "mistakes".

4. The Years of Democracy: Sobelman Criticizes Mandelstam

By the end of the 20th century, good circumstances for research in the history of science arose in Russia. Many archival documents became available for research; many themes which were prohibited in the Soviet Union became open. But there is another point. Many high level specialists were concentrated in the institutes of the Academy of Sciences, and under a deficit of young scientists, these specialists often turned to historical subjects. Their historical essays were published in the authoritative scientific journals.

In 2002, the head of the laboratory at the Institute of Physics (FIAN), Sobelman, published an analytical article dedicated to Mandelstam's

criticism of Rayleigh's theory of the blue sky and the Mandelstam–Planck polemics. In the present section, Sobelman's analysis of these polemics is under consideration. In the beginning Sobelman writes (2002: 85):

> When discussing the Mandelstam-Planck polemics I will endeavor to assume an unbiased attitude. I will note fallacies and inaccuracies, but in doing this I will not simplify the problems that faced the physicists a century ago. I will also try to show that the dispute between Mandelstam and Planck was actually concerned not with a particular problem of light scattering. The case in point was a controversy about whether a medium can be homogeneous despite the thermal molecular motion in the medium. Or whether a medium without fluctuations is possible, as we would put it today. But at that time the concept of fluctuations, their unavoidable and universal nature did not exist. The works of Smoluchowski and Einstein made their appearance later. Planck proved to be right in this dispute. Although he did not invoke the notion of fluctuations explicitly, the results for light scattering in gases he arrived at turned out to be the same as if he were doing all the calculations with due regard for fluctuations.

Let us reproduce Sobelman's argumentation in favor of Planck and contrary to Mandelstam (2002: 87):

> Mandelstam indeed proceeded from the presumption that a transparent medium is homogeneous. Although he does not explicitly declare it, he admits that oscillators are regularly located in space. According to him, the interaction of oscillators through their radiation fields results in the complete compensation of radiative damping.

There is no attenuation of the intensity of a light beam, and there is no scattering which would result in the attenuation. By contrast, Sobelman emphasized that Planck adopted, after Rayleigh, that independent oscillators incoherently scatter light. He constructed a theory which would give the attenuation of intensities of a light beam. He introduced fluctuations implicitly. Later on, when the concept of fluctuations was realized (Smoluchowski, Einstein), it becomes clear that scattering in rarefied gases is determined by the fluctuations of density or the number of particles, i.e., by the quantity.

But for an ideal gas, one finds that simply equals ., i.e., the number of oscillators in a unit of volume. In other words, the result arrived at is precisely the same as in the consideration of the light scattering by individual oscillators. "In the Mandelstam— Planck discussion Planck was fated to obtain the correct result. He supposedly sensed that the thermal molecular motion is bound to disturb homogeneity" (ibidem).

By reacting to Planck's objections, Mandelstam again proceeded from his treatment of homogeneity, that is from the regular spatial arrangement of oscillators. Sobelman writes (2002: 89):

> In response to Planck's criticism, pointing out that the radiation fields of the neighbors should also be included,", "Mandelstam took these into account in the subsequent papers. He carried out an extensive calculation of the radiation fields of the oscillators in the medium, but in the summation of the fields of the neighboring oscillators be made every effort to retain the homogeneity of the medium. In calculating the resultant sums, a large volume V is divided into cells, each of which contains strictly one particle. As a result, Mandelstam obtained a complete compensation for the radiative friction forces <...> No attenuation occurs due to scattering <...>

Following Klimontovich, Sobelman appealed to Lorentz' (1910) . True, in contrast to Klimontovich, Sobelman did not write that Lorentz "had reconciled" Planck and Mandelstam. Sobelman (2002: 89) writes that

> one can see from the text of the paper that the paper was a direct answer to the questions posed by Mandelstam. Lorentz gave a through derivation of the formulas which define the interaction of oscillators in the medium via their radiation fields. The resultant sums over the oscillators of the medium surrounding a given oscillator were calculated in two ways—first assuming the oscillators of the medium to be regularly distributed in space, and next for an irregular distribution. In the former case, the result he obtained is that in the absence of dissipation the $\varepsilon(\omega)$ function is real and Im $\varepsilon = 0$. In the latter case, he arrived at the result of Rayleigh and Planck.

In conclusion, Sobelman writes that his article is principally historical: "The works of Lorentz and Einstein dotted the i's and crossed the t's. The Mandelstam–Planck polemics ceased" (2002: 90). In his 1913 article which will be described in the following section, Mandelstam completely abandoned the postulate of optical homogeneity of a medium which he adopted in his articles dedicated to the criticism of Planck's theory. E. L. Feinberg (2003) in his recollections referred to Sobelman's paper. Feinberg writes about "young Mandelstam's self-confidence and his aggressiveness."

5. Ideological Presumptions

5.1. Patriotism and Progressivism

What is ideology? There are many answers to this question. W. V. O. Quine, for example, distinguished between the ideology of a theory (a set of theoretical predicates involved in the formulation of a theory) and its ontology (the domains of the predicates).

In this article, the term "ideology" is a collection of ideas and beliefs that govern human behavior. It is not necessarily an ideology proclaimed by politicians or by the church. This is an ideology that is clearly and implicitly present in society, the ideology of a nation, nationality, class, a group figure etc.

What were the motives behind those who covered Mandelstam's criticism of Rayleigh's theory and the controversy between Mandelstam and Planck? The first (on the surface) prerequisite was patriotism: Mandelstam is a representative of Soviet science, which, of course, can sometimes make mistakes, but on the whole follows the right path. Yes, Rayleigh's criticism and controversy with Planck took place in the Strasbourg period of Mandelstam's scientific career. But the Strasbourg period immediately preceded the Soviet period.

Mandelstam and Papalexy who graduated from Strasbourg University became great Soviet scientists.

The history of the Nobel Prize for the Raman effect (see above) became an important argument in favour of Soviet patriotism. The decision of the

Nobel Committee was controversial, and it was in favour of an English-speaking scientist and disparaged the contribution of Soviet scientists.

So, those who insisted on the correctness of Mandelstam in his critical speeches concerning Rayleigh and Planck, directly or indirectly turned out to be patriots of Soviet (or, as they say now, domestic) science. But behind their approach to Mandelstam's critical articles lay another idea - the idea of scientific progress. Who can be opposed to scientific progress? Slogan – "Back to the cave"? However, the idea of progress becoming an ideology presupposes a straight line in the development of science: the line of replenishment and deepening of knowledge. Of course, progressivism does not eliminate the idea of scientific revolutions. But within the framework of this ideology, scientific revolutions line up in one line.

Progressivism stands against pluralism, the idea of diversity within the development of science, the development by means of the formulations of alternatives, competitive theories, different interpretations of scientific facts. The main point is that pluralism presupposes alternative trends in the development of science.

In the Soviet scientific literature, the idea of scientific revolutions was rather popular (Lenin spoke about the up-to-date revolution in the development of science in his book "Materialism and empiriocriticism" which became a kind of Bible for the Soviet ideology). It is worth emphasizing that the sequence of revolutions formed a straight line in the Soviet literature and in the world view of most Soviet scientists.

It is interesting that even in 21st century Russia the idea of a straight line in the development of science is rather popular. One prominent figure in Russian philosophy, Academician V. S. Stepin (2011), constructed the following line consisting of four "global revolutions": the emergence of scientific ideals, the formation of the structure of science (scientific disciplines and research areas), the emergence of non-classical science, the emergence of post-non-classical science.

The present author criticized the idea of the "post–nonclassical science," which followed the "nonclassical science," which in turn replaced "classical science" (Pechenkin, 2017).

Mandelstam's biographers and people who wrote on the history of Mandelstam's ideas draw the following straight line: 1) Rayleigh's theory of the color of the sky and Planck's theory of dispersion – Mandelstam's criticism of both Rayleigh's theory and Planck's ideas – Smoluchowski–Einstein's theory of fluctuations (Mandelstam participated in this development). Fabelinsky wrote the following (1965: 9):

> the fruitful ideas of Smoluchowski on fluctuations as the cause of light scattering lay at the base of the statistical theory of light scattering developed by Einstein <... > Fluctuations not only destroy the optical homogeneity within the substance but also lead to the destruction of the mirror smoothness of the surface of a liquid or the boundary of two immiscible liquids <...>

As a result of the molecular roughness of the surface of a liquid, molecular light scattering takes place in directions different from the directions of specular reflection of the primary light beam. Mandelstam

(1913) gave the theory of the phenomenon and experimentally discovered the molecular scattering by the surface of a liquid. .

However, progressivism cracked as the Soviet Union collapsed. In Sobelman's paper another straight line is drawn: Planck's theory of dispersion, Lorentz' 1910 paper on dispersion, the Einstein theory of fluctuations.

An approach is possible, however, which differs both from Mandelstam's biographers and from Sobelman. It refers to Planck's papers, which Mandelstam held up to criticism. Within this approach, the Mandelstam-Planck polemics are not essential. "Planck's paper of 1902 is of interest because of its early date and ... because Planck derives partly the same result as Lorentz, but along rather different lines" (Van Kranendonk, Sipe 1977: 295).

Thus, several lines of development of the theory of light scattering arose.

5.2. Introjection

In the present paper, we fix the phenomenon of introjection. By introjection, we mean the introjection of the state ideology into the treatment of scientific relations and in the long run – scientific facts. More precisely, we mean the introjection of ideological language into scientific language.

The Mandelstam disciples who treated his attack of Planck's theory of dispersion were not full of belief in communism and in the happiness which communism promises to humankind and human beings. Probably some of them were very critical with respect to the Communist Party's standard slogans. Nevertheless, an ideological language was an essential part of their common sense, it was an essential part of their scientific rhetoric. The above story of the Nobel Prize for the discovery of combinational scattering of light (Raman effect) told for the fact of such rhetoric. The elucidation of the Mandelstam-Planck polemics in the Soviet scientific literature is another fact.

Let me refer to some of the characteristic expressions in the literature on Mandelstam:

> The school of physicists which arose within the Moscow period of Mandelstam's activity is remarkable not only for its brilliant penetration into physics, but also its skillful operation with contemporary conceptual technique, its concrete application, its logical thought, correct formulation of physics problems, its ability to separate essential from inessential. (Akademik 1979: 26); The complete overall clarity in the interpretation of quantum mechanics (Ibid: 52); In his lectures and seminars L. I. Mandelstam gave an exhaustive explanation of a whole range of fundamental issues" (ibid: 33).

Let me also cite some characteristic expressions which appeared in the main journal which published reviews of physical literature and program papers (*Physics Uspekhi*). I do not turn to special ideological papers, say the papers criticizing the Copenhagen interpretation of quantum mechanics (there were such papers, too). I take ordinary review papers

in *Physics-Uspekhi* (Advances in Physical Sciences): "From the very beginning he announces that he is the enemy of positivism" (1958, 66(4): 602), "he was a convinced champion of atomism" (1957 vol. 61: 7), "there is no doubt that the methods presented here have a great future" (1951 vol. 43: 158).

One more citation.

The great Soviet theoretical physicist M. A. Markov wrote the following: "Bohr can be blamed for agnosticism, for subjective idealism and especially for positivism." So, for Markov, positivism and subjective idealism were not philosophical positions. They were something to be blamed for (Markov 2010).

It should be noted that Markov was one of the non-orthodox physicists in the Soviet Union. He could allow himself to defend the Copenhagen interpretation of quantum mechanics. Nevertheless, the Soviet ideological language was the "house of being" for him, too.

Conclusion

This paper invites the reader to recall great Soviet science, with its great achievements in mathematics and physics. It is not devoted to criticism of the Soviet organization of science. Nevertheless, we try to consider events which elucidate the specifics of Soviet science, science occurring within a totalitarian society.

In the Russian historical and philosophical literature, many papers are dedicated to the attack against Mandelstam as an idealist and cosmopolitan. This attack occurred in 1948–1955 (after Mandelstam's death). Here we do not take this extreme situation under consideration.

Mandelstam was a world-class physicist. Here, however, we do not take his scientific results under consideration. We concentrate on the treatment of his research work in the scientific literature, mainly in the secondary scientific literature, namely -- in books, reviews, biographies, scientists' recollections, and meditations on the development of science... This literature is influenced by ideology. We do not mean official ideology as it is expressed in slogans, programs, and other official documents. However, there is an ideology of common sense, of ordinary language. This ideology influenced the presentation of scientific ideas in the scientific literature and the interpretation of scientific theories.

The paper shows that in a totalitarian society even a world-class physicist tends to become an "element," a "detail" of the great social and ideological engine. By recalling the world class physicists we can not avoid the pictures of the totalitarian structure. However, we equally reach the depth from which we notice the glittering existence of the talent.

Acknowledgments

The author is grateful to Mr. Joseph Leighly who helped to prepare this text for publication.

References

Akademik L. I. Mandelstam: K 100-letiyu so dnia rozhdeniya, 1979. Moscow: Nauka (in Russ.).

Essays on outstanding figures in Russian science, 1948. Moscow: GITTL (in Russ.)

Fabelinsky, I. L., 1968. *The Molecular Scattering of Light.* Springer (in Russ. – 1965)

Feinberg, E. L., 2003. *Epocha i lichnost'* (The epoch and personality). Moscow: Fizmatlit. (in Russ. There is an English version).

Gans, R., Happel, H., 1909. Zur optik der kolloidaler Medium, *Ann. Phys*. 29, S.277-300.

Gorelik, G. S., 1950. *Kolebania i volny* (Oscillations and waves). Moscow: GITTL.

Klimontovich,Yu. L., 1996. On my 1935 paper. In: *Vospominaniya ob akademike M. A. Leontoviche* (Recollections on Academician M. A. Leontovich). Moscow. P. 66-67 (in Russ.)

Klimontovich, Yu, 1982. *Statisticheskaia fizika* (Statistical physics). Moscow: Nauka (in Russ.).

Kranendonk, J. van, Sipe, J. E., 1977. Foundations of the Macroscopic Electromagnetic Theory of Dielectric Media. *Progress in Optics*, vol. 15: 245-350.

Kudriavtsev, A. S., 1971. *Istorija fiziki* (The history of physics). Moscow: Prosveshchenie. (in Russ.).

Landsberg, G. S., 1976. *Optika* (Optics). Moscow: Nauka. (in Russ., there is an English translation)

Mandelstam, L. I., 1947-1955. *Complete Works*. Vol 1-5. Moscow: Izd. AN SSSR.

Markov M.A., 2010. *On Three Interpretations of Quantum Mechanics*. Liberkom.

Pechenkin, A., 2014. *Leonid Isaakovich Mandelstam: Research, Teaching, Life*. Springer.

Pechenkin, A., 2015. Does Prigogine's Non-linear Thermodynamics Support Popular Philosophical Discussions of Self-organization. *Acta Baltica Historiae et Philasophiae Scientiarum*. Vol. 3(2): 35-52.

Pechenkin, A., 2019. *L. I. Mandelstam and His School in Physics.* 2nd edition. Springer.

Planck, M., 1902, 1904. *Sitzungsber. Konig. Preuss, Akad.* 24, 470; 24, 480.

Planck, M., 1907. Zur Theorie der Dispersion. *Phys. Z.* Bd. 8.

Planck, M., 1908. Zur Theorie der Dispersion. *Phys. Z.* Bd. 9.

Sivukhin, D. V., 2006. *Kurs obshchei fiziki* (General course of physics). Vol. 4. Optics. Moscow: Fizmatlit (in Russ.).

Stepin, V. S., 2011. *Istorija i filosofija nauki* (The history and philosophy of science). Moscow: Academic project (in Russ.).

Trubetskov, D., 2003. Vvedenie v sinergetiku (*Introducion to synergetics)*. Moscow: Nauka (in Russ.).

Sobelman, I. I., 2002. O teorii rassejanija sveta v gazakh (On the theory of light scattering in gases, *Physics-Uspekhi,* vol. 45 (1): 75-80.

Volkenstein, M. V., 1972. *Perekrestki nauki* (Crossroads of science). Moscow: Nauka (in Russ.).