

## **‘The Todorov Equation’ for the Pleasure of Thinking: Interview with Academician Ivan Todorov**

(Commented and annotated by Milena Angelova)

### **Abstract**

Interview by Ivayla Alexandrova with Academician Ivan Todorov (1933–2025), Tzvetan Todorov’s brother.<sup>1</sup> The conversation took place on October 13 2023 at the Institute for Nuclear Research and Nuclear Energy at the Bulgarian Academy of Sciences in Sofia. Acad. Ivan T. Todorov (1933–2025) was one of the most famous Bulgarian physicists. Todorov’s main scientific interests revolved around axiomatic quantum field theory, conformal field theory, and symmetry principles in quantum (field) theory. He was particularly drawn to many aspects of conformal field theory and applications of Lie group theory, Kac-Moody algebras, and quantum groups. His research also reflected a profound interest in the structural connections between quantum (field) theory and mathematics, including number theory. He was repeatedly invited to be a consultant to the Nobel Committee in the process of nominating laureates for the Nobel Prize. Among his numerous contributions, he made fundamental contributions to the axiomatic foundations of quantum field theory and conformal theories. The total number of scientific works by Acad. Ivan Todorov exceeds 250, including 11 monographs, most of which have been published by the most prestigious scientific publishing houses. He delivered lectures by special invitation in nearly 30 elite world scientific canthers, and reports at dozens of the most authoritative international conferences and symposia. Acad. Todorov received numerous awards and distinctions during his lifetime. In 2014, he published an autobiographical book *Science, Personalities, Experiences*. In this interview, Ivan Todorov spoke from his own life experience about the intersecting effects – on his chosen research topics, methodological approaches, the enriching people around us, and “the pleasure of reflection”.

<sup>1</sup> Footnotes, references and title were added by Milena Angelova.

**Ivayla Alexandrova:** Let's start with your father – Todor Borov<sup>2</sup>, pseudonym of Todor Tsvetanov Todorov, the great Bulgarian bibliographer. He studied in Berlin. For 20 years he was director of the Bibliographic Institute, from 1944 to 1949 he was director of the National Library. He authored books. He was involved in the unpublished manuscripts of Yana Yazova, he had personal connections with Elin Pelin, with Professor Alexander Balabanov, with Anton Strashimirov, Yosif Herbst, Hristo Yassenov. A human encyclopaedia.

**Ivan Todorov:** He was officially director of the Bibliographic Institute from April 1945, before that he wrote a book "Why do we need a Bulgarian Bibliographic Institute?" (Borov 1941), but at the Institute you say that it was 20 years ago, before that it was a dream for years to maybe have a Bibliographic Institute. He started the Bibliographic Institute at 15 Khan Krum Street – the house in which we lived since the beginning of the war, somewhere in 1940 or 1939, we were there from the time before the bombings. But officially, as an institution, the Bulgarian Bibliographic Institute came later, shortly before my father became director of the National Library. His relationship with Alexander Balabanov<sup>3</sup> was closer than with the others you listed. Alexander Balabanov was the best man of my mother and father and the godfather of me and my brother Tzvetan. He was sad that we were named after our grandfathers, I was named after our mother's father, Ivan (Peev Plachkov), and my brother was named after our father's father, Tsvetan (Todorov). He was sad because none of us are named Alexander (Laughs), none of us bear his name. And my father suggested to Tzvetan, my brother, to name his son Alexander, so he has a grandson Alexander.

**IA:** Tell me in detail about your father's relations with these people, with Elin Pelin, with Yana Yazova, about Todor Strashimirov and about Yosif Herbst...

<sup>2</sup> Todor Borov (1901–1993) was an eminent bibliographer. He initiated the establishment of the Bulgarian Bibliographic Institute and was his director. He teaches Librarian Studies and Bibliography at Sofia University, and has supported the development of a number of bibliographies. T. Borov created his own specific research method, based on a combination of bibliographic and textological research, a unique and clear genre in Bulgarian humanitarian sciences, which stand for 'a critical-bibliographic study'. See: Янакуева (2010).

<sup>3</sup> Alexander Balabanov (1879–1955) was a classical philologist, literary historian, translator and public figure. He graduated in classical philology in Leipzig and Erlangen (1898–1904). In 1907 he was a playwright at the National Theatre. From 1908 he was a lecturer in classical literature and philology at Sofia University. He translated texts from Aesop, Sappho, Anacreon, Aeschylus, Sophocles, Euripides, Aristophanes, Plato, works by Verlaine and Goethe's Faust, etc. Founder of the newspaper Razvigor (1921–1927). Author of the books: "History of Classical Literature", "The Cloud as a Motif in Poetry", "Love and Poetry", "I Am in This World", "The Balkan Slytherin". See: Georgieva (2019).

**IT:** Herbst<sup>4</sup>, in particular, was killed before we were born and I have very few personal memories of those connections. Elin Pelin was alive and I have heard more about him. These are memories from 80 years ago. My father edited Elin Pelin’s works and this continued with subsequent editions, even after Elin Pelin’s death. I can convey somewhat disparate memories from different times, from when my father told me something.

First, let me tell you that his pseudonym, “Borov”, was suggested by Elin Pelin when they were publishing the literary magazine *Razvigor*<sup>5</sup>, which Balabanov had started. Once in the editorial office there was a discussion about my father having a pseudonym, at that time he was still a philology student, and that’s how I remember it – Balabanov said: “It’s good to have a pseudonym...” My father started thinking and Elin Pelin said: “Borov!...” (Laughs)

I wasn’t with my father when he met with Elin Pelin. What I remember is what was passed down, things my father told me. Elin Pelin’s early works, up until the First World War, are his true classics. At home, people talked about the story “Nane Stoichko’s Willow”. Later I realized that it was also one of the early ones (1912), but Elin Pelin returned to it in the 1930s and often chose it for readings as an author. My father told me how the three of them were with Balabanov, and Elin Pelin started talking about Nane Stoichko. My father loved to talk, and when he started to say something, Balabanov kicked him under the table – listen! It was a rare occasion when Elin Pelin had the urge to say something about how he saw something he was writing about! I remember that.

**IA:** And did he talk about the Tsar?

**IT:** About the Tsar?<sup>6</sup> First of all, my father did not know the Tsar. Elin Pelin and Balabanov both did. I have heard my father say that the Tsar had noted, and had told Balabanov, not directly to my father, that Elin Pelin presented a not very joyful picture of the kingdom. In general, if something specific should be said, it does not come to mind, but the general impression is – the Tsar was spoken of with sympathy. My knowledge of him is not only from home, of course,

<sup>4</sup> Joseph Herbst (1875–1925) was Bulgarian journalist and translator. Herbst, who apparently associated with leftist circles in Bulgaria, was killed in 1925.

<sup>5</sup> *Razvigor* was a literary newspaper published in Sofia in 1921–1927 and in 1937. The newspaper was founded by Alexander Balabanov. Its editors were Elin Pelin, Dimitar Mitov, Todor Borov, Georgi Tsanev and Alexander Paskalev.

<sup>6</sup> Boris III of Bulgaria (1894–1943) was the Tsar of the Kingdom of Bulgaria from 1918 until his death in 1943.

so what I can say about the Tsar will not be a precise reflection, it is difficult for me to distinguish from the earliest years, after all I was a boy who was interested in what was happening. When the Tsar died there was a great pilgrimage to Alexander Nevsky cathedral. But since it is about impressions related to my father, I think it is better to stop there.

I have seen Yana Yazova<sup>7</sup> at most once or twice. But I knew her sister. Nikola Balabanov<sup>8</sup>, brother of Prof. Alexander Balabanov, was an actor. Before we moved to Khan Krum Street, we lived on Fritjof Nansen Street, opposite the current National Palace of Culture. There were 12 Balabanov brothers and Nikola Balabanov was one of the younger ones, with a big age difference with Alexander Balabanov. Nikola Balabanov read children's stories on Radio Sofia and I had listened to him. And then we lived in the same apartment building. He was married to Mila, Yana Yazova's sister. So, I have seen and have an image of sister Mila many times. A slender, nice woman. And of course, I have seen photos of Yana Yazova, and it is difficult for me to separate what I have heard since. But I think I also have a memory of her. Later I realized that she was close to Alexander Balabanov, he praised her and tried to introduce her to writers, to give her opportunities.

**IA:** Alexander Balabanov was the connection with your father. But Todor Borov also collects the works, the poems of Smirnenski?

**IT:** Here we are changing the subject. With Smirnenski<sup>9</sup> also, my father was close and with his brother, Toma Izmirliiev, I would hear his name all the time. My father also edited the early editions of his poems and I have known and heard Smirnenski's work since childhood. We were also friends and neighbors – our villas next to each other in

<sup>7</sup> Yana Yazova was the pen name of Lyuba Gancheva (1912–1974), a Bulgarian writer and intellectual. She was born in Lom and received a Master's degree in Slavic philology from Sofia University in 1935. Gancheva also studied French philology at the Sorbonne. She published a historical drama *The Last of the Pagans* and a novel *The Captain* in 1940. From 1942 to 1943, she co-edited the children's magazine *Blok* with Nikola Balabanov, brother of Prof. Alexander Balabanov, her sponsor and lover. Later in life, she was pressured to write poetry promoting communism but she instead chose to become a recluse. She was found murdered in her home in Sofia in 1974. See Велучков (2007).

<sup>8</sup> Nikola Balabanov (1898–1969) was an actor at the Plovdiv and Rousse Theaters, at the Free Theater in Sofia, at the Renaissance Theater, and from 1923 – at the National Theater. In the period 1922–1952 he participated in various Bulgarian films – *Under the Old Sky* (1922), *Merry Bulgaria* (1928), *The Song of the Balkans* (1934), *Gramada* (1936), *Under the Yoke* (1952), etc. N. Balabanov was the husband of the lawyer Mila Gancheva – sister of Yana Yazova.

<sup>9</sup> Hristo Izmirliiev (Smirnenski) (1898–1923) was a Bulgarian poet and prose writer whose works championed communist ideals. He died at the age of 24 from tuberculosis.

Boyana, with Hadzhiev<sup>10</sup>, the publisher of Hemus, where the works of both Elin Pelin and Smirnenski were published.

During the bombings<sup>11</sup> we were in Boyana. There was still no running water at the villa there, we carried jugs and demijohns from a fountain on the road above our place. It was cramped when, because of the bombing, their siblings and their children gathered in the small house, built and not quite finished at the beginning of the war. It was difficult for our parents, but we, the children, were happy to have company. But I have some memories of the bombings later on. I remember quite a few things, I will tell them in sequence.

The first major bombing was on 10/01/1944, but already there had been one at the railway station in the fall of 1943. The planes came and they were not that accurate, the station remained intact, but one bomb fell on Asparuh Street, near our house, and everything shook. It was a night bombing and we were a bit scared. I never went to a hiding place. Our parents went without us when we moved to Boyana. During that night bombing, our family got on the move, we, the children, stayed in bed. However, the shaking was terrible. And then our family decided to go to Boyana, although living conditions in the winter there were not especially comfortable, but we moved there.

The next experiences were two major bombings. Our family was in Sofia and we were waiting for them to return. I have no memory of January 10 1944, but on March 30, a major bombing followed, when they set Dondukov Boulevard in Sofia ablaze. You could see the city – it was all in smoke and flames. The night bombings were a spectacle – searchlights shining upwards, trying to catch the planes, the fires. Then there was a bombing the night before, on March 29, at night. We were all in Boyana at the villa. And the next day our family went down to the city to see if our house was intact, to see what had happened. People had been evacuated, but our family went down there. And the bombing began during the day. This is what I remember: The city in smoke, flames, you saw from above

<sup>10</sup> Hristo Hadzhiev (1876–1952) was the co-founder, editor and long-time director of the Hemus Publishing House, founded in 1918. Hemus was the most significant book publisher in Bulgaria in the years between the two world wars. The publishing policy of Hemus gradually developed a tendency to publish Bulgarian authors at the expense of translated literature. In 1947, the publishing house was nationalized.

<sup>11</sup> The Bulgarian capital Sofia suffered a series of Allied bombing raids during World War II. In August 1943, British Prime Minister Winston Churchill and US President Theodore Roosevelt launched Operation *Tidal Wave*, the aim of which was to neutralize Germany's allies – Romania and Bulgaria – and force them to capitulate.

Systematic bombings begin over the territories of both countries. From 14/11/1943 to 17/04/1944, 11 air raids were carried out over Sofia. See Gigova (2011).

from the villa. The bombing ended, the sirens sounded to signal the end of the bombing, when the planes had left. Hours passed and no one came, our people did not return. It was just me and my brother – in 1944 I was 11 years old, my brother was 5. Our neighbours, the Hadzhievs, lived across the road, they invited us in, so that we would not be on our own. Many hours passed after the end of the bombing, there was no one. After the bombing, no trams were running. We understood that even if nothing terrible had happened, there was a reason for them to be late, because the transport was damaged. Anyway, we sat, and I do not really remember what I was thinking at the time. Our people eventually came and my mother told me that they had seen us from the windows, coming along the road, that I had been walking back and forth (smiles) – this is how I expressed my anxiety. Not to cry, not to think the worst, but to pace in silence. Tzvetan was probably already asleep, about him I can't say, but this is a memory from the bombings.

**IA:** You mentioned the name of your brother, Tzvetan Todorov, who defines himself as a literary critic and theorist, his philosophical reflections on self-determination are of great importance for anthropology and sociology. Tell us about things from the inside? As far as you know. He went to live in Paris, were you separated?

**IT:** Yes, he went to live in Paris in 1963, at a time when I was not in Bulgaria, I was in Dubna<sup>12</sup>, in the then Soviet Union. I had been there since January 1958. I graduated from Sofia University in 1956. After that I was appointed to the then Physics Institute at ASEB (Atomic Scientific and Experimental Base). This was the time after the 20th Congress<sup>13</sup> with Khrushchev's at the time unpublished report. Then the Institute for Nuclear Research and Nuclear Energy (INRNE) of the Bulgarian Academy of Sciences was founded and one of my professors, Prof. Hristo Hristov<sup>14</sup> (later, academician), became director when

<sup>12</sup> Dubna is a town in Moscow Oblast, Russia. It has a status of *naukograd* (i.e. town of science), being home to the Joint Institute for Nuclear Research, an international nuclear physics research centre and one of the largest scientific foundations in the country. The town of Dubna was officially inaugurated in 1956, together with the Joint Institute for Nuclear Research (JINR), which has developed into a large international research laboratory involved mainly in particle physics, heavy ion physics, synthesis of transuranium elements, and radiobiology. In 1960, a town of Ivankovo situated on the opposite (left) bank of the Volga was merged into Dubna. It is also home to MKB Raduga, a defence aerospace company specializing in design and production of missile systems, as well as to the Russia's largest satellite communications centre.

<sup>13</sup> The 20th Congress of the Communist Party of the Soviet Union was held during the period 14–25 February 1956. It is known especially for First Secretary Nikita Khrushchev's "Secret Speech", which denounced the personality cult and dictatorship of Joseph Stalin. See: Smith (2017).

<sup>14</sup> For more on the founding of the Institute in Sofia and the role of Prof. Hristo Hristov, see Hristov (2014).

the Institute was founded and came here. Already from my student years, Professor Hristov paid attention to me and I owe a lot to him. I think that the establishment here of a good theoretical group, which is attributed to me, started with him and that was important. Not everyone who showed talents and abilities was given a chance. I am one of four academicians of that time, that's how many of us were – three plus one, who were not members of the communist party. There was Rostislav Kaishev<sup>15</sup> – in physics and chemistry, Ivan Kostov<sup>16</sup> – a geologist, I was the third, then Blagovest Sendov<sup>17</sup> – the mathematician, he was also not a member of the Party. He was being patronized and was a friend of Todor Zhivkov, but this was thanks to his activity related to computers and his professional activities. He was appreciated and approached. He was professional and among the professionals, he managed to inspire confidence in himself among those in power, but he was not an *apparatchik*.<sup>18</sup> I mean that that was rare. Far from often, but... Here there were such local oases where something could still be done, and they depended on people with positions, ready to accept capable collaborators – rare bosses who were not afraid that one of the young people they raised might become their rivals.

You asked me a completely different question, I digressed. Let me get back to Tzvetan. So, it was just then that Professor Hristov, at the newly opened Institute, sent me on a secondment to Dubna. A hundred and fifty kilometres, somewhere north of Moscow, the new Joint Institute for Nuclear Research was created, which all socialist countries joined. I went there in January 1958, thanks to the recommendation and decision of Professor Hristov. The thing is, in 1958 I was away for a long time. At first it was for two years, but then the work went well and they asked the Institute for extensions. And it ended up that I stayed for 10 years and then I kept my connections, I went for a month at a time. By the mid-1960s,

<sup>15</sup> Rostislav Kaishev (1908–2002) was a Bulgarian physicochemist and a member of the Bulgarian Academy of Sciences. His most significant contributions to science were in studies of crystal growth and nucleation.

<sup>16</sup> Ivan Kostov Nikolov (1913–2004) was a Bulgarian geologist, mineralogist and crystallographer.

<sup>17</sup> Blagovest Sendov (1932–2020) was a Bulgarian mathematician, diplomat and politician. Sendov was the rector of Sofia University, and the Chairman of Bulgarian Academy of Sciences. He had more than 200 articles in fields related to mathematics and computer science.

<sup>18</sup> An *apparatchik* (Russian: *аппаратчик*) was a full-time, professional functionary of the Communist Party of the Soviet Union or the Soviet government *apparat*, someone who held any position of bureaucratic or political responsibility, with the exception of the higher ranks of management called *nomenklatura*. James Billington describes an *apparatchik* as "a man not of grand plans, but of a hundred carefully executed details" (Billington 2017).

the Soviet Union had opened up more to Western scientists, there were conferences and visits to Dubna, there were many acquaintances and I received an invitation, I even received two invitations at the same time – I had to choose. From the United States, from Princeton, from the Institute for Advanced Study at Princeton University. The man we spoke with in Dubna was a very bright person – an Italian, Tullio Regge.<sup>19</sup> He had experienced polio or something else, he was tall, a big person, but he had difficulty walking. At that time, he was not yet walking with crutches, but you could see that he was walking unsteadily. He had a sense of humour, had broad interests, he was a permanent member of the Institute for Advanced Study in Princeton, he had recommended me and I was invited there. At the same time, a French theoretical physicist, Louis Michel<sup>20</sup>, whom I had met in 1966 in Moscow at the Congress of Mathematicians, invited me to the Institute for Advanced Study in Bures-sur-Yvette, near Paris. And I preferred to go to France first and postponed my trip to the United States. My first trip was actually to Trieste – where an International Centre for Theoretical Physics (ICTP) had been created. Its founders were the Trieste physicist Paolo Budinich<sup>21</sup> and Abdus Salam<sup>22</sup> (from Pakistan, professor at Imperial College, London). ICTP became a centre for theoretical physics for the “Third World” – that was the term at the time – India, Pakistan, North Africa, and so on. But at the same time, because the doors were opening and the Iron Curtain was starting to crack, they very soon gave people from socialist countries the opportunity to go too. So, my first such month-long trip to the West was to Trieste, in 1966. It’s also close, you can go by train.

**IA:** And when did you see your brother? In what year?

**IT:** Exactly when going to Trieste in 1966. And he went to France in 1963. He was born in 1939 and graduated here (Sofia University) in 1961. Then he was assigned to be a teacher in the village of Dulgopol, Varna district. He was there for a year and retained good feelings about his students. They phoned him, some of them went to France and saw

<sup>19</sup> Tullio Eugenio Regge (1931–2014) was an Italian theoretical physicist known for his introduction of geometrical principles to the formulation of what have come to be called “Regge poles” and the “Regge calculus,” a simplified form of general relativity. See: (Castellani et al. 2019).

<sup>20</sup> Louis Michel (1923–1999) was a French mathematical physicist at the *Institut des Hautes Études Scientifiques* (IHÉS). His name is associated with Michel parameters describing the phase space distribution of leptonic decays of charged leptons, the Bargmann–Michel–Telegdi equation describing spin evolution in a magnetic field, and the Michel–Radicati theory for the SU(3) octet.

<sup>21</sup> Paolo Budinich (1916–2013) was an Italian theoretical physicist.

<sup>22</sup> Mohammad Abdus Salam (1926–1996) was a Pakistani theoretical physicist. He shared the 1979 Nobel Prize in Physics with Sheldon Glashow and Steven Weinberg for his contribution to the electroweak unification theory.

him. In the fall of 1962, before he left for France, in November my first son was born, my only son in fact, Todor – named after my father. He now lives in America with his mother, from whom I am separated.

The first memory of the time before Tzvetan left is orders, correspondence on the occasion of the birth of the child. Because at that time my wife – her name was Lyudmila, was giving birth in Sofia. I was in Dubna. There was a misfortune with a birth before that, when the first child, a girl, was to be born in Dubna. The child died at birth... the first misfortune. Then we decided that the second birth should be in Sofia, her brother was a doctor and under better conditions... That explains why we were separated. They had ordered me from Dubna, from Russia, to buy a stroller. And I remember that my brother sent, I don't know if it was a telegram or a card: "No, don't buy a stroller!" – there was a belief that one shouldn't buy one before the child was born. Just like now, I don't accept congratulations on my 90th birthday before it's here (Laughs). There was and is the announcement on the door – we held a seminar because my people wanted to celebrate my big anniversary. I said that it would be better if they celebrated the anniversary of the seminar that we started here. About it I think, I have a feeling, that it is my most significant work. It is every Thursday and continues today at the same time. And now I attend, but I can't see well and I can't really take part anymore, except when I'm speaking about something...

**IA:** Can you tell me something else about your brother? I had a small personal contact with him by phone. He came here to Bulgaria secretly, and he went to the seaside, to Sozopol. Because they were friends with Vesselin Branev<sup>23</sup>, and we were friends too, and Vesko had given me your brother's phone number. I called him, I wanted to do an interview, I was ready to go to Sozopol. He said: "No. Please, don't say I'm here!..."<sup>24</sup>

<sup>23</sup> Veselin Branev (1932–2014) was a Bulgarian film director, screenwriter, film critic and writer. In 1983 he made his directorial film debut with *Hotel Central*, which was entered into the competition at the 40th Venice International Film Festival to large critical acclaim. In 1997 he moved to Canada, where he mainly focused on his literary activity. He is the author of the semi-autobiographical novel *Sledeniyat chovek* ("The tracked man") (2007). See: Luca (2015)

<sup>24</sup> IA: A week after my interview with Acad. Ivan Todorov, on October 18, 2023, during the Ninth International Film and Literature Festival Cinélibri, the film performance "*Bulgaria in Me*" was held at the French Cultural Centre. Lea Todorov, the daughter of Tzvetan Todorov, as a screenwriter and director, presented an emotional film performance with texts, archives and videos, which she dedicates to her father and his ambivalent relationship with his native country. In 2014, three years before his death, he asked his daughter to film one last journey: "A journey together through an unknown country. The one who left communist Bulgaria 51 years ago and who is returning with such difficulty..., as if he is afraid of meeting his distant double there. The double he would have become if he had stayed in this totalitarian state." Film footage shot by his daughter, shown at this performance, confirmed this visit to Sozopol.

**IT:** He once came without calling first, to us, in Sofia, and he saw Toncho Zhechev.<sup>25</sup> I think it was in Shoumen district, somewhere there, Toncho's village...

**IA:** I can't tell you the exact year, I didn't make a note of it. But let's continue with the seminar.

**IT:** So about the seminar... Of course, no one thought of compiling an archive, but I found such a pile of notebooks, they are hardly all, where I took notes from the reports presented.

**IA:** How nice that you have such an archive. And I know that you also have the correspondence with Blaga Dimitrova?<sup>26</sup>

**IT:** Yes, that was in the later years. I saw Blaga Dimitrova many times, that was in my father's later years, they often went with Dancho (Yordan Vassilev<sup>27</sup>), her husband, to Boyana, to the villa, and I was present at the conversations. They talked about everything – about literature, about politics, about what was happening in the world.

**IA:** I have read the poem by Konstantin Pavlov<sup>28</sup> that he dedicated to you? So you were close to him too? He did not allow everyone to get close to him.

**IT:** Yes, I must admit that I was pleasantly surprised when this poem that Kotseto dedicated to me came out, because we hardly knew each

<sup>25</sup> Toncho Zhechev (1929–2000) was a writer, literary critic, and humanitarian. His most popular work, *The Bulgarian Easter or the Passions of Bulgaria*, appeared in 1975. In the essay *The Bulgarian Ulysses and the Truth about his Homecoming* (1985), he developed a controversial view of the Bulgarian national character based on the famous poem *The Spring of the White-Footed Girl* by Petko Slaveykov. Zhechev makes a remarkable novelistic debut with the book *The History and Theories of a Pygmalion* (1983).

<sup>26</sup> Blaga Dimitrova (1922–2003) was a poet, writer, and Vice President of Bulgaria (1992–1993). In the 1970s, her works became more critical of the communist government, and she received reprimands for not being politically correct. Four of the poetry books Dimitrova wrote in the 1970s – *Fireflies Fading*, *Rubber Plant*, *Questions*, and *Hobbyada* – were all rejected by state publishing houses with no specific reason given. She wrote 27 poetry books, eight novels, four plays, essays, travelogues and non-fiction (memoirs, biographies and literary criticism).

<sup>27</sup> Yordan Vassilev (1935–2017) was a Bulgarian literary critic of 15 collections, including two books for Bagryana, co-authored with Blaga Dimitrova. He was chairman of the National Democracy Club, as well as a deputy in the 7th Grand National Assembly and in 36 National Assembly, where he was elected chairman of the National Security Commission. As a member of the "group of the 39's," he refused to sign the new constitution (1991).

<sup>28</sup> Konstantin Pavlov (1933–2008) was a screenwriter and poet. His first two books, *Satires* (1960) and *Poems* (1965), were confiscated by the communist authorities before they reached the public. For more than twenty years, Pavlov was banned from publishing and his poems circulated only clandestinely ("Samizdat") in privately copied form. At the end of the seventies, the communist apparatchiks relented somewhat and allowed him to write screenplays for the state film industry (but no poetry). Several of his screenplays were filmed and in 1980 he was granted the Grand Prix at the Karlovy Vary film festival for his screenplay of the film *"Illusion"*. In 1983 *Old Things*, his third volume – screenplays and poems – appeared. It provoked another ban that lasted until the fall of communism in 1989, after which he was finally able to publish nine volumes of poetry and five plays. His collected works in four volumes appeared in 2002. See: Дойнов (2009).

other in reality, we knew each other in absentia. We went together once, they had a house near Pavlovo. We went a few times, my father was there too. Rather, my wife, she had a closer acquaintance with Mimi Pavlova – through the dog route (Laughs). He mentions this big dog, which also went into his poetry. Boryana, my wife, had some friendly dog left to look after. We didn’t even have private conversations with him. His liking, or rather our mutual liking, was all more in absentia, through mutual acquaintances. The first poems of his that I read were typewritten copies of his poems, including “Five Old Men”. So, this is more at a distance, from shared close friends and acquaintances. This is the truth. If it had been closer, I wouldn’t hide it.

**IA:** Let me take you back a little: How did you choose the mathematical quantum field theory? Why did you choose it?

**IT:** Back in junior high school, right after the bombings, I went to school at Denkoglu.<sup>29</sup> We were there for a year or so and when the bombings started there was no school, and we took an equivalency exam. I went to junior high school in 1944. There was a teacher there who I remember – Lambreva. Apparently, she encouraged extracurricular activities, gave us topics to talk about, and I chose to talk about Marie Curie. So, my very first acquaintance with physics was from a junior high school report that I gave at the age of 12 about Marie Curie.

**IA:** How it is predetermined and how a person somehow intuitively knows where he will go...

**IT:** Yes. In my case, this continues to the book you saw (Todorov 2014). My interest in science has always been intertwined with my interest in scientists who do science, and that is why I still follow the archives on the history of physics and the history of mathematics. Then there was Vetrenska – the physics teacher at the Second Boys’ Gymnasium, who aroused liking among the students. She was relatively young, behaved in a sharp and interesting manner, and we tried to “shine” in front of her, so to speak. At the same time, in the Second Boys’ Gymnasium, I also had events and acquaintances with good old Bulgarian and history teachers – in history it was Andrey Tsvetkov, in Bulgarian it was Barova. She was an old teacher and there was a moment when I could have followed in the footsteps of my father and mother – they were fellow students, they graduated in philology. I think the fact that

<sup>29</sup> Ivan Denkoglu School, founded by the generous patron Ivan Denkoglu (1781–1861), is the oldest modern secondary school in Sofia.

the humanities were politicized at the time also played a role, while physics, mathematics and mental pursuits (chess, for example) did not require quotes from Marx. In any case, my father did not try to impose anything on me, but if he said anything at all at that time, he approved of my going into the exact sciences. He thought maybe I should do astronomy, something abstract, because I was distracted, not noticing what was going on around me.

**IA:** In 1956, you defended your thesis under Yaroslav Tagamlitsky.<sup>30</sup> In your book, you wrote that he began his first lecture with number theory from the point of view of the concepts used and with Euclid's theorem, which states that there is no greatest prime number.

**IT:** Yes, I will tell you. I mentioned Hristo Hristov, as my first supervisor in scientific work and as a professor of theoretical physics, who was my patron and helped me, but my first teacher in higher education was Tagamlitsky. It was not in order and normal for a physicist – I think I was the only one in our course – to defend a thesis in pure mathematics. I needed special permission – they gave it to me. Tagamlitsky was a born teacher. A man who loved students, loved to discover who among them was capable. At that time, the lectures were in huge auditoriums, because they had decided that they needed mathematicians in Bulgaria and were accepting 400 students, too many. Most of them were weak students and had no real interest, but the easiest major to get into was Mathematics. I was in Physics, but the courses were general and although we were divided into two streams, it was in the largest auditorium, 22, in the then new northern wing of the central building of the University. A huge auditorium, the lectures were early, it was cold. A large course, a load, with exams, there were also exercises, there weren't many assistants then. And the first lecture, I've described it. At the end of each lecture, he regularly gave assignments. There were three assignments for everyone to solve and one more difficult one, which was not mandatory for everyone, but if anyone wanted to, they could try to solve it. I was among those few people who tried to solve the optional assignments. And the professor, in this way, from the huge course of 200 people, already identified a few people, maybe five to six people, whose names he learned, sometimes

<sup>30</sup> Yaroslav Aleksandrovich Tagamlitsky (1917–1983) was a Bulgarian mathematician of Russian origin. Since 1954 he has been a professor of differential and integral calculus at Sofia University, and in 1961 he was elected a corresponding member of the Bulgarian Academy of Sciences. See: Virtual Museum Mathematics and Informatics in Bulgaria. [http://mmib.math.bas.bg/?page\\_id=602](http://mmib.math.bas.bg/?page_id=602)

called us up to the board and very soon invited us to a circle, in extracurricular time to get together and he set us tasks. And now I am amazed at this man who had one or two assistants, and he collected 400 works, from which he separated those with tasks and himself was responsible for them. He lived this way, he was passionate about this. I will tell a slightly longer story here, it is important. I will shorten it at the end. When we were already graduating, the last year, so it was in 1956, an International Conference was held in Bulgaria, at which from the Soviet Union there was a famous mathematician Sergei Lvovich Sobolev<sup>31</sup>, from France there was an elderly mathematician – Danjoy (Arnaud Denjoy<sup>32</sup>). I had a role, besides giving reports like the other circle members, I translated the French reports from French (I had studied for a year at the French College before it was closed).

**IA:** Prof. Tagamlitsky actually made the transition at Sofia University from intuitive to rigorous modern mathematics, did he carry out a “coup”?

**IT:** Yes, because his predecessor at the Department of Differential Integral Calculus was Kiril Popov<sup>33</sup>, older brother of Metodiy Popov, also a famous biologist and anthropologist. Kiril Popov was a little deaf in his old age and he taught according to the old system. I have listened to and seen him outside of lectures, and Tagamlitsky started with us, and indeed his lectures were rigorous, we learned clear logical thinking. There is a danger that a person, if he teaches logically flawlessly, will lose understanding. Tagamlitsky made an effort to convince us that he needed proof. He was born a teacher to teach students who are ready to take on something and learn. At that time, it seemed like there were more such students. Now the biggest misfortune in Bulgaria is

<sup>31</sup> Sergey Lvovich Sobolev (1908–1989) was a Soviet mathematician working in mathematical analysis and partial differential equations. Sobolev introduced notions that are now fundamental for several areas of mathematics. *Sobolev spaces* can be defined by some growth conditions on the *Fourier transform*. They and their embedding theorems are an important subject in *functional analysis*. Generalized functions (later known as *distributions*) were first introduced by Sobolev in 1935 for *weak solutions*, and further developed by Laurent Schwartz. Sobolev abstracted the classical notion of *differentiation*, so expanding the range of application of the technique of Newton and Leibniz. The *theory of distributions* is considered now as the calculus of the modern epoch. See: Kerimov (2009).

<sup>32</sup> Arnaud Denjoy (1884–1974) was a French mathematician who did outstanding work on the functions of a *real variable*. Denjoy combined topological and metrical methods to attack problems of real analysis. In 1934 he wrote that his greatest achievements had been the integration of derivatives, computation of the coefficients of a converging trigonometric series, a theorem on quasi-analytic functions and differential equations on a torus. See: Choquet (1975).

<sup>33</sup> Kiril Popov (1880–1966) was a Bulgarian mathematician who is best known for his contributions to the fields of ballistics and thermodynamics.

that we have, that we always continue to have, it seems that the Slavs, if I may say it a little racist, are capable of mathematics, there are disproportionately many Bulgarians, Russians, and Poles who excel in mathematics. And so far, Bulgaria has been taking one of the first places in mathematical Olympiads for students, for years. But these boys and girls, after their last year of high school, don't even enrol, they just go straight to American educational institutions, there are people who propose this to them... And they disappear...

**IA:** And then? In your book you write about the same Professor Tagamlitsky, about his disappointment when he realized in 1956 that his generalized Cone Theorem was a consequence of the well-known theorem of Odessa mathematicians Crane and Milman about extreme points? I don't want to focus on that, it is described in the book we mentioned. I just want to ask: How is it discovered in your science? I have the feeling that it is something extremely complicated. Because such disappointment has happened to others, for example, to Pasquale Jordan<sup>34</sup>, who is also one of the famous, among the biggest names – Heisenberg<sup>35</sup>, Born<sup>36</sup>, Dirac<sup>37</sup>, Pauli<sup>38</sup>, Schrödinger<sup>39</sup>...

<sup>34</sup> Ernst Pascual Jordan (1902–1980) was a German theoretical and mathematical physicist who made significant contributions to quantum mechanics and *quantum field theory*. He contributed much to the mathematical form of matrix mechanics, and developed canonical *anticommutation relations for fermions*. He introduced *Jordan algebras* in an effort to formalize *quantum field theory*; the algebras have since found numerous applications within mathematics. See: Jones (2008).

<sup>35</sup> Werner Karl Heisenberg (1901–1976) was a German theoretical physicist, one of the main pioneers of the *theory of quantum mechanics* and a principal scientist in the German nuclear program during World War II.

<sup>36</sup> Max Born (1882–1970) was a German-British theoretical physicist who was instrumental in the development of quantum mechanics. He also made contributions to solid-state physics and optics, and supervised the work of a number of notable physicists in the 1920s and 1930s. Born shared the 1954 Nobel Prize in Physics with Walther Bothe for his fundamental research in quantum mechanics, especially in the statistical interpretation of the wave function.

<sup>37</sup> Paul Adrien Maurice Dirac (1902–1984) was an English mathematical and theoretical physicist who is considered to be one of the founders of quantum mechanics. Dirac laid the foundations for both *quantum electrodynamics* and *quantum field theory*. He was the Lucasian Professor of Mathematics at the University of Cambridge and a professor of physics at Florida State University. Dirac shared the 1933 Nobel Prize in Physics with Erwin Schrödinger for the discovery of new productive forms of atomic theory.

<sup>38</sup> Wolfgang Ernst Pauli (1900–1958) was an Austrian theoretical physicist and a pioneer of quantum mechanics. In 1945 Pauli received the Nobel Prize in Physics for his contribution through his discovery of a new law of Nature, the exclusion principle or "*Pauli principle*". The discovery involved *spin theory*, which is the basis of a *theory of the structure of matter*. To preserve the conservation of energy in beta decay, he posited the existence of a small neutral particle, dubbed the *neutrino* by Enrico Fermi, detected in 1956.

<sup>39</sup> Erwin Rudolf Josef Alexander Schrödinger (1887–1961) was an Austrian-Irish theoretical physicist who developed fundamental results in quantum theory. In particular, he is recognized for postulating the *Schrödinger equation*, an equation that provides a way to calculate the *wave function* of a system and how it changes dynamically in time. Schrödinger coined the term *quantum entanglement* (1935).

**IT:** Well, there is a difference here. Jordan was slightly ahead of Dirac, but they were contemporaries. He gave one work to his teacher Born and he forgot it in his suitcase and during that time others published the same thing. But this was a kind of genteel rivalry. Tagamlitsky worked alone, he was enthusiastic about his own discovery, and it provided food for good problems that were within the power of good students. And this was his circle. He made interesting applications of the endpoints. If you think of a pyramid, each point of it can be represented as a combination of its edges, the edges are the endpoints, and if we want to understand something about each point of the pyramid, it is enough to check it for the endpoints. But then I don't know how it happened, whether he read and came across or rather saw something quoted. And he was somehow a maximalist, he had applications that were fresh, others had not thought of them, and his works were noticed. He received a letter from a renowned mathematical publishing house in the United States, in which they proposed that he write a monograph on his works. But he did not take the plunge. He thought about it, but he thought it was a small thing to make applications of a theorem that others had discovered. And he went without writing such a book. He even told us that if he was going to write – it had to be genuine. When we expressed our regret, he said: “If I don't succeed, my students will write”. We didn't write it either, but we kept a memory of him. My article about him actually came out – when he died, a collection of articles by his students about him was published (Genchev et al. 1986). The most devoted of his students was Dimitar Skordev<sup>40</sup>, who became a great logician and founded a Bulgarian school of mathematical logic. First of all, he was a student of Tagamlitsky, then he specialized in mathematical logic in the Soviet Union under a famous hereditary mathematician – Andrey Andreevich Markov.<sup>41</sup> He had such a feeling, a sense of responsibility to leave a trace of our teacher. A real event, an oasis at the University, far from everywhere there was one... I simply don't know of any other place where there was another such lively circle – it existed for at least 10 years and the best mathematicians of this generation came out of this circle.

<sup>40</sup> Dimiter Skordev (1936–2022) was a professor in the Department of Mathematical Logic and Applications, Faculty of Mathematics and Computer Science at the University of Sofia. Doyen and pioneer of mathematical logic research in Bulgaria who developed a Bulgarian school in the theory of computability, namely the algebraic (or axiomatic) *recursion theory*. Skordev's field of scientific interests include computability and complexity in analysis, mathematical logic, generalized recursion theory, and theory of programs and computation.

<sup>41</sup> Andrey Andreyevich Markov (1903–1979) was a Soviet mathematician, the son of the Russian mathematician Andrey Markov Sr, and one of the key founders of the Russian school of constructive mathematics and logic. He made outstanding contributions to various areas of mathematics, including differential equations, topology, mathematical logic and the foundations of mathematics.

**IA:** And of these big names – Heisenberg, Born, Dirac, Pauli, Schrödinger, who are the people you personally know, were you close to? Did you work together?

**IT:** Of the names you listed, I was not close to anyone, but I knew Dirac best, I had a chance to talk to him and he listened to my report. And I knew Heisenberg personally. I was invited by Heisenberg, he was in his last years in Munich, where they created The Max Planck Institute for Physics (MPP)<sup>42</sup>, today it bears the name of Werner Heisenberg. I was invited to his 70th anniversary, I went from Sofia to Munich to his anniversary conference. All of us invited spoke there, and presented reports. But my personal communication with Heisenberg was more human than scientific. I will open a parenthesis: In mathematics and mathematical physics, it is young people who set the tone. In mathematics, there are Fields medals<sup>43</sup>, there is no Nobel Prize, but Fields medals are awarded to mathematicians up to 40 years old.

**IA:** And you became an academician at the age of 40? What was the basis? You are known for the “Ivan Todorov equation”<sup>44</sup>?

**IT:** Yes. That’s right. I was the youngest to become an academician. Yes, there is a “Todorov equation” – in the relativistic two-body problem. At that time, I had three scientific books published, two in Russian, translated into English (and the first one also into Japanese), and one – in Bulgarian. But... let me continue a little about the meeting with Heisenberg. At that time, he was 70 years old, and there was a young American physicist – Ken Wilson<sup>45</sup>, who soon after received the Nobel Prize. In our circle, this had an impact. Young people were revolving around Wilson, and Heisenberg, the jubilee, was left alone. I don’t know if he was jealous of this attention, he didn’t show it openly. He rather showed irritation towards fashionable talk that

<sup>42</sup> *The Max Planck Institute for Physics* (MPP) is a research institute located in Garching, near Munich, Germany. It specializes in high energy physics and astroparticle physics. The MPP is part of the Max Planck Society and is also known as *the Werner Heisenberg Institute*, after its first director in its current location.

<sup>43</sup> The *Fields Medal* is a prize awarded to two, three, or four mathematicians under 40 years of age at the International Congress of the International Mathematical Union (IMU), a meeting that takes place every four years. The name of the award honours the Canadian mathematician John Charles Fields. The *Fields Medal* has for a long time been regarded as the most prestigious award in the field of mathematics and is often described as the *Nobel Prize of Mathematics*.

<sup>44</sup> In quantum field theory, the Todorov equation from 1971 is well-known, describing a pair of spinless particles in a bound state. The equation itself is a modification of the Klein-Gordon equation. See: Todorov (1971, 2005).

<sup>45</sup> Kenneth Geddes “Ken” Wilson (1936–2013) was an American theoretical physicist and a pioneer in using computers for studying particle physics. He was awarded the 1982 Nobel Prize in Physics for his work on *phase transitions* – illuminating the subtle essence of phenomena like melting ice and emerging magnetism. It was embodied in his fundamental work on the *renormalization group*.

had no real basis, but was only fashionable. But the main thing – he stayed alone, and I found him interesting as a person. And I took advantage of that and went with him. We had an excursion to a high place near Munich, I think there was a monastery nearby, there we drank beer in huge mugs. And Heisenberg taught me a lesson that when you pick up these big mugs, you don't grab the small handle, but you put your hand under the handle and hold the whole mug. Unfortunately, to my shame, if you like, this is the memory I can relate (Laughs) – that he taught me how to hold a mug. After that, I devoted a lot of time to reading about and from him.

**IA:** And what attitude did these geniuses have towards Einstein, for example?

**IT:** I haven't spoken to any of them about Einstein, so I'll answer you based on what they've written and what we've read. So, not all of them... Bohr, Heisenberg, Pauli, who have been setting the tone for a long time, treat Einstein with great respect for creating a theory of gravity. But they don't accept his critical views on quantum theory. There were public discussions with Niels Bohr <sup>46</sup>, but there is something that is particularly interesting and I wrote about it in the journal *The World of Physics*<sup>47</sup>, where most of my articles are. I wrote about it and it will be published in February 2023, on the occasion of the Nobel Prize in Physics for 2022 (Todorov 2023). This Nobel Prize is interesting in many ways, it resurrects a work by Einstein from 1935. Niels Bohr responded to this publication negatively.<sup>48</sup> Pauli, also very critical, urged Heisenberg to write something authoritative in order to counteract the effect of the article. Only one of the big names, Schrödinger, came out immediately after this article with sympathy. But Schrödinger and Einstein were considered, and this is described in my article, as already senile, decrepit old men to whom no attention should be paid. And the point, the interest in this Nobel Prize of 2023 was that years after this work from 1935, in the 1960s, a whole direction was resurrected and slowly, struggling with prejudices, began to develop, which became fashionable – quantum cryptography,

<sup>46</sup> Niels Henrik David Bohr (1885–1962) was a Danish theoretical physicist who made foundational contributions to understanding atomic structure and quantum theory, for which he received the Nobel Prize in Physics in 1922. Bohr was also a philosopher and a promoter of scientific research.

<sup>47</sup> The magazine "The World of Physics" is a quarterly scientific magazine, published by the Union of Physicists in Bulgaria.

<sup>48</sup> The *Bohr–Einstein debates* were a series of public disputes about quantum mechanics between Albert Einstein and Niels Bohr. Their debates are remembered because of their importance to the philosophy of science, insofar as the disagreements—and the outcome of Bohr's version of quantum mechanics becoming the prevalent view—form the root of the modern understanding of physics.

quantum informatics, “quantum computers”, which are laid out in this article by Einstein, Podolsky, Rosen – the three authors.<sup>49</sup> Einstein provided the idea, but there are signs that Boris Podolsky wrote it.

**IA:** And what is this science? Another way of thinking? Ideas of geniuses?

**IT:** Good question! And if someone gives you a quick answer, don't pay attention to it, because the question is complex and needs to be thought through. What is the main thing? Everything I would say about this would not be complete, but I will say one thing. There is sometimes a childish curiosity and a childish view of things, which over time lose their original freshness and people already begin to think with accepted schemes, in the creation of which they may even have participated. Einstein, it seems to me, retained something from the years when, alone in Bern, working not at the University, but at the Patent Office, he began to reflect and create a series of remarkable works that were published in 1905 – his *annus mirabilis*. There, along with the theory of relativity, which everyone knows is Einstein's discovery, there is an article about photons, quanta of light. It is interesting that Einstein's Nobel Prize was for this article, and not for the theory of relativity. There may be other reasons, because the theory of relativity caused philosophical disputes and, moreover, it has strong predecessors – Lorentz<sup>50</sup>, Poincaré<sup>51</sup>, and the article on photons is truly the most revolutionary. Einstein thought about the

<sup>49</sup> *The Einstein–Podolsky–Rosen paradox* is a thought experiment proposed by physicists Albert Einstein, Boris Podolsky and Nathan Rosen, which argues that the description of physical reality provided by quantum mechanics is incomplete. In a 1935 paper titled “*Can Quantum-Mechanical Description of Physical Reality be Considered Complete?*”, they argued for the existence of “elements of reality” that were not part of quantum theory, and speculated that it should be possible to construct a theory containing these hidden variables. Resolutions of the paradox have important implications for the interpretation of quantum mechanics (Einstein, Podolsky, and 1935).

<sup>50</sup> Hendrik Antoon Lorentz (1853–1928) was a Dutch theoretical physicist who shared the 1902 Nobel Prize in Physics with Pieter Zeeman for their discovery and theoretical explanation of the *Zeeman effect*. He derived the *Lorentz transformation* of the special *theory of relativity*, as well as the Lorentz force, which describes the combined electric and magnetic forces acting on a charged particle in an electromagnetic field.

<sup>51</sup> Jules Henri Poincaré (1854–1912) was a French mathematician, theoretical physicist, engineer, and philosopher of science. As a mathematician and physicist, he made many original fundamental contributions to pure and applied mathematics, mathematical physics, and celestial mechanics. Poincaré made important contributions to algebraic geometry, number theory, complex analysis and *Lie theory*. He famously introduced the concept of the *Poincaré recurrence theorem* and popularized the use of non-Euclidean geometry in mathematics as well. Poincaré discovered the remaining relativistic velocity transformations in 1905. Thus he obtained perfect invariance of all of *Maxwell's equations*, an important step in the formulation of the *theory of special relativity*, for which he is also credited with laying down the foundations for, further writing foundational papers. In 1912, he wrote an influential paper which provided a mathematical argument for quantum mechanics. The Poincaré group used in physics and mathematics was named after him.

topic until the end of his life. Already long after 1935, in 1952, he wrote about it to his, perhaps, closest friend Michele Besso<sup>52</sup>. Their friendship began at the Polytechnic in Zurich. Besso, an Italian Swiss, became Einstein's colleague at the Patent Office and played a special role in his life. Einstein called him "The best sounding board in Europe". Besso introduced him to the views of the Viennese physicist-philosopher Ernst Mach<sup>53</sup> and is the only name that appears with gratitude in Einstein's first article (1905) on the theory of relativity. They remained close even after that – over 100 letters from Einstein to Besso and even more from Besso to Einstein have been preserved. And here I return to your question, in a letter two years before his death, Einstein wrote: "I have been thinking about the photon for more than half a century and I see that I still do not understand it". He is not satisfied with something half-baked that works. The accepted understanding of quantum theory is very strange. It is known that experience changes the state of a microparticle. If we measure, for example, its coordinates, which determine its place in space, it passes into a state with certain coordinates. If we don't measure them, or if we measure its momentum instead, then not only do we not know its coordinates, but, according to the theory, particles have no trajectories, no definite coordinates. The theory says nothing about nature without an observer. Physicists are trained to accept this strange picture without asking questions. Einstein refuses to accept it. I have talked about his 1935 work with Podolsky and Rosen and the path from it to the Nobel Prize in Physics for 2022 in my aforementioned article in "The World of Physics" (Todorov 2023), and I don't want to spoil the plot here.

**IA:** So, it turns out that Poincaré is right when he says that truth attracts us and flees from us, it is never fixed? Does science discover new worlds? Or does it create them?

**IT:** This is a philosophical question. I am definitely in favour of discovering, not inventing. In mathematics, this problem is especially acute, and both opinions are held by people more committed and more deserving than me, so I am simply expressing my feeling. In

<sup>52</sup> Michele Angelo Besso (1873–1955) was a Swiss-Italian engineer who worked closely with Albert Einstein.

<sup>53</sup> Ernst Mach (1838–1916) was an Austrian physicist and philosopher, who contributed to the understanding of the *physics of shock waves*. The ratio of the speed of a flow or object to that of sound is named the *Mach number* in his honour. As a philosopher of science, he was a major influence on logical positivism and American pragmatism. Through his criticism of Isaac Newton's theories of space and time, he foreshadowed Albert Einstein's theory of relativity.

mathematics, there is no material world, there is a Platonic world of ideas. And the conviction of working mathematicians, of the majority (the exceptions are mainly philosophers), is that they do not invent/create these things, but discover them – with intense thinking. They have always existed, but have not been understood.

Let us take this often-cited example of prime numbers. We know when people started counting, the emergence of trade played a big role, because they had to measure and count, and the study of whole numbers led to the concept of a prime number (which is divisible without a remainder only by itself and by one). One can maintain the opinion that people create these concepts and create their properties. But when a person thinks about numbers, he sees that there are mysteries there and that there are regularities and that he does not create the regularities, they are there, in the world of numbers. And from this point of view, this is Plato's view – there are truths that we gradually discover, we do not create, they were there. Okay. I expressed one of the two opinions.

**IA:** And do we live in the best of all possible worlds?

**IT:** This is Leibniz...

**IA:** And are the others inhabited? If not, does science make the world better? Or does its role differ?

**IT:** This brings us to such questions that have been discussed a lot lately. Especially with the recently released film about Oppenheimer.<sup>54</sup> You might like it because it is for young people. When I saw it, there was a 30-year-old boy in the cinema and another, 20, they were delighted. Because we, the older ones, know more, we found flaws. I can say that there is a book that has been translated into Bulgarian (Bird, Sherwin 2022), a big and thick biography of Oppenheimer – “The American Prometheus”, by Kai Bird and Martin Sherwin (2005). There are also gossipy things in it that it could do without, but it creates a more authentic and deeper image of Oppenheimer. There are no factual errors in the film. It is noisy and spectacular. The New Yorker is a bit of a snobbish magazine – it published a critical article about the film, saying that “if they had simply and honestly listed the facts of Oppenheimer's life, it would have been a more interesting and profound image than this film” (Brody 2023). They cast an actor with blue eyes, but they didn't teach him to look like Oppenheimer. I

<sup>54</sup> *Oppenheimer* (2023) is biographical drama film written, produced, and directed by Christopher Nolan.

didn't see him in person when I went to Princeton, it was a year after he had died, but I had heard and read about that sometimes-chilling gaze. For example, it is said that Max Born<sup>55</sup> of Göttingen, one of the creators of quantum mechanics, suffered from the contemptuous gaze of Oppenheimer, who visited him in the 1930s. By the time I was at Princeton, a book of memoirs about Oppenheimer had come out (Dyson 1979). Born, who outlived Oppenheimer, was among those invited to participate with his memories of their work together and he refused. He could not overcome his insult... The contemptuous blue gaze. I learned it from the book's editor, Freeman Dyson.

**IA:** And do we live in the best of all worlds?

**IT:** Look, Leibniz<sup>56</sup> is an idol of Gödel<sup>57</sup> and that is why I like him. I understand that this is not superficial – optimism, and perhaps, in some sense, it is even a sad statement, because we see what the world is like today. I sympathize with Leibniz, I can understand him and I admit that my interest and sympathy for him increased under the influence of Gödel, who holds him in high regard (See: Parsons 2010). I have nothing to add.

**IA:** Are there any limits in quantum field theory? Where does it start? Where does it end?

**IT:** Quantum field theory is the theory we have reached. It is the most comprehensive theory. It combines the two greatest discoveries of the early twentieth century, two of the three – the special theory of relativity and quantum mechanics. Quantum mechanics was initially inconsistent with the theory of relativity of 1905. Gravity remains, despite all efforts, still outside its scope, there is no true theory of quantum gravity. There are still unresolved questions in quantum field theory, but there are enough achievements to show that there is a true theory – it covers everything from the smallest micro-particles to galaxies. Interestingly, the understanding of atoms and stars help each other: the nuclear reactions at the heart of thermonuclear bombs happen in stars, and they also explain the light and heat of the Sun.

<sup>55</sup> Max Born (1882–1970) was a German-British theoretical physicist who was instrumental in the development of quantum mechanics. He also made contributions to solid-state physics and optics, and supervised the work of a number of notable physicists in the 1920s and 1930s. Born shared the 1954 Nobel Prize in Physics with Walther Bothe for his research in quantum mechanics, especially in the statistical interpretation of the wave function.

<sup>56</sup> Gottfried Wilhelm Leibniz (1646–1716) was a German polymath active as a mathematician, philosopher, scientist and diplomat who is credited, alongside Sir Isaac Newton, with the creation of calculus in addition to many other branches of mathematics, such as binary arithmetic and statistics.

<sup>57</sup> Kurt Friedrich Gödel (1906–1978) was a logician, mathematician, and philosopher.

There are, I insist on this, there are now fashionable theories from the early 1980s – string theory and superstring theory. I could say more about them, but they are still dreams. There are mathematical results, but their relation to the observed world is not clear, and there is a sad phenomenon that because they have become fashionable, a generation or more than one generation of physicists know only this and in fact somehow impoverish science. And because it does not find application where scientists hoped, these generations do not know real physics. The pioneers of string theory are very strong minds and they enriched science and continue to enrich it. But their regiments of students – tens of thousands, they are distributed in smaller tasks, they do not have the vision of the creators, and it is not clear whether these small tasks have any relation to the world. Those trained for such hopeless tasks do not have the imagination of the pioneers to discover new horizons in pure mathematics. A generation of people has emerged who, it seems to me, will not leave a trace in science. While in quantum field theory, even routine studies, if they are of good quality, are at least small steps towards knowledge of nature. Because the area of applicability of quantum field theory is very wide, wider than was initially thought. And its methods also help to understand statistical physics, thermodynamics, hydrodynamics. This is a field that is undoubtedly concerned with knowledge of the physical world.

**IA:** And will we ever reach a unified theory of everything? Is that achievable? Is such a peak achievable?

**IT:** And this is a question on which cleverer people than I have expressed their opinions. In this case, to an opinion that most people in our field now share – that there will never be one. This is in a sense a betrayal of Einstein’s dreams. He dreams of a unified field theory, but he dreams of understanding in the same profound way that he understood gravity, of understanding electrodynamics and, say, the quantum world. His specific program may one day be achieved, but it will not be a “theory of everything” – there was such a term. It will expand the boundaries of the known, from which new tasks will be discovered.

**IA:** And can progress lead us away from science?

**IT:** I would say that in terms of the hobbies of the younger generation, it has already led us away. I am an old man, I can remember the 1960s.

A colleague from Russia, Lenya Ponomarev<sup>58</sup>, characterized them in 2000 as: “I remember the 1960s. It is hard for us to believe that there was a time, just two generations ago, when young men aspired to science, and girls preferred physicists to naval officers...”

**IA:** And artificial intelligence, will it be able to create new physics?

**IT:** I don’t know. Artificial intelligence, you know, has contradictory statements about it. It is sad that at the current stage of development, the tasks of using it to cause harm, military tasks, dominate the interest. And the military is investing a lot of money in this. Many people are expressing concern, there have been petitions and movements to bring it under control. Experience shows that it is difficult: “you can’t stand in the way of progress”. They say that when the Russian poet Mandelstam<sup>59</sup> first heard the word “progress” as a child, he cried... I think that in the period from the end of the 19th to the first third of the 20th century, before the discovery of uranium chain reactions in the late 1930s, the pursuit of “progress” was purely curious, not stimulated by the desire to kill more efficiently. It is inevitable that when there is war, the achievements of science will be applied to military purposes. But the creators of the revolution in physics in the first third of the 20th century were not inspired by military applications and were not paid for it. And this latest fashion – quantum informatics, has been financed by the military from the very beginning. Its positive effect was that it allowed the work of “quantum dissidents” inspired by Einstein – Bohm<sup>60</sup>, Bell<sup>61</sup>, etc. to be evaluated, albeit with a great delay.

**IA:** Mathematics as a language is related to physics. What other areas of culture is physics connected to?

**IT:** In the 1960s, which I remember with fondness, there was talk of physicists and lyricists. I think there has always been a kinship at some deep level. Both mathematics and music, and physics and fine

<sup>58</sup> Leonid Ponomarev (1937–2019) was Soviet physicist, who made a contribution to the solution to fundamental problems of contemporary physics. He proposed the model of large mesic molecules, which was the starting point of a new line of research, namely, mesonic chemistry.

<sup>59</sup> Osip Emilyevich Mandelstam (1891–1938) was a Russian and Soviet poet. He was one of the foremost members of the *Acmeist school*. He was arrested during the repressions of the 1930s and sentenced to five years in a corrective-labour camp in the Soviet Far East. He died that year at a transit camp near Vladivostok.

<sup>60</sup> David Joseph Bohm (1917–1992) was an American scientist who contributed unorthodox ideas to quantum theory, neuropsychology and the philosophy of mind. Among his many contributions to physics is his causal and deterministic interpretation of quantum theory known as *De Broglie-Bohm theory*.

<sup>61</sup> John Stewart Bell (1928–1990) was a physicist from Northern Ireland and the originator of *Bell's theorem*, an important theorem in quantum physics regarding hidden-variable theories.

arts, and even religion. There is a vivid example of this – Father Pavel Florensky<sup>62</sup>, an Orthodox priest, mathematician, electrical engineer, encyclopedist, religious philosopher. He was 17 years old when he experienced a religious crisis (after a visit to Leo Tolstoy). He entered Moscow University to study mathematics (1899) in order to reconcile the scientific and spiritual worldviews. He studied with mathematician Nikolai Bugaev<sup>63</sup> and became friends with his son, the symbolist poet Andrei Bely.<sup>64</sup> He gave up a teaching position at the university after graduating to enter the theological academy. The motto of his spiritual dissertation (1914) is “knowledge is born of love”. Rozanov<sup>65</sup> calls him “the Pascal of our time”. In Soviet times he refused to emigrate. He was shot in 1937. Interest in his work was awakened in the 1960s, starting from the school of semiotics in Tartu.<sup>66</sup>

**IA:** Last question: Poincaré talks a lot about truth and says that only it is beautiful. However, can it turn out that truth is sad? Physics of sadness?

**IT:** (Laughs) I don't want to quote Georgi Gospodinov. No, science is not sad. The pursuit of science gives meaning. For a person who is engaged in science, it gives meaning to life. It gives him something permanent that is not an object and does not give in to destruction. You are talking to an old man – 90 years old, about the end and about everything. A close physicist with whom we had worked, Gerhard Mack<sup>67</sup>, died recently, this year. My students were involved in our work together and he helped to create a Bulgarian school of mathematical physics. It was known that he was ill. I had heart operations, two, and ... I had the experience of lying in a hospital, when one can only console oneself with thoughts. And when I found out that Gerhard Mack was

<sup>62</sup> Pavel Alexandrovich Florensky (1882–1937) was a Russian Orthodox theologian, priest, philosopher, mathematician, physicist, electrical engineer, inventor and neomartyr. In the second half of the 1920s, he mostly worked on physics and electrodynamics devoted to the geometrical interpretation of Albert Einstein's theory of relativity. Florensky died in Stalin's Gulag in 1937. See: Goltz (1990).

<sup>63</sup> Nikolai Vasilievich Bugaev (1837–1903) was a Russian mathematician. Bugaev was an active member and president (1891–1903) of the Moscow Mathematical Society. He also wrote influential philosophical essays in which he trumpeted the virtues of mathematical analysis and decried the influence of geometry and probability.

<sup>64</sup> Boris Nikolaevich Bugaev (1880–1934), better known by the pen name Andrei Bely was a Russian novelist, Symbolist poet, theorist and literary critic.

<sup>65</sup> Vasily Vasilievich Rozanov (1856–1919) was one of the most controversial Russian writers and important philosophers in the symbolists' of the pre-revolutionary epoch.

<sup>66</sup> The Tartu–Moscow Semiotic School is a scientific school of thought in the field of semiotics that was formed in 1964 and led by Juri Lotman.

<sup>67</sup> Reference to the title of the novel *The Physics of Sorrow* (2011) by Georgi Gospodinov.

in a serious condition and lying in a hospital, I wrote to him that even at 80 years old we still have the pleasure of thinking. Apparently this struck a chord that resonated with him. And he wrote me an answer: “Yes, the pleasure of thinking...!” With an exclamation.

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