

## Professor Dirac and Soviet physicists

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The article recounts Professor Dirac's acquaintance, scientific contacts, and friendship with Soviet physicists. Particular attention is devoted to his relations with Professors P. L. Kapitsa, I. E. Tamm, V. A. Fock, and Ya. I. Frenkel'. A chronicle of Dirac's visits to the Soviet Union before and after the war is presented. The article concludes with the author's brief personal impressions of his meeting with the English scientist.

Upon arriving in Leningrad in May of 1934, Niels Bohr said in an interview with an *Izvestiya* correspondent: "I never lost touch with Soviet science and I have many friends among Soviet physicists. I hope to strengthen these ties now and to visit the Soviet Union again. This happens with everyone who visits here. Many scientists have told me so, particularly young physicists. Professor Dirac has visited the Soviet Union many times and speaks of it with such affection!"

This excerpt from Bohr's interview could serve as an epigraph for a short account of P. A. M. Dirac's (1902–1984) ties with Soviet physics and physicists. A typical scientist in the classical mold, Dirac preferred working in depth on a limited number of fundamental problems and, like most classical scientists, he usually worked alone. Thus it is significant that over the years two of Dirac's four or five co-authors—P. L. Kapitsa and V. A. Fock—were our compatriots. At the same time, these "numerical indicators" are quite inconsistent with Dirac's exceptional mobility, which began as early as the late 1920s. He traveled widely over all the continents (perhaps with the exception of the Antarctic) not only to satisfy his interest in other countries, nature, peoples, and cultures which did not dim with age, but also because of his urge to communicate with physicists of different generations: from the older (here Bohr and Ehrenfest are the outstanding examples) to the younger, including of course the physicists of Dirac's own.

In the late 1920s and 1930s no other major foreign physicist visited our country as often as Dirac. He came to the Soviet Union in 1928, 1929, 1930, 1932, 1933, 1935, 1936, and 1937!

How did he first become acquainted with Soviet theoretical physicists (in addition, of course, to reading their papers which were published in German from the early 1920s until 1932 in *Zeitschrift für Physik* and from 1932 to 1937 in *Physikalische Zeitschrift der Sowjetunion*—Dirac himself knew no Russian)? It can be asserted that his contacts originated primarily through two physicists: Petr Leonidovich Kapitsa who worked for over ten years from 1921 onwards at the Cavendish Laboratory, serving as the prime representative and disseminator of our science abroad, and Pavel Sigismundovich Ehrenfest, a longstanding friend of Soviet physics, who lived for several years in pre-Revolutionary Petersburg and never lost touch with our country after his 1912 departure for Leiden.

Anna Alekseevna Kapitsa, the widow of Petr Leonidovich, counts Dirac as one of his closest friends. Kapitsa and Dirac got to know each other in the first half of the 1920s. Dirac's name first appears in the proceedings of the now

famous Kapitza Club of Cambridge in 1924; from 1925 onward he becomes one of the most active participants of this Club.<sup>1)</sup> By the way, all Soviet physicists who visited England gave talks about their work at the "English Kapitza Club": in the minutes we find mention of talks by S. A. Boguslavskii, A. F. Ioffe, I. V. Obreimov, K. D. Sinel'nikov, D. V. Skobel'tsyn, Ya. I. Frenkel', Yu. B. Khariton. It is likely that Dirac's personal acquaintance with Soviet physicists N. N. Semenov and Ya. I. Frenkel' also occurred through Kapitsa, when they all gathered in England in the summer of 1926 for the congress of the Association for the Advancement of Science.

At the Dirac memorial symposium convened in October of 1986 in Moscow by the Institute of History of the Natural Sciences and Technology at the Academy of Sciences of the USSR (we shall often cite from the materials of this interesting symposium), P. E. Rubinin's address quoted several letters from P. L. Kapitsa's extraordinary archives which testified to the extremely close friendship between the two scientists. It appears that after P. L. Kapitsa's return to the USSR these ties became stronger still. In the summer of 1935 Dirac spent his entire summer vacation with Petr Leonidovich at Bolshevo near Moscow, thereby giving up an extremely enticing alpinistic adventure in the Caucasus (there is much about the preparations for this journey in letters addressed to I. E. Tamm). During this time Dirac helped Kapitsa in organizational matters, assisting in the transfer of the invaluable scientific equipment from the Mond laboratory to the future Institute of Physical Problems. Dirac lived at Kapitsa's house for long stretches of time in 1936 and 1937; he did the same during his post-war visits to our country.

When it came to Soviet theoretical physicists, Dirac's closest friend was I. E. Tamm. We have some documental evidence about their acquaintance, also made abroad. In the spring of 1928 Tamm worked under P. S. Ehrenfest at Leiden on a Lorentz fund fellowship. On March 7, 1928, Igor' Evgen'evich reported on Dirac's work on relativistic quantum mechanics at Ehrenfest's seminar. Ehrenfest wrote about it to A. F. Ioffe on April 13: "I am marvelously impressed by Dirac's latest work on electron spin. Tamm explained it to us very well and will continue research in this area. To Tamm's joy Dirac will spend May and June in Leiden" (Ref. 2, p. 207). Indeed, in May of 1928 Dirac arrived in Holland. Ehrenfest entrusted his assistants with meeting Dirac at the train station. Tamm came along. As no one knew what Dirac looked like, they picketed the exits of every coach armed with reprints of Dirac's latest paper. Ehren-

fest's guess worked: Dirac got "hooked" by one of his reprints.

About the same time Tamm recorded in his diary: "Dirac is patiently teaching me what's what; I am very proud to say that we've become good friends" (Ref. 3, p. 98). Another letter from Ehrenfest to Ioffe strikes the same chord: "Tamm and Dirac have become great friends. In the middle of June they will travel to Leipzig, where Debye and Heisenberg are organizing a week-long discussion on quantum mechanics" (Ref. 3, p. 279). In May of 1931 Tamm made a working visit to Cambridge and introduced Dirac to mountain climbing. This "sportive exchange" was reciprocated in various ways: having learned to ride a bicycle from Tamm at Leiden, Dirac now taught his friend to drive a car. In memoirs about his grandfather, L. I. Vernskii cites a letter from K. K. Tikhonov to Igor' Evgen'evich (dated February 5, 1967): "... Summer of 1936, Caucasus, El'brus mountain. The group of students I was leading on a climb of El'brus was joined by two scientists: Soviet physicist Tamm and English physicist Paul Dirac. After two days and an acclimatization at the Resting Point of the Eleven, we reached the Western peak of El'brus ... I remember our unsuccessful attempts to get a "USSR Mountain Climber" badge for Paul Dirac for this ascent. What if we get the badge for Dirac now, thirty years later? ... A few years ago I received a short letter of greetings from Dirac, he remembers that climb" (Ref. 3, p. 77).

Clearly, Dirac's friendship with Tamm was cemented above all by the similarity of their scientific interests. Thus it was Tamm who, in 1930, demonstrated that when computing the scattering of  $\gamma$ -quanta by electrons one should consider the negative energy states proposed by Dirac. A perusal of Tamm's paper shows clear signs of his fruitful collaboration with Dirac.

With his unusually lively and impulsive personality, the tireless storyteller I. E. Tamm was the exact opposite of the methodical Dirac, whose reticence was about his most pronounced character trait. And so, in 1931, the denizens of Cambridge were amazed to see Dirac walking about caught up in a lively conversation with some short foreigner—Igor' Evgen'evich. Blessed with a natural perceptiveness and a good memory, Tamm recalled many funny anecdotes associated with Dirac. They are told in a lively fashion in the collection *Reminiscences about Igor' Evgen'evich Tamm* (Ref. 3).<sup>2)</sup>



FIG. 1. Leiden, 1928. From left to right: P. A. M. Dirac, O. N. Trapeznikova, I. E. Tamm, I. V. Obreimov.

I. E. Tamm's letters to Dirac (as well as letters from V. A. Fock, Ya. I. Frenkel', and a number of other Soviet scientists, obtained from the Churchill College Archives at Cambridge University with the generous cooperation of R. Peierls and D. Shoenberg) are peppered with the fascinating questions that occupied the correspondents in the 1930s. These epistolary materials (together with some of Dirac's replies to his Soviet colleagues which survive in the State and family archives of our country) shall probably be published and commented upon in the proceedings of the Moscow Dirac memorial symposium. Here we shall only quote from three of Tamm's letters. The first was written with the impression of the positron discovery fresh in mind.

5 VI 33, Moscow

Dear Dirac,

I always was a bad correspondent, but with years I am becoming worse and worse. I feel very acutely all the disadvantages of this my shortcoming, as I lose the contact with all people, even those most dear and interesting to me. Many times this year I was about to write you, especially after Blackett's and Occhialini's paper appeared. I got used to say, that your prediction of the antielectron has no parallel in the history of science. One can think about Leverrier and Adams, but your case is different. Your theoretical prediction about the existence of the antielectron, being unstable in the "ordinary space" outside the nucleus, seemed so extravagant and totally new, that you yourself dared not to cling to it and preferred rather to abandon the theory. And now the experiment unexpectedly proved you to be right ...

One often hears people to say, that the unobservable negative electrification of the world, produced by the negative energy electrons, is a metaphysical notion. I personally am also inclined to think, that this notion in its present form will find no place in the future structure of physics, but nevertheless I think one has to use this notion and work with it. The notion of immovable and unobservable ether, formed by



FIG. 2. Dirac in the Caucasus, 1936.

Lorentz about 1890, was also a metaphysical one and was banned from physics in some 15 years by Einstein, but the Lorentz transformation and other premises for Einstein's work would be hardly established, if one did discard this notion right from the beginning.<sup>4)</sup>

The other two excerpts are from letters written in May of 1934, under the fresh impression of meetings with Neils Bohr, first in Leningrad and then in Khar'kov, at a conference where I. E. Tamm reported on the "electron-neutrino" theory of nuclear forces.

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Dear Dirac,

I returned only the day before from Leningrad, where I spent 3 weeks at Joffe's Institute, and found here your kind letter. I appreciate it very much, but unfortunately there is no chance for me to go abroad this summer. I will try to manage to come to the atomic conference in October, although your absence from it diminishes its attraction for me very considerably.

Bohr came to Leningrad with his wife and Rosenfeld on the 30 IV and I have had the opportunity to make his acquaintance. He made a very great impression on me; his smile is charming! I hope to have with him some discussions on some physical points in Kharkov—in Leningrad his time was too much occupied. The theoretical conference begins in Kharkov on the 18th.

I mentioned to Bohr occasionally the discussion we have had with you last autumn about Bohr's theory of the absence of any intellectual and psychological differences between nations: he argued on the point for about an hour and, as you did rightly tell, totally convinced me.

Kharkov, 21 V 34

Dear Dirac,

I have delayed my letter from day to day, wishing first to discuss the question with Bohr, and then on the conference. Now at last all this is done and there seem to be no objections (except those of Landau, which are not the point).

I see now my letter is probably too long for "Nature" and marked with the pencil some sentences which may be left out. . . . Please strike the sentences if you find it necessary in order to get the letter printed. Could you not correct the proofs? Excuse me for giving you troubles.

We discuss with Bohr the possibility of him coming to USSR in August again with his elder son and climbing with me in the Caucasus. It seems that his plan may be quite real, since Mrs. Bohr seems to have given to it her approval. It would be delightful if you could also come for say 3–4 weeks. Do consider the matter.

Yours very sincerely,  
Ig. Tamm.

In replying to this letter on June 7, 1934, Dirac wrote: "I sent your note to *Nature* and the editor accepted it, as he did Ivanenko's note. I will proof-read it." This letter contains an interesting comment in favor of the neutrino hypothesis as the only method of preserving the law of conservation of energy; Dirac adds: ". . . And until there is some new development, one should not act disagreeably towards

this particle."<sup>6)</sup> Let us note that Dirac thought the "new development" was provided by Shankland's paper claiming a violation of energy conservation in the Compton effect. Dirac was the first to support that paper and expressed hopes that the conclusion was correct (in his 1935 note in *Nature*), whereas Tamm—I believe after Shankland's work was discussed at the March Meeting of the Academy of Sciences of the USSR in 1936—wrote to Dirac: "I heard that Bethe checked the details of the Shankland experiment that Compton sent him and came to the conclusion that these experiments are not at all convincing. Ioffe and Alikhanov are of the same opinion, although they are only familiar with Shankland's paper in Phys. Rev. What do English experimenters think of this?" (letter dated May 9, 1936).

Dirac established longstanding scientific contacts with V. A. Fock which are reflected in the English and Soviet archive materials. But even before consulting the archives I heard of these contacts from Vladimir Aleksandrovich himself. He told me (in 1972) of the exceptionally good mathematics preparation provided by the Petrograd University in the late 1910s and early 1920s, recalling with particular sympathy the course on the theory of linear differential equations taught at the time by Ya. D. Tamarkin. From those reminiscences he hopped to 1928, when he met (apparently for the first time) Dirac in Göttingen. Fock said: "I remember how I went on a walk with Dirac in 1928 and he told me of his work. I knew no English at the time and we spoke German. I quickly understood the point of his discourse and he even began to doubt me, asking whether I understand everything. But thanks to Tamarkin I assimilated it immediately. And I explained this to Dirac. He gave me a slightly quizzical look and asked: "In fünf Minuten?" ("in five minutes?", German)." And Fock ended his story with his unusually pleasant laugh.

The scientific contacts between Dirac and Fock were very intense in the very beginning of the 1930s. Their letters reflect this: for instance, they contain interesting facts about the prehistory of the Landau and Peierls well-known paper (1931) on the extension of the uncertainty principle to quantum field measurements and also on the origins and evolution of the important paper authored by Dirac, Podolsky, and Fock on quantum electrodynamics, work on which began during Dirac's visit to Leningrad in 1932. Another series of letters relates to the last (post-war, 1960) edition of *Principles of Quantum Mechanics* (Ref. 8).<sup>7)</sup>

If we refer back to the dates of Dirac's visits in the USSR listed in the beginning of this article, it is obvious that some of these coincide with the various conferences that took place in our country. From 1928 onward Dirac participated in these conferences and during the pre-war years there was probably no major event to which he was not invited. (We emphasize that correspondence materials indicate Dirac was expected at the 1929 First All-Union Theoretical Physics Conference in Khar'kov, at the 1930 First All-Union Physics Congress in Odessa, and at the 1937 Second All-Union Conference on Nuclear Physics in Moscow, but every time something prevented him from attending during the rather strictly specified time periods.)

Dirac's first visit to the USSR took place in August of 1928. He came to the Sixth Congress of Russian physicists with a large group of foreign physicists (M. Born, P. Debye, A. Lande, R. Mises from Germany; C. Darwin and O. Ri-

chardson from England; L. Brillouin from France; F. Frank from Czechoslovakia and others). The congress began in Moscow, and afterwards about 200 participants travelled to Nizhniĭ Novgorod (now Gorkiĭ) and boarded a specially chartered ship which took them down the Volga with stops in the major university town on the Volga—Kazan' and Saratov. There plenary sessions of the congress were convened, and the participants gave scientific and popular talks to students, teachers, and engineers interested in the achievements of the new physics. Seminars took place on board, including theoretical seminars in the course of which Dirac reported on the theory of the electron. He had the opportunity to meet young Soviet theorists: D. D. Ivanenko, L. D. Landau, L. V. Rozenkevich, and others.

In the spring of 1930 Dirac participated in the Khar'kov conference on theoretical physics. Unfortunately I could not locate the titles of Dirac's talks at that conference, but we have indirect evidence on this active participation and its benefits to the Soviet participants: on December 20, 1930 Dirac was elected an active member of the Ukrainian Physicotechnical Institute (of which he was notified in a letter dated January 28, 1931 by the Institute's director I. V. Obreimov). At about the same time Khar'kov hosted the First All-Union Mathematics Congress, at which such participants in the physics conference as V. A. Fock and Ya. I. Frenkel' gave talks. It is possible that Dirac was also present at the meetings of that conference, which included in addition to Soviet mathematicians such prominent foreign scientists as J. Hadamard, E. Borel and others. The Khar'kov physics conference of 1930 is also significant because Dirac brought with him the English proofs of the first edition of his immediately famous *Principles of Quantum Mechanics*, which came out in England that same year. It was decided in Khar'kov that the book would be translated into Russian: D. D. Ivanenko was chosen as the editor and the young theorist M. P. Bornshteĭn as the translator. The first Russian edition (there were five altogether) came out in 1932.<sup>9</sup> Soon after the appearance of the English edition Ya. I. Frenkel' wrote from the U. S., where he was at the time (May 17, 1931): "I am now absorbed in Dirac's book (parts of which I had perused in Khar'kov, when it was still in proof)" (Ref. 6, p. 442).

In 1931 Dirac's fame, scientific works, and close ties with Soviet physicists prompted his nomination for the rank of a Foreign Corresponding Member of the USSR Academy of Sciences. The nomination was sponsored by Academicians A. F. Ioffe, P. P. Lazarev, L. I. Mandel'shtam, V. F. Mitkevich, D. S. Rozhdestvenskiĭ, and S. A. Chaplygin; it was particularly supported by Khar'kov physicists. Dirac was elected to the Academy on February 16, 1931 (he remained a Foreign Member of the USSR Academy of Sciences for the rest of his life).

In 1932 there was a conference on solid state physics in Leningrad at which problems in semiconductor physics, magnetism, ferroelectricity, crystal optics, and binding forces were discussed. Dirac took part in that conference, giving a report on his theory of electron interaction. Interestingly, upon returning to England P. Dirac and R. Fowler reported on the Leningrad conference materials at one of the Kapitza Club meetings in Cambridge (October 25, 1932).

The First All-Union Conference on Nuclear Physics was scheduled for September of 1933 to coincide with the



FIG. 3. Dirac at the First All-Union Conference on Nuclear Physics, Leningrad, 1933. A sketch by the painter N. A. Mamontov.

fifteenth anniversary of the foundation of the Physicotechnical Institute (PTI). The participants were riding the crest of the stellar year for nuclear physics, which witnessed the discovery of the positron and the neutron, and the development of the proton-neutron model of the nucleus. The discovery of the positron signified the triumph of Dirac's theory: his "computed" antiworld manifested itself by the first representative particle. The conference sessions were shot through by the neutron and positron; Dirac's talk prompted much interest and a lively discussion with the participation of V. A. Fock (as already mentioned), V. Weisskopf, D. D. Ivanenko, I. E. Tamm, and others (see Ref. 10 for details about this conference). Several days later Dirac gave a popular version of his talk at the PTI anniversary ceremony that took place in the concert hall of the Vyborg Culture Palace.

It should be said that Dirac's arrival in Leningrad was known beforehand. He was met at the Leningrad seaport by



FIG. 4. P. A. M. Dirac, Ya. I. Frenkel's sketch, 1936.

a correspondent of the *Vechernyaya Krasnaya Gazeta* (Red Evening Paper). Answering his questions, Dirac said that he held communication with Soviet theorists in high esteem, singling out I. E. Tamm, V. A. Fock, and D. D. Ivanenko.<sup>10</sup>

As mentioned already, Dirac did not visit the Soviet Union for conferences only. He was attracted by the opportunity to visit our country and the physical institutes of Leningrad, Moscow, and Khar'kov unconstrained by "collective" events, simply to discuss questions that interested him with colleagues at seminars, in their offices and homes, during vacations near Moscow, in the Crimea, and the Caucasus (at the seashore and in the mountains). Simply put, he loved our land and his Soviet friends.

During his visit in the Soviet Union in 1935 or 1936 he turned up in Leningrad and lived in the apartment of my father, Ya. I. Frenkel', for several weeks (during the first half of the 1930s he would stay at I. E. Tamm's when in Moscow). Our house was located in the pleasant park of the Polytechnical Institute, a few minutes' walk from the Physicotechnical Institute. I have my own, albeit vague impressions of a silent man in a grey suit who lived in my father's study. During that visit my father painted an oil portrait of Dirac and made several pencil sketches. Dirac recalled the fairly long posing sessions later, in 1973. Sitting still would lull him into sleep; to "perk up" Dirac Frenkel' would entertain him with funny stories and anecdotes...

The war ruptured scientific contacts of scientists from various countries for many years. Its victorious conclusion in May of 1945 heralded the hope of their rapid resumption. And indeed, as early as June of 1945, as the USSR celebrated the 220th anniversary of the Academy of Sciences, many foreign scientists attended the jubilee celebration, including such physicists as the Joliot-Curie couple, F. Perrin and P. Auger from France; I. Langmuir from U. S.; and E. N. Andrade and M. Born from England. To the sincere dismay of Soviet theorists Dirac, Peierls, and several others were miss-

ing from the English delegation. Later we learned the reason for this was their participation in classified uranium research. For instance, Dirac studied the problem of heavy element isotope separation (theoretical aspects of centrifugal separation).

Many years passed and finally, after a nearly 20-year-long absence, Dirac visited our country again in 1957. He traveled to Moscow, where he saw old friends at the Institute of Physics Problems and at Moscow University; to Leningrad, where he visited the University and the Physicotechnical Institute, gave a talk, met V. A. Fock, and arranged for a Russian translation of the latest (fourth) English edition of his *Principles*.

On October 9, 1957, in the main lecture hall of the All-Union Society for the Dissemination of Political and Scientific Knowledge [as the "Znanie" (Knowledge) society was known then] Dirac gave a lecture on the topic of "Electrons and Vacuum".<sup>11</sup> In addition to other topics, he developed the concept of vacuum polarization, which he first sketched out already in his report at the First All-Union Nuclear Physics Conference in Leningrad (1933). He began the lecture with the words: "I am glad to be in the Soviet Union and to meet Soviet physicists, whom I know well and whose work I hold in high esteem" (Ref. 11, p. 3).

There is no room here to recount the content of that (and other) Dirac talks that he gave for Soviet audiences. It suffices to mention one example which illustrates Dirac's master of the lecturer's art. When discussing the notion that physicists must study the laws of electron motion and interaction with other particles, Dirac remarked: "I think there is a fruitful analogy between problems facing physicists and the game of chess. The various particles considered by physicists are akin to different chess pieces. Quite naturally, it is immaterial what the chess pieces are made of—wood, ivory, or a symbol of paper,—what counts is how these pieces can move. In order to follow a game of chess and understand the various positions it is quite sufficient to understand the laws of the pieces' motion. Analogously, all we need to know in atomic physics is the law of motion of various particles" (Ref. 11, p. 12).

Interestingly, it is possible that this chess analogy was born in Dirac's mind precisely during that Moscow visit. I. D. Rozhanskii remembered that in those days Dirac regularly attended the Botvinnik-Smyslov match and was quite caught up in the struggle for the world championship.

The 1957 visit was followed by two more: in 1965 and 1973.

I would like to conclude this paper by recalling this last visit which is quite clear in my own memory. Not long before Dirac's arrival in Leningrad a request by P. L. Kapitsa was passed on to me to meet the guest at the train station and accompany him to the Physicotechnical Institute, where he was to give a talk. I was very pleased by Petr Leonidovich's request, for I then had the opportunity to meet Dirac, whom I remembered vaguely and heard so much about.

I approached the meeting with two new—as compared to the pre-war—impressions. The first, older one had to do with Dirac's Leningrad visit in the fall of 1957 and fitted in with the notion of a "wise eccentric." I was out of town in 1957, but I did save a letter about Dirac visiting our house and reminiscing about old times and friends. The posthumous edition of my father's *Principles of Atomic Nuclei* had



FIG. 5. P. A. M. Dirac. A portrait by Ya. I. Frenkel' (oil), 1936.

been recently published and my mother wanted to present a copy to Dirac. In response Dirac reasonably said that perhaps she should not, as he knew no Russian. Certainly my mother knew that and the gift was meant to be purely symbolic. Summing up the episode she wrote: "Dirac is still the same lovable eccentric."

The second impression was born in 1967 when the book devoted to reminiscences about Niels Bohr came out in our country.<sup>12</sup> Dirac was one of the authors and his several pages made the strongest impression on me, an impression that did not change one whit as I reread his article now. These pages testified to Dirac's acute perception: he perfectly remembered and recounted examples that illustrated Bohr's credo and worldview, the external and "internal" aspects of his personality. I cannot resist at least one quotation from Dirac's contribution: "when considering abstract philosophical problems Bohr always paid particular attention to the possible duality of interpretation implicit in the very meaning of words. This duality could determine the truth or falsehood of a proposition. Bohr thought that the highest wisdom must always be expressed in words that cannot be interpreted in a unique fashion. Consequently, the truth of highest wisdom is not absolute, but rather is relative with respect to one of the meanings contained in the words' duality; the opposite proposition is thus equally true and wise. Bohr illustrated this by the following example: 'There is a God' is an expression of ultimate truth and wisdom and, conversely, 'There is no God' is also an expression of ultimate truth and wisdom" (Ref. 12, pp. 24–25).

And so, on a fresh July morning in 1973 I drove up to the Moscow railway station where, as it turned out, Dirac was awaited by Vladimir Aleksandrovich Fock and several others. We knew the number of the car in which Dirac was traveling with his wife. As the train appeared in the distance, a warm shower started. Passengers disembarked from the cars but the Diracs were nowhere to be seen. Just as we began to worry, there appeared Professor A. F. Andreev (from the theoretical department of the Institute of Physics Problems) who accompanied Dirac on his Leningrad trip and told us that Dirac and his wife rode in a different car. We all moved to meet him and then I saw Dirac. I would say he looked touching: he wore a raincoat while the head was protected from the rain by a plastic kerchief which oddly contrasted with his moustache and, indeed, his entire figure. Introductions were made. When my turn came Dirac calmly remarked that I changed a great deal over the forty years that passed since he met me as a small boy. He invariably introduced his wife, Mrs. Manci Dirac, who charmed us immediately with her simplicity and friendliness, with the words: "Allow me to introduce to you 'Wigner's sister'" (the reference is to the well-known theoretical physicist).

The Diracs were lodged at the "European" hotel. They drove there in the minivan that was intended for their luggage, bypassing the many private cars that came to meet them at the train station. The Diracs, as well as part of the welcoming party, took over the minivan and drove to their hotel on Brodsky street by the way of Nevsky prospect aglow after the rain.

Dirac's report at the Physicotechnical Institute was devoted to problems of general cosmology. The audience gathered in the assembly hall of the Institute was most struck by the question of universal constants and their dimensionless

combinations. Dirac's conclusion is now famous: he formulated the "hypothesis of large numbers" among the consequences of which is the diminution of the gravitational constant with time. Dirac at the time was quite hopeful of an experimental verification of this conclusion that could arise from an accurate measurement of the Mars orbit.

The day the Diracs arrived in Leningrad V. A. Fock arranged for them and A. F. Andreev to visit at his house. Vladimir Aleksandrovich was so kind as to invite me to come along. He lived in the famous academic building on Vasil'evskii Island. In Leningrad that building is known as the "house of cast iron plaques" because of over twenty memorial plaques on the façade that honor the scientists who once lived there. That evening Dirac looked rather tired at first. V. A. Fock wanted to photograph him. Mrs. Dirac looked at her husband, who sat meekly in front of the camera, and said: "Paul, why are you so sad? Come now, smile. Think of Kapitsa!" Dirac's face lit up with a kindly smile and Mrs. Dirac explained: "Professor Kapitsa was such a kind and merry man; Paul loves him so!"

Over dinner the conversation turned to the tragedy that befell Leningrad during the blockade years and to the war. At the time M. Born's book *My Life and Views* had just come out.<sup>13</sup> I recalled the frightening numbers cited by Born who wrote in his book: "In World War I, the total number of killed was approximately 10 million,—95% of whom were soldiers and 5% civilians. In World War II over fifty million were killed, comprising almost equal numbers of soldiers and civilians (52% to 48%). During the war in Korea of the nine million dead 84% were civilians and only 16% soldiers" (Ref. 13, p. 151 in English original, p. 136 in Russian translation). Clearly nuclear war that had come to threaten humanity would increase this disparity even further: the overwhelming majority of the victims would be civilians. The only way out is to make war impossible. Everyone became gloomy. A moment later Dirac said: "The tendency noted by Born allows for another means of escape: in order to survive one must become a soldier!" His paradoxical, albeit sad joke lightened the tension and the conversation picked up again. I remember returning from Vasil'evskii Island to the hotel. The weather was perfect and the Diracs let the awaiting car go. The night was white and clear. We crossed the Lieutenant Schmidt Bridge and walked along Neva's left bank, passed the Bronze Horseman, and then



FIG. 6. V. A. Fock and P. A. M. Dirac, Leningrad, July of 1973.





FIG. 7. Leningrad, July of 1973. From left to right: Mrs. M. Dirac, P. A. M. Dirac, A. F. Andreev (photographed by the author).

reached Nevskii Prospect by the way of the majestic St Isaac Square and Herzen Street. The peaceful town was beautiful.

The next day Diracs were our guests. Having learned of this several PTI staff gave me photographs taken during Dirac's brief conversation with the director of our institute V. M. Tuchkevich and other theorists, and then during the lecture itself. With great reluctance I promised to ask for Dirac's autograph on several of the photographs. I remembered his tired figure standing after the lecture by the iron fence that separates the PTI from the street. He was surrounded by a dense throng of people who were asking him to inscribe his Russian editions. When the Diracs arrived at our house I decided to get the unpleasant business out of the way at once. He obediently sat down at the table and signed on the back of a dozen photographs in his strikingly precise and distinct handwriting. I did not have the heart to ask him to inscribe my copy of *Principles of Quantum Mechanics*, which I regret very much today.

At the dinner table the conversation strayed onto the topic of "autograph hunters." I know a funny story about this that Otto Hahn once told me," said Dirac. "An 'autograph hunter' once approached Hahn. When Hahn signed the back of this photograph the hunter, to his surprise, presented the distinguished professor with two more copies. 'But why do you need these?' queried Hahn. 'I made a deal with a friend to trade three signed photos of you for one autograph of Schmutzer.'" Dirac explained: "Schmutzer was a boxer popular in the 1930s. 'Such'—he concluded—"is the price of fame!" That evening, as well as during his entire Leningrad stay, he did not strike me as either eccentric or reticent. He told several funny stories and then recalled warmly I. E. Tamm, my father, and several other of his Soviet and foreign colleagues. This impression was further reinforced when, a year later, in response to my request Dirac sent me a charming (I cannot find a different word for an article to be published in a serious physics journal!) letter, reminiscing of the time when in the mid-1930s he fulfilled a request of my father and braved incredible misadventures to deliver a then-rare medicine to Leningrad.

In our country collections of reminiscences about physicists written by their students, co-workers, and colleagues are becoming more and more popular. I hope this tradition will become rooted in the West as well, so we can learn more

P. A. M. Dirac  
Leningrad  
22 July 1973

FIG. 8. Facsimile of Dirac's signature.

about Dirac—a remarkable physicist and human being—through the reminiscences about him of tens of people with whom he came in contact—in science and in life—in England, U. S., Germany, Denmark, Japan, China, Australia, New Zealand. . .

Editor's Note: I have left transcriptions from the Russian everywhere as Kapitza. But when the quotation is from the English I left it in the English usage—Kapitza.

G. M. Volkoff

<sup>1</sup>I am sincerely grateful to Mrs. A. A. Kapitza, who permitted me to become acquainted with the proceedings of the Kapitza Club.

<sup>2</sup>Let us note here that although Dirac, unfortunately, did not participate in this collection,<sup>3</sup> he did write a special article for the collection of papers entitled "Problems of Theoretical Physics" dedicated to Tamm's memory.

<sup>3</sup>These opinions were expressed by V. A. Fock in the discussion following Dirac's talk, "The Theory of the Positron," given in September of 1933 in Leningrad; see Ref. 5, p. 144.

<sup>4</sup>Ya. I. Frenkel' wrote Dirac in a similar vein on May 5, 1933; see Ref. 6, pp. 353–354.

<sup>5</sup>The paper in question was by I. E. Tamm (Ref. 7).

<sup>6</sup>I am grateful to I. E. Tamm's family for making Dirac's letters to Igor' Evgen'evich available to me.

<sup>7</sup>We do not expand on this topic both for lack of space and because A. B. Kozhevnikov and T. I. Efremidze gave a report on this in Moscow.

<sup>1</sup>Manuscript department of M. E. Saltykov-Shchedrin State public library, Ya. G. Dorfman's file, No. 261, bin 10, p. 5.

<sup>2</sup>Ehrenfest-Ioffe, Scientific Correspondence (in Russian), edited by V. Ya. Frenkel', Nauka, L., 1973.

<sup>3</sup>Reminiscences about Igor' Evgen'evich Tamm (in Russian), 2nd ed., edited by E. L. Feinberg, Nauka, M., 1986.

<sup>4</sup>P. A. M. Dirac, Discrete Subgroups of the Poincaré Group, in: Problems of Theoretical Physics: Igor' Evgen'evich Tamm in Memoriam (in Russian), edited by V. I. Ritus (editor-in-chief E. L. Feinberg), Nauka, M., 1972, pp. 45–51.

<sup>5</sup>The Atomic Nucleus: Collected papers presented at the First All-Union Nuclear Conference (in Russian), edited by M. P. Bronshtein, V. M. Dukel'skii, D. D. Ivanenko, and Yu. B. Khariton, GTTI, L., M., 1934.

<sup>6</sup>Ya. I. Frenkel'. Reminiscences, Letters, Documents (in Russian), edited by V. M. Tuchkevich, Nauka, L., 1986.

<sup>7</sup>I. Tamm, Nature **133**, 981 (1934).

<sup>8</sup>P. A. M. Dirac, *The Principles of Quantum Mechanics*, 4th ed., Clarendon Press, Oxford, 1958 [Russ. transl., Fizmatgiz, Moscow, 1960].

<sup>9</sup>P. A. M. Dirac, *The Principles of Quantum Mechanics*, 1st ed., Clarendon Press, Oxford, 1930 [Russ transl. as *The Foundations of Quantum Mechanics*, GTTI, M., 1932].

<sup>10</sup>V. Ya. Frenkel', First All-Union Nuclear Conference, in: A. F. Ioffe Memorial Readings, 1983 (in Russian), edited by V. M. Tuchkevich, Nauka, L., 1985, p. 74.

<sup>11</sup>P. A. M. Dirac, *Electrons and Vacuum* [Russ. transl., Znanie, M., 1957]. This paper is more readily available in a Czech translation: *Elektrony a Vakuum, Pokroky matematiky, fyziky a astronomie* **4**, 309 (1959).

<sup>12</sup>Niels Bohr: *Life and Works* (in Russian), edited by B. G. Kuznetsov, Nauka, M., 1967.

<sup>13</sup>M. Born, *Physics in My Generation*, Springer-Verlag, New York, 1969 [Russ. transl. as "My Life and Views," Progress, M., 1973].

Translated by A. Zaslavsky