FROM THE HISTORY OF PHYSICS

The discovery of superfluidity. Letters and documents

(On the 60th anniversary of the discovery of superfluidity)

P E Rubinin

On December 3, 1937 P L Kapitza sent a brief note to the "Doklady [Reports] of the Academy of Sciences of the USSR" and to "Nature", in which he announced the discovery of superfluidity [1]. 'Nature' published this note in 'Letters to the Editor' on January 8, 1938, together with the letter from his former laboratory in Cambridge [2]. The results reported in the communication of J F Allen and A D Misener from the Mond laboratory were very close to those obtained by Kapitza.

The publication date of these two announcements in "Nature" may well be regarded the birthday of an outstanding discovery of our century, which started a new branch of science — the physics of quantum fluids.

Kapitza recognized at once the importance of his discovery. In a popular lecture in December 1940 he said, "It was for the first time in my life that I discovered such a fundamental property of matter. I did a lot of experiments in different areas, but this was a matter of good or bad luck. When the chance came by, one should not have missed it".

This documentary chronicle will allow the reader to appreciate the measure of Kapitza's 'good luck', and the long and thorny road to the 'chance' that he did not miss...

Many of the documents presented here are filed in the Kapitza Archive at the Institute for Physical Problems of the Russian Academy of Sciences, and are published for the first time. The from Bohr's letter to the Nobel Committee for physics of 29 January 1947, in which he nominates Kapitza for the Nobel Prize for 1947, is reproduced here courtesy of the Niels Bohr Archive in Copenhagen.

1. From the letters of Kapitza to his mother¹

Cambridge,

19 April 1934

My dear Mother,

I am writing only a short letter to you today, just to share my joy. Today I managed to produce liquid helium by a new method on which I have been working exactly 13 months and 14 days. This is a big achievement in the area of low temperatures. By this method it is possible to get liquid helium ten times more economically than before, and much faster. The main thing, however, is that it is no longer

P E Rubinin P L Kapitza Institute for Physical Problems of the Russian Academy of Sciences, ul. Kosygina 2, Moscow 117973 Russia Tel. (7-095) 137-32 30 E-mail: rubinin@kapitsa.ras.ru

Received 24 September 1997 Uspekhi Fizicheskikh Nauk **167** (12) 1349–1360 (1997) Translated by A S Dobroslavskiï; edited by M S Aksent'eva necessary to use liquid hydrogen as the cooling medium, just liquid air. This makes the entire process safer and simpler. I have been very close to the realization of this technique for the past 2 or 3 months, and this has made me work so tirelessly and write little to you lately. I shall write a long letter soon $\langle \ldots \rangle$ (Ref. [4])

New Forest,

14 May 1934

... Two or three days ago I finished my experiments on the liquefaction of helium, and the preliminary results were published the day before yesterday²

... I will try now to explain to you the essence of my work. You see, in order to obtain low temperatures, liquefied helium is used as a coolant. This gas is the hardest to liquefy, and its temperature when it is liquefied is -269° Celsius or 4.2° absolute [scale] (-273.2° is absolute zero or theoretically the lowest possible temperature). So far the liquefaction of helium had been achieved through a very complicated process. It was necessary to have liquefied hydrogen and liquid air in large quantities. the so-called Thomson–Joule effect was used for liquefaction. It is a secondary thermodynamical effect. $\langle ... \rangle$ The yield of liquid helium was very low, 1% of that possible theoretically. Is was impossible to get the full yield, because this would require using a primary effect rather than a secondary phenomenon like the Thomson–Joule effect.

There is only one such phenomenon, known as the adiabatic expansion of gas. Essentially, the compressed gas must be made to do some work at low temperature. Then it will be liquefied with a very high efficiency. The problem is that at such low temperatures everything is solidified, and it is impossible to find lubricants to make any mechanism work. Everything freezes up.

Strange as it is, all attempts to overcome this difficulty have so far been unsuccessful. Now, at last, I have managed to design and build a mechanism which can be used to make gas do work at any temperature, however low it may be³. As a

¹ Kapitza Olga Ieronimovna (1866–1937), specialist in children's literature and folklore, professor of the A I Herzen Pedagogical Institute in Leningrad.

² Reference here is made to Kapitza P L "Liquefaction of helium by an adiabatic method without pre-cooling with liquid hydrogen". *Nature* **133** 708 (1934).

³ In a popular article published in the same year Kapitza wrote, "We abandoned the idea of using a lubricant or even a tight piston. Our piston moves quite freely inside the cylinder, thus allowing the compressed gas to flow through the gap between cylinder and piston. However, the machine is so designed that the amount of gas escaping through the gap during this brief interval does not exceed 2-3%" (Ref. [5]). In other words, Kapitza used gaseous helium as the lubricant.

23 October 1934

result, the yield is 10 times as high as it used to be. The main thing is that it is no longer necessary to use explosive and costly liquid hydrogen. While until now the liquefaction of helium could be carried out only in 2 or 3 specially equipped laboratories, I hope that from now on it will be possible to do it everywhere at minimal cost.

So you see, my dear, that this work of mine does not have, so to say, the merit of a scientific discovery, and is solely concerned with a technical simplification⁴ of one of the most complicated experimental processes, and one of the most important for studying processes in solids. Now my next step, the most important and the most interesting, will be to combine these low temperatures with strong magnetic fields. I shall just take a rest and then get down to this.

In all likelihood, this autumn we shall come over to you $\langle \ldots \rangle$ (Ref. [4])

Pyotr Leonidovich and his wife Anna Alexeevna came to Leningrad in early September 1934, having taken a car tour of Scandinavia. Kapitza took part in the International congress dedicated to the centenary of Mendeleev, and then went to Kharkov where for a few days he familiarized himself with the work being done in the Ukrainian physico-technical institute, where he had served as a consultant since 1929; he spoke of his works, including the new helium liquefier, which very much interested the cryogenists in Kharkov.

On the 24th of September Kapitza was summoned to Moscow, to the Kremlin, where he was told that he would not be able to return to England: now he was to work in the USSR. Anna Alexeevna returned to Cambridge in early October, to the children. Pyotr Leonidovich stayed with his mother in Leningrad.

2. Kapitza to his wife

Leningrad,

5 October 1934

 $\langle \ldots \rangle$ I am writing to you on the third day after your departure instead of having written on the second $\langle \ldots \rangle$ Now I shall start a tale of myself, although nothing of interest has happened in these days. $\langle \ldots \rangle$ On the 4th I started my day with a walk to the Botanical Garden. Went to see the conservatory, the guide was an old man who gave very good explanations. Then, after breakfast, I began my studies. I bought Pavlov's book on conditional reflexes and am occupied with them now.

My mood is much better, although melancholic. But somehow I even feel happy. As a matter of fact, I no doubt got run down in the past months in Cambridge, staging the helium experiments, and then this tour of Scandinavia and all the rest, and now this forced vacation is good for me $\langle ... \rangle$ (Ref. [4])

3. Kapitza to Ernest Rutherford

Leningrad,

Dear Professor,

I am gradually recovering from the shock. You know probably all about it from Anna, this is why I have not written you before. Thank you very much indeed for all your kindness and also for the help to keep an eye on my boys in the lab. There are only two things necessary. First, to Keep Milner from making too mary gadgets $\langle ... \rangle$. And the second to tell Shoenberg that the experiment is more importent than the theory⁵... And this is all. I will try to do remainder by the post...(Ref. [12] p. 166)

4. Kapitza to his wife

Leningrad,

2 November 1934

2 November 1934

 $\langle \ldots \rangle$ Yesterday I went to Ivan Petrovich [Pavlov]. $\langle \ldots \rangle$ We had a good talk. He is willing to give me the opportunity to work in his laboratory, and as soon as I get ready I will start experiments on the mechanics of muscles. $\langle \ldots \rangle$

Indeed, you cannot imagine how little we know about how muscles work. The direct conversion of chemical into mechanical energy is only observed in the animal nature. $\langle \ldots \rangle$ Of course, this problem need not be resolved by a physiologist. All you need to know is the structure of the muscle, and this can be learned very quickly. Ivan Petrovich also believes that in 2 or 3 months a physicist can get sufficiently prepared for this problem, and welcomes this job $\langle \ldots \rangle$ An even greater advantage is that there is no need for space and a large laboratory, and I will be able to start everything by myself $\langle \ldots \rangle$ (Ref. [4])

5. Kapitza to V I Mezhlauk⁶

Leningrad,

Comrade V I Mezhlauk,

In reply to your request of 26 October (handed to me only on the evening of 31 October), I am writing to inform you about the scientific work I propose to carry out in the USSR. As you know, my main work up to now has been in the field of cryogenic magnetic research and was performed in my Cambridge Institute. These are some of the most technically complex investigations of contemporary physics and demand an exceptionally well equipped technical base and highly qualified supporting personnel. In Cambridge I developed my work over 13 years⁷, and my colleagues developed their expertise in the course of constructing the unique and original apparatus with which my laboratory was equipped. I had at my disposal the services of the British industry, which, owing to the crisis, was willing to carry out individual orders.

To begin this work afresh the whole laboratory must be recreated. Without carefully selected and specially trained

⁴ Nevertheless, the Nobel Prize for physics was awarded to Kapitza also for this 'technical simplification' in 1978. Professor Lamek Hulthén (Swedish Academy of Sciences), who introduced the laureates in physics at the Nobel Prize celebration on December 10, 1978, in his speech about the Kapitza's works said, 'Foremost among his works $\langle ... \rangle$ stands an ingenious device for liquefying helium in large quantities — a prerequisite for the great progress made in low temperature physics during the last quarter century' (Ref. [6], p. 21).

⁵ David Shoenberg and Christopher Milner were research students in Moud Laboratory. Their recollections about Kapitza can be found in Ref. [7].

⁶ Mezhlauk Valery Ivanovich (1893–1938), in 1934–1937 Deputy Chairman of the Council of People's Commissars of the USSR, Chairman of State Planning Committee of the USSR.

⁷ In the original mistakenly '14 years'

assistants and mechanics, without the technical drawings, data, etc., and under my sole guidance it would take several years of intensive work in any country to do this, and only if there was good support from industry. In the Soviet Union, where technical resources are extremely overloaded, many materials are unavailable, and above all, in the absence of trained assistants, I do not see the possibility of taking the responsibility for scientific research similar to that I worked on in Cambridge. As I have already told you, the only possibility of achieving this would be to send young scientists to work with me in my laboratory and so gradually transferring the technical expertise from Cambridge to the Soviet Union. I should like to remind you that over the last two or three years I have more than once suggested that some of our young Soviet scientists should be sent to work with me, and I offered to give them priority over several other foreigners wishing to join me. $\langle \ldots \rangle$ To my great regret this was not accepted. In the present circumstances I definitely do not consider it possible to undertake the creation of a new laboratory, and I have therefore decided that my work in the Soviet Union should be in a different field.

In fact I have long been interested in the so-called biophysical phenomena of living nature which are amenable to study using physical laws. In particular, I am interested in the mechanism of muscular action. Since this field lies at the boundary of two fields of knowledge, it has always been somewhat neglected in spite of its great scientific interest. In recent years A V Hill and his school have made considerable advances in this field, as was recognized by the award of a Nobel Prize a few years ago. My close acquaintance with Hill, who often consulted me on questions of physics, gives me the opportunity of getting to know the direction in which his work is going and its methodology. No one is working on these problems in the Soviet Union, and since they do not require any enormous or powerful apparatus, but only sensitive and accurate instruments, I propose to enter this field. Moreover, Hill, who is a specialist in mathematics, has somewhat overemphasized the thermodynamic aspects of muscular processes and left the physical aspects — just those that interest me - on one side. I have also consulted IP Pavlov and found that he approves the general trend of my proposals, which he finds interesting, though he has never worked on these problems himself. Moreover, Ivan Petrovich [Pavlov] has amiably agreed to provide space for me and the necessary technical facilities in his laboratory. As soon as I have finished studying the essential literature, I shall start experimental work. $\langle \dots \rangle$ (Ref. [12], pp. 317, 319).

6. Rutherford to Niels Bohr

Cambridge,

6 December, 1934

My dear Bohr,

You may have heard the news about the retention of P Kapitza in Russia, but I had better give you the information we have.

Kapitza and his wife went to Russia in the summer with return visas, and he gave some lectures in the University of Kharkov and attended the Mendeleev Conference⁸. A few days before his return, he was peremptorily summoned to Moscow and told they wished him at once to work on Physics problems in Russia. $\langle \ldots \rangle$ He was refused his passport, but Mrs Kapitza was allowed to return to England to look after his affairs.

On hearing of this from Mrs K., I wrote an unofficial letter to the Russian Ambassador⁹ here to explore the situation, and I enclose herewith copies of my letter and of his reply¹⁰. From this you will see that he definitely states that K. as a Soviet citizen is required to stay in Russia. Various informal representations have been made by interested parties to see what can be done about the matter, but no indication has been received of any change of view of the Soviet authorities.

We held a meeting of the Mond Laboratory Committee a few days ago and reported the situation to the University and to the Royal Society, suggesting that Kapitza should be given leave of absence for one year in order to give time for further negotiations. I have little doubt that both the University and the Royal Society will move in the matter and make representations both here and in Russia to the appropriate authorities.

While it is quite clear that as a Soviet citizen, the U.S.S.R. has a complete right of using K's services as it thinks fit, yet the present situation is very unfortunate for the relations between English and Russian Science. They have been well aware throughout of Kapitza's work, and allowed him to be made a Royal Society Professor and to be responsible for the building of a special Mond Laboratory¹¹ without any indication that his services would be required in Russia. As soon as the new laboratory is in working order and Kapitza is about to reap the fruits of the organization and services, he is summarily required to drop his work in England and work in Russia. $\langle \ldots \rangle$

Of course, I have always had at the back of my mind the probability that K. would return to Russia eventually, but it is exceedingly awkward for him and for us to leave his laboratory and his research students¹² in the air in this way. I think that K. feels he has been badly treated, and I believe has definitely refused to undertake any work in physics until he is allowed to return.

In the meantime, I understand he has started work with Pavlov on Physiology $\langle ... \rangle$ In the meantime I have taken charge of the laboratory to keep things running for a year to give time for discussion and consideration. $\langle ... \rangle$ (Ref. [10])

On December 1, 1934, Kapitza, who stayed with his mother in Leningrad, received a telegram from V P Volgin, the Permanent Secretary of the Academy of Sciences of the USSR: "Please attend meeting fourth December wire [your] consent". The meeting took place at the Presidium of the Academy on the 10th of December. It was attended by the

⁹ In 1932–1943, the Plenipotentiary Representative (ambassador) of the USSR in Great Britain was Ivan Mikhaĭlovich Maĭskiĭ (1884–1975).

¹⁰ A Russian translation of Rutherford's letter to I M Maĭskiĭ of 12 October 1934 is reproduced in the article by V D Esakov entitled "Why P L Kapitza was not allowed to travel abroad" (Ref. [9]). The reply of I M Maĭskiĭ of 30 October 1934 can be found in Ref. [7], p. 383.

¹¹ In November 1930, the Council of the Royal Society in London allocated Z 15,000 from the funds bequeathed by L Mond, a chemist and businessman, to the establishment of a laboratory in Cambridge for P L Kapitza. He was appointed a research professor of the Royal Society and Director of the Mond Laboratory. The grand opening of the Laboratory took place on February 3, 1933.

¹² Reference here is made to David Shoenberg and Christopher Milner. Also, the physicists H Niewodnichanczanski from Poland and H A Boorse from the United States came to Cambridge in the autumn of 1934 to work with P L Kapitza.

⁸ The International Mendeleev congress, dedicated to the centenary of D I Mendeleev, took place in Leningrad on September 11–13, 1934.

Academicians A N Bakh, S I Vavilov, V P Volgin, I V Grebenshchikov, G M Krzhizhanovskiy and N N Semenov. The meeting was concerned with the prospects of Kapitza's work in the USSR.

On December 11 Pyotr Leonidovich wrote to his wife in Cambridge: 'Am writing to you from Moscow, where I have already been talking for 3 days without any particular results. ... I am writing in a haste, must go to talk again. I have to find out whether they agree to buy out the laboratory and all the rest' (Ref. [4]).

On the same days Kapitza writes in his letter to V I Mezhlauk: 'In order to transfer all the technical experience and recreate my laboratory here, I consider absolutely necessary the availability of all the technical data stored in the archives of the laboratory; secondly, the purchase and delivery here of all the instruments and apparatus which were built from sketches, and detailed information which is not available in the archives of the laboratory. Finally, invitation to the [Soviet] Union of my two principal foreign specialists for the start-up period of work in the laboratory, not exceeding 3 or 4 years. It will be not easy nor cheap to get all this, but with the correct and proper appeal to Cambridge University through Prof. Rutherford, I believe, all this is not impossible. In any case, I am willing to do my best for the success of these negotiations (...) (Ref. [8], pp. 33, 34).

On December 21, 1934, the issue of Kapitza was discussed at the meeting of the Politbureau of TsK VKP(b) [Central Committee of the All-Union Communist Party of the Bolsheviks].

7. Decision of the Politbureau of TsK VKP(b)

21 December 1934

186. On Kapitza

1. Establish the Institute for Physical Problems within the Academy of Sciences of the USSR.

2. Appoint Prof. Kapitza P L Director of the Institute...

3. Charge Comrades Kaganovich, Yagoda¹³ and Mezhlauk V. with selecting within two days a candidate for the Deputy Director of the Institute in charge of procurement and administration, and staff the Institute with research workers¹⁴.

5. Charge the Council of People's Commissars with organizing the construction of the laboratory of the Institute with a view to completing the task in September 1935...

9. Charge the People's Commissariat for Heavy Industry (Comrade Pyatakov¹⁵) with giving all assistance to Kapitza in manufacturing the necessary equipment in the USSR.

¹⁵ Pyatakov Georgy Leonidovich (1890–1937), in 1934–1936 First Deputy of the People's Commissar for Heavy Industry of the USSR.

Allow Kapitza to invite two assistants from the Cambridge laboratory for 2 or 3 years.

10. Charge Comrade Mezhlauk V, the People's Commissariat for Foreign Affairs and People's Commissariat for Foreign Trade with considering the issue of the possible purchase of equipment and drawings of Kapitza's laboratory from Cambridge University.

Execution to be supervised by Comrade Mezhlauk V (Ref. [9] p. 552)

8. From letters of Kapitza to his wife

Moscow,

26 January 1935

... Take a close look at how the industry is organized, and the disorder scares you, while in reality everything works, cities are growing, factories, machinery, like never before. So perhaps our fate is confused and absurd, but will something emerge for our science after all?

The main thing is not to stay passive and idle. I will completely move to physiology only when I see that there is nothing I can do for our science in the mainstream of my expertise. Therefore I am taking every opportunity to recreate my laboratory here ... (Ref. [4])

cow	8 March 1935
	0 10101011 1900

...I often see my laboratory in my dreams, and painfully want to work... (Ref. [4])

Moscow

Mos

...Got a letter from John¹⁶. They want to start up my helium liquefier. I am a little worried that they will not manage without me, and it will break down. Tell him about it... It is infinitely sad that somewhere else people are working with my ideas, and ours [bosses], instead of being proud of their comrade's achievements, only torture his soul... (Ref. [7] p. 385)

Moscow

31 March 1935

11 March 1935

...I feel everything turning upside down inside me:they deign to receive me, or they do not; they keep me waiting at the door for an hour and a half, or they do not; they will let me go abroad, or they will not... In a word, like a piece of dogshit on the sidewalk — kicked around by passers-by, swept away by a cleaner... (Ref. [4])

Moscow

13 April 1935

...My life now is marvelously empty. At times I clench my fists and am ready to tear my hair and go berserk. With my instruments, with my ideas, in my laboratory other people live and work, and I am sitting here alone, and I do not understand whoever needs this. I want to shout and break chairs. Sometimes I feel my mind is going... (Ref. [7] p. 386).

¹³ Kaganovich Lazar Moiseevich (1893–1991), Stalin's deputy in the Party in the mid-1930s; Yagoda Genrikh Grigorievich (1891–1938), People's Commissar for Internal Affairs in 1934–1936.

¹⁴In spite of its omnipotence, the 'triumvirate' could fulfil this assignment only in part: L A Ol'bert was appointed as the 'Red' Deputy Director, who had earlier been in charge of establishing and running of the Optical Institute in Leningrad (the Research Director of which was S I Vavilov). Kapitza, however, did not get into step with Ol'bert, and the latter left the Institute in February 1936, being succeeded by Kapitza's protege O A Stetzskaya. As for the 'research workers', the physicists 'assigned' to the Institute by Decision of Politbureau of January 2, 1935 (B M Vul, M A Divil'kovskiĭ and V V Gey) were never on the payroll of the institute (Ref. [9] p. 552).

¹⁶ Cockcroft, Sir John Douglas (1897–1967), since 1925 worked in the Cavendish Laboratory where Kapitza was his first research supervisor. Was Kapitza's assistant in the Magnetic Laboratory in the Cavendish and his deputy in the Mond Laboratory. One of Kapitza's closest friends during his Cambridge years. In 1935–1946 Director of the Mond Laboratory, in 1946–1959 Director of the nuclear research center in Harwell.

Moscow

21 May 1935

...You are sending *Nature* to me, which arrives regularly. I cannot read the articles which relate to my work, they drive me half-crazy. You know, I understand the state of those addicts who are deprived of their hash. I understand that people may go mad, but I never thought I could be driven into such a frenzy by being left without my research work... (Ref. [4])

Moscow

31 May 1935

...V I [Mezhlauk] believes that the purchase of the lab is just a matter of money. It would be hard to think of a more absurd approach. He tells me, "They'll ask 200 thousand, we'll offer 10. And we'll meet somewhere in between". I warned him from the outset that he is wrong. Mai[skiy], it seems, is not much subtler... (Ref. [4])

The negotiations of the Soviet embassy in London with Rutherford on the purchase of equipment of the Mond Laboratory came to a stalemate. Above all, this happened because our authorities were unwilling to admit Kapitza to these negotiations. Rutherford, on his part, did not want to help anyone but Kapitza. As he wrote to Kapitza on September 25, 1935, "my sense of gratitude to the USSR is not particularly strong" (Ref. [7] p. 398). In the meantime in Moscow, on the Vorobyovy Hills, was going at full speed the construction of the laboratory building of the Institute for physical problems specially designed by Kapitza to house the equipment from his Cambridge laboratory.

Kapitza's battle with the Soviet state machine was lingering on, driving him sometimes to the verge of nervous breakdown, as we can see from the excerpts from his letters. His friends and relations feared for his health. The powersthat-be also got their due. Here is Kapitza's account of his 'conversation' with V I Mezhlauk: "...Perhaps I was speaking too bluntly, and V.I. started back in his seat a few times, but I could not have acted otherwise; all that had been building up for so long inside me suddenly burst out, 'he wrote to his wife in March 28, 1935.' V.I. said that he had only heard the expressions I used when serving in the army. He obviously did not like my speech, and perhaps I ought to have been more restrained, but I could not hold it any longer — after all, there is a limit to one's nerve. Let them do what they want..." (Ref. [4]).

All the same, Kapitza was adamant: if they buy out his laboratory from the British and invite his assistants from Cambridge to Moscow, he would work on physical problems. If not, he would switch to physiology...

On June 28, 1935, he wrote to his wife, "So far I am thinking of continuing my work in physiology. $\langle ... \rangle$ You tell Ruth[erford] I'll make a very good biophysicist..." (Ref. [4])

9. Decision of the Politbureau of TsK VKP(b)

22 August 1935 'Special File'

303. On the Institute for Physical Problems

Approve the proposal by Comrade Bauman¹⁷ concerning the purchase of the English laboratory for the Institute for Physical Problems, allocating the requested funds limited to 30 thousand pounds sterling, and also authorizing the exchange of appropriate letters between Kapitza and Rutherford with a view to the deal being concluded on behalf of the Government of the USSR.

Excerpt forwarded to Comrade Molotov¹⁸ (Ref. [9] p. 553).

10. Rutherford to Kapitza

25 September 1935

My dear Kapitza,

Chantry Cottage,

...I think I ought to make clear to you the general attitude of the Univ., R.S., etc. with regards to your work. $\langle ... \rangle$ Youdid the best you could with the facilities given you... You have added a new department of work in the Cavendish Lab and this will continue, but no doubt with much less distinction than if you were present to guide it.

As the Mond Lab will continue to be devoted to low temperature work, it is essential to have hydrogen and helium liquefiers available. As I mentioned above, I should be only too glad to help you by arranging for duplicates to be made of any apparatus in the Lab you require. As soon as the duplicates are available, we could arrange to send you either the original or the duplicate, as you prefer, provided the whole cost is financed by the USSR. $\langle ... \rangle$ I know that Cockcroft will be very pleased to get any special things you require from this country to equip your Laboratory... (Ref. [7], pp. 397–399).

11. Decision of the Politbureau of TsK VKP(b)

25 September 1935 'Special File'

266. On Kapitza.

Suggest that Comrade Rabinovich¹⁹ should help the Embassy of the USSR in London in negotiations with Rutherford²⁰ on the sale of the laboratory to Kapitza (Ref. [9], p. 553).

12. Rutherford to F Ya Rabinovich

Cambridge

5 October 1935

Dear Mr. Rabinovitch,

I thank you for your letter, which I received yesterday, and at the same time I received an official statement from the U.S.S.R. Embassy. These will be quite sufficient for University purposes.

I have arranged to call a special meeting of the Managing Committee of the Royal Society Mond Laboratory to consider the proposals you put before me. This is an essential preliminary before bringing the matter to the formal attention of the University, which has the final decision in all these matters.

¹⁸ Molotov Vyacheslav Mikhaĭlovich (1890–1986), in 1930–1941 Chairman of the Council of People's Commissars [Prime Minister] of the USSR.
¹⁹ Rabinovich Filipp Yakovlevich (1885–1937), since 1929 Head of Exports Department at the People's Commissariat for foreign trade of the USSR. Closely acquainted with Academician A N Krylov, and well disposed towards Kapitza.

²⁰ Name 'Rutherford' misspelt in the Russian text.

¹⁷ Bauman Karl Yanovich (1892–1937), in 1935–1936 Head of Department of science, scientific and technical inventions and discoveries of TsK VKP(b).

1254

1 December 1935

I am at present uncertain how the University will regard the matter, and there are certain obvious difficulties, but I will do my best to see that we can make some arrangement convenient to all the parties concerned. As I told you, I am naturally very anxious to give a helping hand to Kapitza to start up his work in Russia...

I was very pleased to meet you and to know that you are deeply interested in Kapitza's welfare...

Cambridge,

8 October 1935.

Dear Mr. Rabinovitch,

A special meeting of the Committee of the Royal Society Mond Laboratory was held yesterday and discussed the question of the purchase of certain apparatus in the Laboratory by the Russian Government. With a view to helping Professor Kapitza to begin his investigations in Russia, they agreed to recommend to the University that the transfer of apparatus should be favorably considered, at a total cost of Z30,000. They will report in this sense to the Council of the University this week, and if the Council agrees, they will report to the Senate of the University to gain its approval.

I am informed by the Vice-Chancellor of the University that even if there is no opposition to the scheme, the necessary authority cannot be given before Christmas of this year, and if there are any objections raised it may take somewhat longer. At the same time, I was asked to inform you that it is not anticipated that any serious difficulty will arise...

The question of the assistants, Mr. Laurmann²¹ and Mr. Pearson²² was also discussed at the meeting, and it was agreed that no pressure should be brought on them to stay in Cambridge if they were willing to go to Russia to help in the laboratory of Professor Kapitza...

You will, of course, understand that the University will expect a written statement that Professor Kapitza will remain in control of the apparatus transferred for as long as he wishes. The transfer is only made to help Professor Kapitza to continue his work in Russia.

For the sum mentioned above, the apparatus to be transferred will consist of either the originals or duplicates of the greater part of the research apparatus in the Laboratory...

In order to expedite matters, I am prepared at once, at my personal expense, to arrange that work should be started on the duplication of the helium liquefier... (Ref. [4])

13. Paul Dirac²³ to Kapitza

Cambridge,

Dear Peter.

13 October 1935

...Negotiations here are being pushed forward as rapidly as possible. I am afraid it will not be possible to satisfy all your

 23 Dirac, Paul Adrien Maurice (1902–1984), was one of Kapitza's closest friends. In 1935, wishing to support his friend, he cancelled his trip to the Caucasus with I E Tamm and spent all summer with Kapitza in Moscow

wishes completely. The liquid helium plant is being very much used now — also in the physical chemistry department — and people here are unanimous that there must be no interruption in the supply of liquid helium. However, they will make a duplicate plant as quickly as possible. (Pearson thinks he can do it in two months.)... (Ref. [11] p. 122)

14. Kapitza to Stalin

Moscow,

Comrade Stalin,

I have been informed that yesterday the Senate of Cambridge University gave its final approval for the transfer of my laboratory to the [Soviet] Union, and the despatch will start within the next few days. Now that I am to continue my scientific research in my country, I want my work here to be most efficient and no less successful than it used to be in Cambridge. I am writing this letter to you because I am sincerely afraid that under the present circumstances this is not possible, and I am confident that no one but you can amend the existing situation.

When more than a year ago I was unexpectedly detained, and my scientific research was interrupted abruptly at the most interesting point, it was very hard for me, then they started treating me badly, and these months in the [Soviet] Union were the hardest in my life. While I can see the reasons for moving my work here, I still cannot understand why I should have been treated so brutally. $\langle ... \rangle$

To continue my Cambridge work, I needed my apparatus. I explained in detail why I need it, why I cannot recreate them anew without drawings, assistants, and the like. At first they promised to purchase my equipment, but I immediately saw it was not in good faith, because when I asked for authorization to negotiate with Rutherford it was refused to me, while it was clear to me that no one else could obtain the equipment. They put me under all kinds of pressure to make me re-establish my work here from scratch, intimidated me, accused me of a lack of patriotic feelings $\langle . . . \rangle$ Finally, they demanded that I should write an obvious lie that I stayed here of my own accord. An absurd demand, since anyone who knows me would never believe that I could have left my work, my laboratory and my students without notice. $\langle . . . \rangle$

Of course, all this time I have been fighting back and defending myself as I could, trying to get my laboratory, and when eventually after 11 months I was granted the authority to conduct negotiations everything was settled. How much easier everything would have been had they done this from the start...

To conclude, I would like to say: whatever will be, however hard it comes on me, in whatever way I am treated, I will work to the utmost. As before, I will strive to make my work successful, and will fight for it to the end... (Ref. [7] pp. 401–403)

²¹ Laurman(n) Emil Yanovich (1890–1954), electrical engineer, in 1917– 1921 worked with Kapitza at the Polytechnical Institute in Petrograd, in 1921 returned to Estonia where he was born. From 1922 he was Kapitza's assistant in the Cavendish and Mond Laboratories.

 $^{^{22}}$ Pearson Henry Edward (1900–1957), chief mechanical engineer at the Mond Laboratory.

and Bolshevo. In mid-August he took part in the negotiations between Kapitza and E Adrian, the leader of the British delegation to the 15th International congress of physiologists, who was asked by Rutherford to meet with Kapitza. The so-called 'Adrian's Report', drawn at the end of the meeting, was actually the first business contact between Kapitza and Rutherford, even before the decision of Politbureau of August 22 (Ref. [11], pp. 120, 121).

15. Anna Kapitza to Kapitza

Cambridge,

2 December 1935

...The apparatus is leaving this week. $\langle ... \rangle$ All this has been done over the last two days. The workers $\langle ... \rangle$ worked all day and night from Saturday to Sunday, and now everything is disconnected and done. Tomorrow they will transport the big machine²⁴, which will be taken to London, inspected there by Lloyd's Underwriters²⁵, packed by them and despatched. Vickers²⁶ takes responsibility only to the steamer, they say they never assume responsibility in the [Soviet] Union because the boxes are loaded on the platform cars poorly, they stick out to all sides, and the cargo often gets damaged by an oncoming train. Please note this and see to it that when everything arrives in Leningrad it should be loaded well. I would advise you to go and meet [the shipment]. I'll send a telegram when everything is loaded and shipped.

At the same time we are shipping the furniture from the laboratory and all the books from the laboratory and home, as well as the piano and all the paraphernalia... (Ref. [4])

Cambridge

7 December 1935

...All machines and apparatus should now be on board, because 'Sibir' ought to have been leaving today, but I am told now she is leaving on the 10th. In 'ARCOS'²⁷ they told me that not only 'Sibir' but also the next steamer are going to Leningrad. If so, we shall also send everything we can with it. $\langle ... \rangle$ In your desk, in the drawers, we left your scientific correspondence and all reprints for the past year. So you can immediately sit down and begin your studies... (Ref. [4])

On December 16, 1935, the first boxes with the scientific equipment of the Mond Laboratory, with furniture and the Kapitzas' personal belongings arrived in the Leningrad port. On December 20 they started coming to Moscow, to the Institute for Physical Problems. And in the middle of January 1936 Anna Alexeevna came to Moscow together with the children, Sergei and Andrei. She and Cockcroft had been in charge of packing and despatching the first shipment of 'cargo' from Cambridge.

16. Kapitza to J D Cockcroft

Moscow,

18 March 1936

My dear John,

I was very sorry to hear that the switch boards are delayed. I was relying on the list of the dates which you gave to the Trade Delegation on the 21st of January. We were hurrying here with the wiring, I made the people to work in two shifts day and night to be ready for the 20th of March, the date I expected to have the switch boards, if you would had delivered them on the 1st of March as I believed. The people here are very disappointed that all the wiring is finished, but there are no switch boards to connect. It looks like a lost effort. $\langle \ldots \rangle$

I am very busy, but I count every minute when I shall again start my work. I do hope you will manage to arrange that Pearson and Laurmann²⁸ are sent here as soon as possible and arrange that their absence will not interfere with the work of the Mond Laboratory. In any case you had almost two years to prepare for their departure and you would agree that [for] starting a new installation you require much more reliable people than for maintaining and running one, therefore I need them more than you do. (Ref. [7] p. 403)

17. Rutherford to Kapitza

5 August 1936

My dear Kapitza,

Cambridge

...I have not your letter with me, but I may later add a note about any special points you mention. Cockcroft has made all the necessary arrangements for the rest of the apparatus to reach you as soon as it is ready, but he no doubt will advise you of probable times. I hope it will not be long before you get the helium liquefier going. The one you left works very well and so far we had no serious trouble with it, and we usually run two or three times a week for experiments... (Ref. [4])

18. Kapitza to Rutherford

Moscow,

19 October 1936

My dear Professor,

...Now we are gradually returning to work again. Things in the lab are taking shape. The staff which we engaged is quite good and, if not sufficiently experienced, is very enthusiastic, and willing to work hard. I hope in a month's time to have the Zeeman effect spectrum taken. This will be the first start — real work will begin when we shall get the helium plant working. Pearson is hard at work but he does not think this will be before the New Year...

Pearson, as I had already mentioned, will have to stay at least three months to finish the liquefiers and then I should like him to stay at least six months more to train the chap to run the apparatus and to do inevitable repairs in the new apparatus. To do it in less time is impossible, as the chap, even if clever, has no experience in cryogenic work²⁹...

I hope that you will help me in this case as you did before. If people in the lab grumble you may tell them that it is only on account of me that they enjoy using the best helium liquefier and elementary human gratitude requires a little privation on their part to help me in my difficulties and troubles. After all, I now have in mind a much better liquefier, which if successful, may be useful to them too. An exchange of experience will make both [of] the labs stronger and will benefit science and humanity (Ref. [12], pp. 296–298)

²⁴ Electrical generator for the production of strong magnetic fields.

²⁵ British insurance company.

²⁶ British industrial concern. The generator of the Mond Laboratory was built at the electrical machine-building plant of this concern in Manchester in 1925.

²⁷ All-Russian Cooperative Society Limited, since 1922 ARCOS Ltd., a joint stock company established in 1920 in London by a delegation of Soviet cooperatives.

 $^{^{28}}$ E Ya Laurmann came to Moscow in June 1936, and worked as P L Kapitza's assistant in the Institute for Physical Problems for over two years. H E Pearson came to Moscow about a month later, in early July 1936.

²⁹ Reference is made to Sergeĭ Alexandrovich Yakovlev (1903–1987), who for many years thereafter was in charge of the helium workshop at the Institute for Physical Problems.

19. Kapitza to Mezhlauk

Moscow

22 February 1937

Most respected Valery Ivanovich!

Today we have made liquid helium, so the laboratory may be regarded as finished.

We are all very happy. I in particular, since I can take up my research again.

Greetings!

Yours P. Kapitza³⁰

20. Rutherford to Kapitza

My dear Kapitza,

Cambridge

...Bohr told me about his trip to you³¹, and I am very interested to hear of the work that you have been able to accomplish. No doubt Pearson, when he returns, will be able to give us the latest information about your big helium liquefier. The Mond Laboratory is very flourishing, and a large amount of work is in progress. $\langle \ldots \rangle$ Some interesting experiments are also in progress on the extraordinary heat conductivity of helium at low temperatures. The conductivity is very large for small differences of temperature, and falls rapidly with the quantity of heat transmitted...

I hope it will not be too long before you are able to come over and see us all again. At the moment I cannot make any plans ahead, but some time I hope I may have the opportunity of seeing you... (Ref. [12], p. 308)

21. Kapitza to Cockcroft

Moscow

My dear John,

It is difficult to believe that there is no more Rutherford³². We all had the feeling that Rutherford is immortal not only by his work, but as a human being — he was so strong and full of life. We both owe a lot to Rutherford. $\langle \ldots \rangle$

Things in the lab are not going badly at all. We just started the new liquefier and the first time it gave four liters per hour; I hope to increase the output considerably. Now it is quite certain that Pearson will be free before the New Year, I will not claim his services any more after that... (Ref. [12], p. 309)

22. Kapitza to the Editor of Nature

Moscow,

3 December 1937

1 November 1937

Dear Gregory,

I am sending herewith a short note: "Viscosity of liquid helium below the λ -point", which I hope you will kindly publish in your "letters to the editor". I think this is an important note and I should be glad if you could arrange it to be published as soon as possible, and with the day of dispatch.

Please do not bother to send the proofs to me here to Moscow, it takes too much time. If necessary please send them either to Prof. P A M Dirac, St. John's College, Cambridge, Dr. J D Cockcroft, The Royal Society Mond Laboratory, Free School Lane, Cambridge, or to Dr. W L Webster³³, 46, Brook St. London, W1.

All my good friends and sufficiently competent to make the necessary corrections.

I hope you will kindly help me in publishing this note very soon... (Ref. [4])

23. Kapitza to Bohr

Dear Bohr,

I had your letter about the death of Rutherford, which apparently crossed with mine. I had a number of letters from friends, and it is indeed wonderful how much the people appreciated Rutherford. I had to give a big public lecture about Rutherford, and write some articles about him.

All this time I was very busy working on the viscosity of helium below the λ -point. Maybe you will remember what I was telling you during your visit here³⁴ about the idea of the work, the experiments are in full progress, but the preliminary results are quire interesting. It appears that really below the λ point the viscosity of helium drops more than a 1000 times. I estimate the viscosity to be 10, it is 10,000 times less than that of hydrogen gas taken at the lowest temperature that the viscosity has been measured.

It is rather difficult to imagine [for] yourself a 'viscousless' fluid, and its properties are quite amusing. It appears, the Keesom data on his experiments about very high heat conductivity of helium II could easily be ascribed to the unmeasurably small viscosity, as the easiness with which the convection starts in the fluid is inversely proportional to the square of the viscosity. The phenomena of the small viscosity are very striking and very easy to observe.

I made the experiments about 20 times varying the conditions and looking for some possible errors, but could not find any. I am sending herewith a copy of my preliminary note to Nature, so if you will be interested you could glance through it. $\langle \ldots \rangle$

Yours very sincerely,

P Kapitza³⁵

18 December 1937

24. Cockcroft to Kapitza

Cambridge

My dear Peter,

...During the last few weeks, we have been working on the viscosity of liquid helium by measuring the flow through capillary tubes having diameters down to 1/50 mm. We have found it impossible to produce laminar flow, and that the viscosity is less than 10^{-9} . We do not get a square law and there are many curious things which may mean the theory of ord[inar]y liquid flow is not applicable.

Yesterday, just as these experiments were being completed, Webster came and told us that you also had been doing similar work, and we were interested to find that you

10 December 1937

Moscow,

9 October 1937

³⁰ See Ref. [8], p. 129.

³¹ In June 1937 Niels Bohr, returning with his wife and son Hans from a round-the-globe tour, spent about a week in Moscow on invitation from P L Kapitza.

³² Ernest Rutherford died on October 19, 1937.

³³ Webster, William L (1904–1975), a close friend of P L Kapitza, worked with Kapitza in the Cavendish Laboratory since 1926. In September 1937 visited Kapitza in Moscow.

³⁴ See Footnote 31.

³⁵ See Ref. [8], pp. 152, 153.

had got similar results.

We had been led to do this by many difficulties in the experiments on the heat conductivity. In particular, for temperatures of about 1.1° the vapor pressure above the liquid in the small bulb appears to drop rather than rise on applying heat.

Webster asked me to see your proofs through the Press, since he is going away to France, and this I shall be glad to do. We shall be sending in a letter to *Nature* this week-end.

With kind regards to all, Yours sincerely John Cockcroft

Todmorden 25 December 1937

My dear Peter,

I have just seen your proofs for *Nature* and returned them. The letter will appear on Jan. 8th.

I do not believe that convection currents can explain our results on heat conduction. There would have to be velocities of the order of the velocity of sound regarding much too high differences of head. We are doing more exp[erimen]ts to clear up the anomalies. I think that in the end the nonlinearity will be accounted for in terms of the other properties of the liquid.

I asked Allen³⁶ to send you a copy of our letter to Nature. The strange thing with capillaries is that the velocity does not depend much on head for fine capillaries but behaves more normally for large capillaries. G I Taylor³⁷ thought that it pointed to slip at the boundaries. We will try to see how far dynamical similarity holds by experiment on different size capillaries. (Ref. [4])

25. Bohr to Kapitza

Copenhagen

26 December 1937

³⁶ Reference is made to John Frank Allen (b. 1908), research worker of the Mond Laboratory (from 1947–1978 professor of physics at University of St. Andrew's in Scotland, currently Professor Emeritus of the same university) who carried out experiments with liquid helium jointly with the Canadian physicist Austin Donald Misener, recipient of the memorial grant of the World Exhibition of 1851. Their note [2] immediately followed Kapitza's letter in the same issue of *Nature*, marked December 22, 1937. The mailing date of Kapitza's letter is December 3, 1937.

I am grateful to Prof. Allen for his permission to quote from a letter he sent to Prof. Shoenberg on 22 October 1997, in which he says: "The first I heard of K's superfluidity work was [when I saw] his letter to *Nature...* When he sent the 'superfluid' letter to *Nature*, he had requested that the proofs be sent to Cockcroft for proofreading. Cockcroft passed it to me to do the job, but when he sent it back he enclosed the letter to *Nature* produced by Don Misener and me (which had one or two comments about K's letter), saying to the Editor that the two letters should be published together, with K's first since it arrived first..."

D Shoenberg at the time was working in Moscow in the Institute for Physical Problems. As far as he can remember, Kapitza asked him to translate into good English the note he sent to *Nature*.

In 1990, recalling the history of publication of these two notes in *Nature*, J F Allen wrote, "Kapitza's method was that of radial flow between two closely spaced discs. He observed turbulent-type flow with an estimated upper limit of viscosity of 10^{-10} Pa s, but he added, prophetically, that such a value indicated that He II must be some kind of 'superfluid''' (Ref. [13] p. 37).

Indeed, it was Kapitza who was the first to pronounce this word. As he wrote in his note, "The present limit [to the viscosity] is perhaps sufficient to suggest, by analogy with supraconductors [sic], that helium below the λ -point enters a special state which might be called a 'superfluid''' (Ref. [1]). ³⁷ Taylor, Geoffrey Ingram (1886–1975), English scientist in the field of mechanics.

Dear Kapitza,

I thank you most heartily for your kind letter with the copy of the note you have sent to Nature about your most beautiful and important discovery of the suprafluidity [sic] of helium below the transformation point. It is indeed a most remarkable and unexpected contribution to our knowledge of the properties of matter which will surely be of great consequence as regards the development of theoretical ideas too. I have even started to speculate whether a similar transformation point should also appear in the atomic nuclei themselves, where we have, as regards dynamical conditions, the closest imaginable analogy with helium at ultra-low temperatures. Now, that may all be just fancy, but if I have any progress with it, I shall write to you again and tell you about it. In the meantime I am very eager to hear from Landau about some remarks I wrote to him concerning his beautiful idea of the neutron state of matter at ultra-high pressures. To-day I just wanted to send you my heartiest congratulations for the great success of your work and the warmest wishes for the New Year to you all from my wife and Yours ever

Niels Bohr³⁸

6 April 1939

26. Kapitza to V M Molotov

Moscow

In my recent studies on liquid helium close to the absolute zero, I have succeeded in discovering a number of new phenomena which promise to shed light on one of the most puzzling areas of contemporary physics. I am planning to publish part of this work in the course of the next few months, but to do this I need theoretical help. In the Soviet Union it is Landau who has the most perfect command of the theoretical field I need, but unfortunately he has been in custody for a whole year.

All this time I have been hoping that he would be released because, frankly speaking, I am unable to believe that he is a state criminal. My disbelief is because such a brilliant and talented young scientist as Landau who, though only 30 years old, has won a European reputation and is moreover very ambitious and has been completely occupied by his scientific work, could hardly have had the motive or found the time and energy for any other kind of activity. It is true that he has a very sharp tongue, the misuse of which together with his intelligence has won him many enemies who are only too glad to do him a bad turn. But for all his bad character, which I myself have had to cope with, I have never noticed any sign of dishonest behavior.

Of course I realize I may be meddling in something which is none of my business, since it lies within the competence of the NKVD, but I must point out the following abnormal facts:

(1) Landau has been in prison for a year but the investigation is still incomplete. This is an abnormally lengthy period of investigation.

(2) Although I am Director of the Institute where he had been working, I have been told nothing of the crimes of which he is accused.

³⁸ Archive of P L Kapitza [4]

1257

(3) The main point is that, for unknown reasons, science both in the Soviet Union and worldwide has been deprived of Landau's brains for a whole year.

(4) Landau is in poor health and it will be a great shame for the Soviet people if he is allowed to perish for nothing.

I therefore make the following requests:

(1) Is it not possible to draw the attention of NKVD to the special desirability of accelerating Landau's case?

(2) If this is not possible, perhaps Landau's brains could be used for scientific research while he is in the Butyrka prison? I have heard that this procedure has been followed in the case of engineers.

P Kapitza³⁹

As usual, this Kapitza's letter 'to the Kremlin' was delivered by his private messenger Anna Alexeevna, who also typed out all such letters of Pyotr Leonidovich. A couple of weeks later Pyotr Leonidovich was summoned to Lubyanka [Headquarters of the NKVD]. Here is his account of the visit recorded by I A Zotikov:

"I was summoned at 1 a.m.... They escorted me to a big office occupied by two men. They turned out to be Beria's deputies Kobulov and Merkulov. Both were later shot. "Do you understand, — they ask, — for whom you are pleading? He's a most dangerous criminal, a spy who confessed to everything. Here, read this..." And they handed me a huge volume. But I did not care to read the file. "May I ask you just one question?" "If you please," they laugh. "Tell me, what did Landau gain by this, what is the motive of those crimes you claim he has committed?" They reply that no-one is interested in his motives. I hang on, and quote examples from books.

We talked till four in the morning. Especially with Merkulov, who was a well-read person. $\langle ... \rangle$ Towards the end of our conversation one of them said, "All right, Kapitza, if you pledge your word for Landau, then give us a written guarantee. If anything happens, you will be held responsible." I wrote a letter⁴⁰, and two days later Landau turned up at the Institute. (Ref. [7] p. 323)

27. From the Decision of the NKVD

28 April 1939

...LANDAU Lev Davydovich, born in 1908 in Baku, prior to arrest professor of physics, non-Party member, and citizen of the USSR, has been convincingly exposed as a member of anti-Soviet group, guilty of sabotage and an attempt to publish and disseminate an anti-Soviet leaflet.

However, taking into account that:

1. LANDAU L D is a major specialist in the field of theoretical physics, and may be useful in future for the Soviet science;

2. Academician KAPITZA P L has consented to pledge his word for LANDAU L D;

3. Acting on orders from the People's Commissar for Internal Affairs of the Union of Soviet Socialist Republics, Commissar of State Security of the 1st Rank Comrade L P

³⁹ See Ref. [12], pp. 348, 349.

Beria to release LANDAU in the trust of Academician KAPITZA;

WE HEREBY ORDER THAT

Detainee LANDAU L D be discharged from custody, the investigation discontinued, and case files sent to archive.

Head of 6th Section of 2nd Division Principal Department for State Security People's Commissariat for Internal Affairs

Captain of State Security

VIZEL'41

28. P L Kapitza. From presentation on 'Properties of liquid helium'⁴²

Moscow

21 December 1944

22 October 1945

...It would seem that, having established the superfluidity of helium, one could explain in this way all the effects of convection. It turned out, however, that the interesting properties of helium only start rather than end at this point. The explanations given by me, my assumptions, were wrong. As a matter of fact, the viscosity of helium is low, but this is not sufficient for attributing its high heat conductivity to the convection mechanism. The forces that induce the convection currents — the forces of gravity — are not sufficient to account for such a heat conductivity. $\langle \ldots \rangle$ We had to look for something else. And then the key to the problem was given by the discovery made by English physicists Allen and Jones at the Mond Laboratory, of which I was once the Director⁴³. They found another effect in helium, also very interesting. They discovered that if you fill a bulb with emery, immerse it in helium and illuminate it, the helium starts to fountain. The jet may be as much as up to 20 centimeters high. This means that light and heat give rise to some forces in helium which produce very vigorous currents.

We began to study these forces... (Ref. [16] p. 15)

29. Kapitza to Bohr

Moscow

My dear Bohr,

It is a great relief to feel that the ordeal of the war is over and we may resume our peaceful life. We all are very happy that you and your family went safely through all your adventures and are now united in Copenhagen. I was always happy to have news from you and your family but every time they came with great delay...

We are all back to Moscow. It is already two years since the Institute resumed normal scientific work. As before the war we have two times a week liquid helium and have found some curious things at low temperatures. I hope you have seen the theoretical work of Landau⁴⁴ on superfluidity of helium which probably you remember we have discovered

⁴⁰ This letter of Kapitza to the People's Commissar for Internal Affairs L P Beria of 26 April 1939 is reproduced in the book *Landau*. *The Physicist and the Man.Recollections of L D Landau* (Oxford: Pergamon Press, 1989) p. 318 [Translated into Russian (Moscow: Nauka, 1988) p. 346]

⁴¹ Ref. [14] pp. 155, 156.

⁴² Presentation was made at the conference on contemporary problems of science at Moscow State University.

⁴³ Reference is made to the paper: Allen J F, Jones H "New Phenomena Connected with Heat Flow in Helium II" *Nature* **141** 243 (1938).

just before the war. It is now proved that superfluid helium is a mixture of normal helium with helium with zero-entropy. This I have proved experimentally and this originated the theory of Landau. This particular property of helium gives in principle the possibilities to approach indefinitely close to the absolute zero and this approach is only limited by technical difficulties. Landau also proved that two kinds of elastical waves must propagate simultaneously in superfluid helium; therefore in helium II must exist two kinds of sound velocities, one at 150 m/sec. (already known one), and another (a new one) at 17-20 m/sec. Peshkov has discovered experimentally the second velocity of sound in helium II...⁴⁵ (Ref. [8] pp. 235, 236)

30. Bohr to Kapitza

Copenhagen,

17 November 1945

...We were very happy in the Institute to welcome a colleague from Moscow⁴⁶ and to get news about our friends whom we have not seen for so long. I was also most interested in the articles enclosed in your letter about the progress of your important researches on superfluidity and Landau's ingenious theoretical analysis⁴⁷. So far we had no opportunity to learn about this progress and our whole group looks forward to study and discuss the articles and, of course, also the many other publications of your Academy from the last five years, which Professor Terletzky brought us and which we were very grateful to receive. (Ref. [4])

31. Bohr to the Nobel Committee for Physics

Copenhagen,

29 January 1947

In reply to the Committee's request to send in proposals for awarding the Nobel Prize for Physics for 1947, I shall propose that this prize be awarded to Professor Peter Kapitza for the development of new ingenious methods for investigating the properties of matter in very strong magnetic fields and at extremely low temperatures, as well as for the important results that his investigations using these methods have given and which, especially as regards the behavior of Helium at low temperatures, have led to the discovery of new surprising phenomena, that in the most striking fashion have illuminated problems of the greatest importance for the development of our knowledge and understanding of the properties of matter under the most different conditions. In connection with this proposal, I would like to state that the reason that I have not repeated this year the proposal that I sent last year to the Nobel Committee for Physics to award the Nobel Prize to Professor Lise Meitner and Professor Otto Robert Frisch, is that after further consideration I am sending this proposal to the Nobel Committee for Chemistry.

Yours sincerely N Bohr⁴⁸

In 1948 Niels Bohr once again nominates Kapitza for the Nobel Prize in physics. Later he did this two more times, in 1956 (together with Landau), and in 1960 (Ref. [16], p. 327). Nevertheless, Kapitza only received his Nobel Prize in 1978, many years after Bohr's death. He was awarded the prize 'for his basic inventions and discoveries in the area of lowtemperature physics'.

The Nobel lecture delivered by Kapitza in Stockholm on December 8, 1978, was, however, devoted to his studies in the field of very high temperatures. It was entitled 'Plasma and the controlled thermonuclear reaction', and Kapitza started with the following words: "The choice of the theme for my Nobel lecture presents some difficulty for me. Usually the lecture is connected with work recognized by the prize. In my case the prize was awarded for work in low temperature physics, at temperatures of liquid helium, a few degrees above absolute zero. It so happened that I left this field some 30 years ago, although at the institute under my directorship low temperature research is still being done. Personally I am now studying plasma phenomena at those very high temperatures that are necessary for the thermonuclear reaction to take place. This research has led to interesting results and has opened new possibilities and I think that as a subject for the lecture this is of more interest than my low temperature works which I have long forgotten..." (Ref. [6], p. 73).

The compiler of this collection of letters was present at Kapitza's Nobel presentation, and can well recall the jolly animation of the audience. (Incidentally, you will not find the words 'long forgotten' in the English text of the lecture published in the Nobel almanac for 1978 [6]; nor do they appear in Kapitza's own notes. He wrote 'my past lowtemperature work', but, speaking in the packed hall of the Swedish Academy of sciences, he could not help changing 'past' to 'forgotten'. The youthful audience (mostly students and postgraduates) immediately noted and appreciated the benign irony of this passado at the Nobel Committee. These jolly young people did not realize, however, what a tragic page in the life of the elderly laureate was hidden behind the hackneyed 'it so happened'. Even in our country not many people knew that it was by the whim of Stalin and Beria that Kapitza was turned out of his institute. Turned out because he did not want to work on the atom bomb under Beria, and bluntly told this to Stalin. And then again, as in 1934, he was deprived of his laboratory, his associates and students, his equipment, including the helium liquefier which was instrumental for the discovery of the superfluidity of helium in Moscow and Cambridge. Again he had to start all over from scratch. This is the reason why he had 'left' low temperature physics and technology.

References

 Kapitza P L "Vyazkost' zhidkogo geliya pri temperaturakh nizhe lyambda-tochki" ("Viscosity of liquid helium at temperatures below lambda point") DAN SSSR 18 (1) 21 (1938) [Comptes Rendus de l'Acad.des Sciences USSR 18 (1) 21 (1938)]; Nature 141 (3558) 74

⁴⁸ Niels Bohr Archive [10].

⁴⁴ Reference is made to the paper: Landau L D "Theory of superfluidity of Helium II" *Zh. Eksp. Teor. Fiz.* **11** 592 (1941); *J. Phys. USSR* **5** 71 (1941). In 1962 L D Landau was awarded the Nobel Prize in physics 'for his pioneering theories for condensed matter, especially liquid helium'. Niels Bohr was one of those who nominated him for this award.

⁴⁵ Reference is made to the paper: Peshkov V P "Second sound in helium II". Dokl. AN SSSR 45 (9) 385 (1944).

⁴⁶ Reference is made to Ya P Terletzky. About his visit to Bohr see: Rubinin P E "Niels Bohr and Pyotr Leonidovich Kapitza". *Usp. Fiz. Nauk* **167** (1) 104 (1997).

⁴⁷ Reference is made to the papers by P L Kapitza "The study of heat transfer in Helium II". *Zh. Eksp. Teor. Fiz.* **11** 1 (1941) and "Heat transfer and superfluidity of Helium II", ibid. p. 581, and L D Landau's paper mentioned above. All these articles were also published in English in *J. Phys. USSR.* Apparently, P L Kapitza sent reprints of these papers to Bohr with Ya P Terletzky.

(1938); Kapitza P L *Nauchnye trudy. Fizika i tekhnika nizkikh temperatur* (Research papers. Physics and technology of low temperatures) (Moscow: Nauka, 1989) p. 306

- 2. Allen J F, Misener A D "Flow of liquid helium II" *Nature* 141 (3558) 75 (1938)
- Kapitza P L "Kogda takoĭ sluchaĭ podvernulsya, nel'zya bylo ego upuskat" (When a chance came by, one should not have missed it) *Khimija i zhizn'* (11) 52 (1987)
- 4. Archive of P L Kapitza at P L Kapitza Institute for Physical Problems of the Russian Academy of Sciences
- Kapitza P L "Novyĭ metod ozhizheniya geliya" (A new method for liquefaction of helium) Sotsialisticheskaya rekonstruktsiya i nauka 8 104 (1934); Kapitza P L Experiment. Theory. Practice (Dordrech, Boston, London: D. Reidel, 1980) pp. 8–11
- Les Prix Nobel 1978 (Stockholm: Almqvist & Wiksell International, 1979)
- 7. Petr Leonidovich Kapitza: Vospominaniya. Pis'ma. Dokumenty (Reminiscences. Letters. Documents) (Moscow: Nauka, 1994)
- Kapitza P L *Pis'ma o nauke* (Letters on science) (Moscow: Moskovskiĭ Rabochiĭ, 1989)
- Esakov V D "Pochemu P L Kapitza stal nevyezdnym" (Why P L Kapitza was not allowed to travel abroad) Vestnik RAN 67 (6) 543 (1997)
- 10. Niels Bohr archive, Copenhagen
- P Dirac and P L Kapitza Pis'ma [Letters] 1935–1937 (published by P E Rubinin) in: Pol Dirak i fizika XX veka (Paul Dirac and Physics of the 20th Century) (Moscow: Nauka, 1990)
- Kapitza in Cambridge and Moscow. Life and letters of a Russian physicist (Eds J W Boag, P E Rubinin, D Shoenberg) (Amsterdam: North Holland, 1990)
- Allen J F "Early superfluidity in Cambridge, 1936 to 1939". Advances in Cryogenic Engineering Vol. 35 (New York: Plenum Press, 1990) pp. 35–39
- 14. "Lev Landau: god v tyur'me" (Lev Landau: one year in prison) *Izvestiya TsK KPSS* **3** 157 (1991)
- Kapitza P L "Svoĭstva zhidkogo geliya ("Properties of Liquid Helium") Prirode (12) 10 (1997)
- 16. Röseberg U Niels Bohr. Leben und Werk eines Atomphysikers (Stuttgart: Wissenschaftliche Verlagsgesellschaft mbH, 1985)