Dear Dr. Vavilov

Unfortunately I am not in position to address you in your language as I would have wished.

I was just described to my colleagues your contribution to the knowledge of surface conditions in semiconductors and specially on the experiments you have undertaken in cooperation with greek research groups. I did not fail, also, to mention your warm feelings towards our country and our culture. Your presence, today, at the Academy of Athens, will surely enhance this fruitful collaboration between scientists of our two nations.

We are now looking forward to hear your lecture on the latest Russian contributions to science and culture.

Will you kindly take the floor.

THE CONTRIBUTION OF RUSSIAN SCIENCE TO THE DEVELOPMENT OF THE MODERN WORLD

ΟΜΙΛΙΑ ΤΟΥ ΑΝΤΕΠΙΣΤΕΛΛΟΝΤΟΣ ΜΕΛΟΥΣ κ. VICTOR S. VAVILOV

«All religions, arts, and sciences are branches of the same tree»

*Albert Einstein**

As a unique example of this unity one can regard Michael Lomonosov, the first of Russian physicists and chemists, a poet and translator of ancients, an author of historical works on the origin of Russians, and one of the fathers of todays' Russian language. Moscow University bears his name at present.

Speaking about Russian culture and science, it is proper to regard Russians both as the children and grand-children of Greeks. As children of Christian, Byzantine Greece, most of religious Russians belong to the Greek Orthodox Church. When we write we use Cyrillic alphabet, and our Russian terminology, in contrasts, for instance, to German terminology is based, first of all, on the Greek language. Remarkable sources and roots of early connections between Greek and Slavic people included not only the relations between the old states, but, beginning with the IX Century, the spreading of Christian Faith, icons books and architecture in their old

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* **A. Einstein,** «Art of my later years». Ed. Philosophical Library, New York 1950, p. 9.

forms. If the ancient and stable friendship between our nations had not been existant, most probably, Russians would now be using latin alphabet and belong to western Churches. When one goes back to the influence of culture and science of ancient, classic Greece we, along with other modern European nations, are grand-children, or even grand-grandchildren. The influence of Greek philosophy, dramaturgy and poetry on the development of Russian culture is well known. Many of us always feel the impact of the impulse unique in the history of the mankind, that was generated on the shores of Mediterranean Sea and spread out to Europe and beyond it.

At the time of German invasion in 1941 I was twenty years old, on active service in our Army, but even before that year I had the luck to see several outstanding scientists, who, as we know now, were the founders of modern Russian physics, chemistry and history. As a physicist, I shall mostly present examples connected to this field of research. But before this it might be proper to say that many of the Russian scientists were deeply interested and active in the field of art. The author of the «Prince Igor» opera music, composer Alexander Borodin, was an outstanding chemist. One of Russian leading theoretical physicists, A. Migdal, was devoted to sculpture and painting. Not long ago, in Moscow we had an exposition of paintings by many well known scientists and even cosmonauts.

Indeed, in reality, science is international. Insufficient information means the barriers due to languages and artificial barriers often erected for political and ideological purposes always slow down its progress. Thus, Russian science and its achievements or drawbacks are always to be regarded conditionally, choosing first of all the most successful scientific fields and schools, their geographic position and subsequent spread-out.

Immediately after the end of the Civil War in 1919, in Petrograd, which recently has become Sanct-Petersburg again. D. Rozhdestvensky founded the State Optical Institute, which soon became an outstanding center of Theoretical and Applied optics. V. Fock, one of the leading figures in Quantum Mechanics, who gave his brilliant lectures in twenties, was working at this institute and Leningrad University. The Optical Institute was the origin of the production of fine optical glass for the devices and astronomy in Russia.

At the same time A. Ioffe organized the Institute of Technical Physics, well known to the world's scientific community, first of all for its achievements in solid state physics. Highly qualified physicists who did their PhD work at Ioffe's laboratories are now working in many of former Soviet Republics and in other countries.

As it is known, the Soviet Union immediately after its foundation has become and remained a highly centralized state. This has resulted in the «transplantation» of the USSR Academy of Sciences from Leningrad to Moscow, where the P. N. Lebedev Institute of Physics emerged in its present state. The history of this Institute, where I have the honour to work for more than 40 years, has been recorded in several books in Russia. I would like to emphasize some highlights in the work done by its scientists. In the beginning of thirties, P. Cherenkov discovered a new kind of visible radiation of condensed media bombarded by fast electrons. The nature of this radiation was explained by I. Tamm and I. Frank. The Nobel Prize was awarded to these three physicists for this discovery in 1958. The achievements of A. Sakharov, whose teacher in theoretical physics was I. Tamm, as well as his political activities, are now well known. The project of a new Constitution of Russia, as it was stated officially in April 1993, will include important contribution by the late Andrei Sakharov. P. N. Lebedev Institute of Physics, which is usually called now «FIAN» was growing into a center of research including many branches of theoretical and experimental physics. After coming from Leningrad of D. Skobeltzyn, there was a growing attention towards nuclear physics, particularly the cosmic rays containing a spectrum of particles and photons of extremely high energies. The relations between P. N. Lebedev Institute of Physics and Moscow University were becoming more and more close. There was an important emphasis on optics and solid state physics.

During the war years, 1941-1945, a major part of my colleagues in the Academy of Sciences and in Russian Universities was on the active service in the Army. Immediately after the victory in 1945, the research in the field of fundamental and applied science had a support by the state which would be thought unbelievable before that time. First of all it is to be due to the necessity of the creation of nuclear arms, and to the use of physical phenomena which were the basis of the present telecommunication and radiolocation. The major attention was paid to the development of physics of semiconductors and dielectrics. The present solid state electronics based, first of all, on the processes in semiconductors, has been a beneficial contribution to the present mankind.

According to the estimate by an American expert, the cost of research and technology of silicon, which is the major material of solid state electronics constitutes about one percent of the profit gained by the production and uses of devices used by all of us. From 1955 on I have participated in the work that resulted in the production of silicon solar cells and other silicon devices. Our results were taken in by

industry and quite soon the electric energy on Russian satellites was supplied by solar cells. When Jawaharlal Nehru visited our Institute in 1961 we presented to him a solar cell driving a small ventilator, wh ch he kept on his desk in New Delhi throughout his life. It is possible that the work of Russian physicists and technologists influenced the Government of India to take a decision on the development to build a great number of autonomous small helioenergetic power stations for villages, which is being done at present.

During my short visits to Greece I have noticed numerous helioenergetic devices for hot water used even in Thessaloniki, in the North of your country. One knows that the energy is expensive here and, on the other hand, you have 320 sunny days in a year in Athens.

I sincerely believe in the widening of uses of solar energy in future for many purposes. The main attraction is, of course, its ecological purity. For your beautiful country and its large cities the elimination of inner combustion engines is a noble aim for the future generations.

Now I return to the contribution of Russian science after the end of the second World War. A great increase of authority of science in the Soviet Union was due to the development of nuclear weapons in 1949. Along with this type of research, other branches of science in the Academy obtained in 1946 and afterwards large funds and modern equipment. Academies of Sciences were organized in Union Republics and their activities were coordinated in Moscow. Scientific conferences have been conducted often in the capitals of Union Republics. I am sure that Professor P. Euthymiou remembers the 1979 Radiation Effects Conference in Georgia, in Tbilisi. I had been invited to Lithuania, Estonia, Tajikistan, Azerbaijan, Kazakhstan, Belarus and other republics which have become independent recently. The invitations have not ceased now, in 1993, which makes one happy. The existence of the Soviet Union for 70 years has played a decisive part in the spread of fundamental research and education of young scientists in «Brother Republics» as we called them. My colleagues and I remember well the physicists who were successfully working in P. N. Lebedev Institute and in Moscow University during the period 1951-1993. My colleague, Professor Kekelidze, who is at present a Professor of Tbilisi University, recently asked me to tell my Greek colleagues that they would be happy to organize a Greek-Georgian seminar on Solid State Physics at any convenient time.

Returning to the main line of my talk, I follow the central direction. After 1953 the collaboration of Soviet scientists with the surrounding world that was

practically unexistant before that year, was resumed. In 1955, when, for a short time I was working as a civil servant of United Nations, for the first time after a long period of confrontation, at the UN Conference in Geneva the aspects of peaceful uses of atomic energy were discussed. They included several branches of physics, chemistry and energetics. At that time many of Western colleagues considered nuclear energy as unprofitable field of engineering.

Even now, in 1993 the question of the delicate balance of the cost of energy and the risk to the population and environment is not solved. A careful analysis of the consequences of Chernobyl disaster shall be both a sad and useful lesson for those who desire a further increase of nuclear power stations' number.

As it is known, in our Institute and, at the same time in the United States quantum generators (lasers) were created. For many years one of their authors — the Nobel laureate N. Basov — was director of the Institute. His works and the works of A. Prokhorov are well known among the physicists. The biographies of both of them are to be found in the Encyclopedia of Nobel Laureates that was recently published in Moscow in Russian translation. I would like to note that both of them were fighting in our Army during the Hitler's Germany invasion into the Soviet Union. Recently, the lasers have become indispensable in optoelectronics, in medicine, for the analysis of atmospheric contamination. At present, there are new ideas concerning the uses of laser pulsed light beams for neutron injection into nuclear reactors that may greatly increase the safety of their operation. There is a certain analogy between the complicated processes in a reactor and the periodic action of conventional internal combustion engine, where work cycle in initiated by an electric spark. If sparks are cut off, the engine stops. A program of experimental work in this direction is going on in our Institute and other laboratories in Russia.

Returning to the field of semiconductor physics, one might draw attention to the experiments of O. Lossev in Leningrad, conducted as early as 1924-28. Their author, who used silicon carbide crystals with spontaneous regions with opposite types of electrical conduction (we call them p–n junctions now) has discovered generation of periodic current oscillations and generation of light (now called electroluminescence).

Immediately after the pioneering results of the discoverers of transistor —Shockley, Bardeen and Brattain — in the United States single crystals of germanium and silicon have been grown in Moscow and Leningrand and a systematic research in the field of solid state electronics started.

In 1968, at the International Conference on Semiconductor Physics in Mos-

cow, L. Keldysh formulated the principles of the creation of international formation of quantized periodic energy band structures in semiconductors, which are regarded to be a foundation of modern physics of superlattices and quantum wells.

Fast expansion of sciense in the Soviet Union during the last two or three decades has resulted in the process of organization of numerous laboratories and universities, and the total number of persons having PhD (candidate of sciences) degree was increasing in a spontaneous and uncontrolled way and now has reached a value greatly exceeding the optimum. On the other hand, a part of my younger colleagues has reached a level of high qualification. My colleagues in the United States and Germany mostly have high opinion of the level of education and the ability to work hard of Russian postgraduates or specialists who are more and more often invited to work abroad.

In our present days, in the field of applied science and technology a conversion is going on, similar to the processes taking place in military industry.

Unfortunately, at present the financing of fundamental research is definitely inadequate.

This leads to the decrease of popularity of fundamental disciplines among the future students. However, as it is known to my Greek colleagues who visited us not long ago, the research is going on in Lebedev Institute of Physics and in Moscow University, and many of us obtain new and interesting results.

The economists who analyze the character of difficult transition period experienced by Russia now in the fields of industry, agriculture, commerce and new relations with the Rebublics that, quite suddenly, became independent, give widely differing estimates of its length. The optimists consider a period of about three years, and the length given by some pessimists increases to three generations.

The fate of nations, in particular, the wars and other disasters which initiate the displacement of large groups of people at the same time stimulate the dispersion of culture and sciense. Recently, Russian scientists, including outstanding personalities, due to several reasons, leave our country. This phenomena includes a sad component, but the final result may be positive. The history of Russia shows that this nation was able to overcome the Tatar-Mongolian yoke that lasted about 250 years, the dark year near 1600, the invasions of Napoleon's army in 1812 and Hitler's army in 1941. I have no doubts that we shall transit with honour the present period of difficulties in science and culture. The example of brave and talented Greek nation and the continuation of our friendship shall help us.