CRISIS IN THE FORMER SOVIET UNION

SOVIET SCIENCE IN DANGER

Unique problems now confront fundamental science in the Commonwealth of Independent States, and they require appropriate Western aid for their solution.

Evgenii L. Feinberg

Fundamental science in the former Soviet Union faces dangers that could lead to catastrophe. The situation for fundamental science is different from those confronting applied science in general and Soviet military technology in particular. Applied science has its own ways to accommodate itself to a market economy, while the proliferation of Soviet nuclear technology is a special problem that has attracted the attention of politicians throughout the world. I will leave such other fields aside and instead speak only on fundamental science, which seems helpless.

The destroyed economy, galloping inflation, social instability and national conflicts in the former Soviet states may immediately lead to:

▷ A drastic lowering of living standards for scientists, technicians and other personnel at scientific institutes. This could be more severe than what is already occurring in society in general.

▷ A drastic decrease of financial support for experimental work, construction of new installations, purchase of new equipment and operation of existing facilities. This threatens the very existence of scientific institutions.

▷ External and internal brain drains—that is, the emigration of fundamental scientists or their transfer to other work within the Commonwealth of Independent States.

These dangers are evident and well understood by the authorities, who do what they can to help. But they face so many similar problems in other spheres that adequate help is not possible. Consider the sobering official statistic that in January of this year, for the first time, mortality in Russia surpassed the birthrate.

Even if economic reform is ultimately successful, we are a long way from considerable improvement, and too many hard years lie ahead. When planning help, therefore, we should distinguish between urgent immediate needs and long-term needs.

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RIA–NOVOSTI–SOVFOTO

Leading figures from three eras juxtaposed at the Congress of People's Deputies at the Kremlin on 14 December 1989. In the painting, Lenin addresses the masses at the end of the tsarist era and the start of the Soviet one. At the podium, Andrei Sakharov makes his last speech. Decorated as the father of the Soviet hydrogen bomb and internally exiled for his advocation of human rights, Sakharov epitomizes both the support of science and the oppression of scientists that occurred under the Soviet regime. At right is Boris Yeltsin, who became the first president of Russia in the post-Soviet era. The economic crisis facing science is greater now than at any time in Russian or Soviet history.

A brief history of Soviet fundamental science

In tsarist Russia there were only a few special institutes for fundamental science—the Pulkov Observatory and the Ivan Pavlov Institute being two examples. Fundamental science instead developed in small, scattered groups at universities.

When the Communist regime took power, it proclaimed that it would establish a scientific basis for the development of society. We know now what came of this. Nevertheless, in accordance with this declaration, from that point on a rapidly expanding system of new scientific institutes was supported. Even in hunger-plagued Petrograd in 1918—a time when the word "famine" was more accurate than "hunger"—two rather high-level research institutes appeared, headed by first-class scientists. The radiochemist Vitaly Khlopin led one institute, which was devoted to radiology and roentgenology, and the physicist Dmitrii Rozhdestvenskii led the other, which carried on optics research ranging from quantum theory to new methods of polishing lenses.

However, scientists were routinely subjected to totalitarian ideological pressure, and there were numerous campaigns against "idealist" and "positivist" scientists. Party leaders of all ranks constantly insisted that scientists extend closer cooperation with and direct help to industry and other spheres of the state economy. All this contradicted the declared ideals of the Communist regime, but it did not stop the development of fundamental science in well-equipped institutes. The importance of fundamental science was officially acknowledged, although to a considerable extent this was merely lip service. Stalin's purges and post-Stalinist political persecution did not pass over scientists, including those of the highest rank and talented younger ones. Their martyrology is lengthy. However, my personal impression is that as a whole scientists suffered less than, say, engineers, writers, priests and some other layers of Soviet society. In general, fundamental science was a prestigious profession. Talented young people who were full of initiative and wanted to evade the everyday moral compromises and lies connected with public life and other professions preferred to go into fundamental science. Certain arts and sciences were maybe the safest spheres in this regard, although ideological pressure and the constant control of "philosophical purity" inevitably led to compromises here as well.

It is remarkable that soon after the Nazi invasion in 1941, bloodthirsty Stalin, who openly despised and hated intellectuals, was clever enough to issue a special decree forbidding the call-up of scientists for war service. In Germany, by contrast, it wasn't until 1944 that Martin Bormann ordered the recall of some 4000 scientists from the army.

Stalin's decree applied to all scientists working in research institutes and universities and other places of higher study. Many technicians working in scientific

institutions were also allowed to remain on duty by special permission. And there was no discrimination between natural scientists or mathematicians and scholars of the humanities, such as philologists and historians. All were exempt from military service even though the general mobilization rules were so severe that in villages you could see only women, children, old men and invalids. The merciless dictator saved the scientific potential of the nation.

Scientists also received special allowances for food during the war. While most people suffered from hunger and food was strictly rationed, the ration for scientists equaled that of plant workers, making them the most privileged among those not engaged in physical work. In 1944 an even better food allowance was established for those having the scientific degree of candidate (equivalent to a Western doctorate), with a still better one for doctors (professors). Again, humanities specialists were treated the same as natural scientists and mathematicians, so these privileges cannot be explained solely by the government's desire to stimulate atomic weapons development.

After the war, science came under severe and ignorant ideological pressure, and scientists were mercilessly persecuted. An infamous example was Lysenkoism in biology. Nevertheless, in many fields of science, tens (if not hundreds) of new, well-equipped institutes appeared, and the living standard of scientists in general was quite satisfactory. Although depressed by constant fear and secret KGB control, scientists were obedient and loyal to the government in their behavior and often even in their thoughts. Later, this led Aleksandr Solzhenitsyn to say that scientists were corrupted. But the word seems to me a gross exaggeration. The all-pervading terror and ingenious propaganda led most scientists to make ideological and moral compromises. A part of their brains became twisted and foolish.

Nevertheless, in the professional sphere, scientists worked successfully. Even in its most horrible Stalinist stage, the Communist regime strongly supported—in its own style—development of fundamental science and succeeded in raising it to a rather high level by international standards. This was impressively demonstrated by the swift application of basic science achievements to important developments such as atomic and thermonuclear weapons, satellites, lasers, aircraft, spacecraft and so on.

One could say that the regime offered science a helping hand, albeit a stern and bloody one.

Fundamental science in democratic Russia

Strangely enough—although this seems strange only at first glance—in our contemporary state, with its rapidly developing democracy, the situation in fundamental science has worsened. Of course, a clear understanding of the importance of science is widespread in both society and the ruling circles. And however critical the present state of the economy, it cannot be compared with that during World War II, when half of the country was lost and tens of millions of men of the most productive age were in the army. But there is another difference between these two periods.

The war and the subsequent years of restoration of industry and agriculture were extremely hard for the people. During the war, ploughs often had to be drawn by cows or even by groups of women. In the terrible hunger years of 1946–47, millions of victorious but exhausted soldiers returned to ruined villages. Nevertheless Stalin, as always, neglected the needs of the suffering. His system of oppression was so strong that he could take from the peasants almost all the products of their slave labor. If Stalin decided to support science he could do so at the expense of the peasants and workers, who then suffered

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Soviet military technology in the form of intercontinental ballistic missiles on display at the 1990 parade commemorating the October Revolution. With the end of the cold war, military expenditures in the former Soviet Union may be greatly reduced, in line with economic realities. However, similar cutbacks in science would not be in the best interest of the country or the world.

N. ADAMOVICH/ITAR-TASS-SOVFOTO

People line up for bread in St. Petersburg in December 1991. Such daily hardships help to accelerate the emigration of scientists from the former Soviet Union. According to the author's computations, a typical scientist earns the food equivalent of about $100 per month, enough for surviving but not for living.

famine, insufficient construction of apartments and unbelievably low pensions for old people.

Such a policy is of course impossible in a democratic state—even if the democracy is not mature but merely pretends to be. Our leaders understand perfectly the need for and the difficulty of supporting the grandiose system of scientific institutes with an army of scientists. Some 70 000 scientists of various ranks currently work in the Russian Academy of Sciences alone. And they are doing mostly fundamental science. The funds spent for applied science—to a large extent military—are an order of magnitude larger. The system cannot be supported by robbing other layers of society, as was done in the past.

Of course, the same situation faces the military. The hypermilitarization of the state, pretending to have an army at least equal to that of the far richer North Atlantic Treaty Organization, was founded on the same principle of robbing the state's own people.

The new policies of Mikhail Gorbachev did away with this nightmare and opened the way to peaceful coexistence, reduction of the army and conversion of the military industry to a civilian one. But this cannot serve as an example for science. Some may propose reducing the scale of Soviet (or Russian) fundamental science to a level that can be properly subsidized by our economy, but this would not be in the best interests of either our country or humanity.

First, consider our national interests. However difficult and critical are these days for our country, they shall pass. Sooner or later, normal living conditions will be established, and so the level of culture—in particular the level of fundamental science achieved by the nation—must be carefully preserved to serve as the foundation for its subsequent development.

A few years ago I heard about the American physicist Robert Wilson's remarkable testimony during a US Congressional hearing on funding for the Fermilab particle accelerator. Wilson was asked what the proposed accelerator would contribute to the security of the US. Wilson answered that the accelerator "has nothing to do with defending the country, except to make it worth defending." Like art and culture in general, scientific achievements make an essential contribution to a nation's value and its very reason for existence.

Reduction of Soviet science would also contradict the interests of the world community. Science is a unique sphere of higher human spiritual activity that is universal. It is sometimes said that art unifies people because its language is understood by all of humanity. This is actually not fully correct. For example, when a poem is translated into another language, it is impossible even in principle to achieve a form that is entirely equivalent to the original. Indeed, how a poem is perceived depends on the wealth of associations accumulated by each individual, and such associations can only be similar to some extent for people from countries with similar cultures.

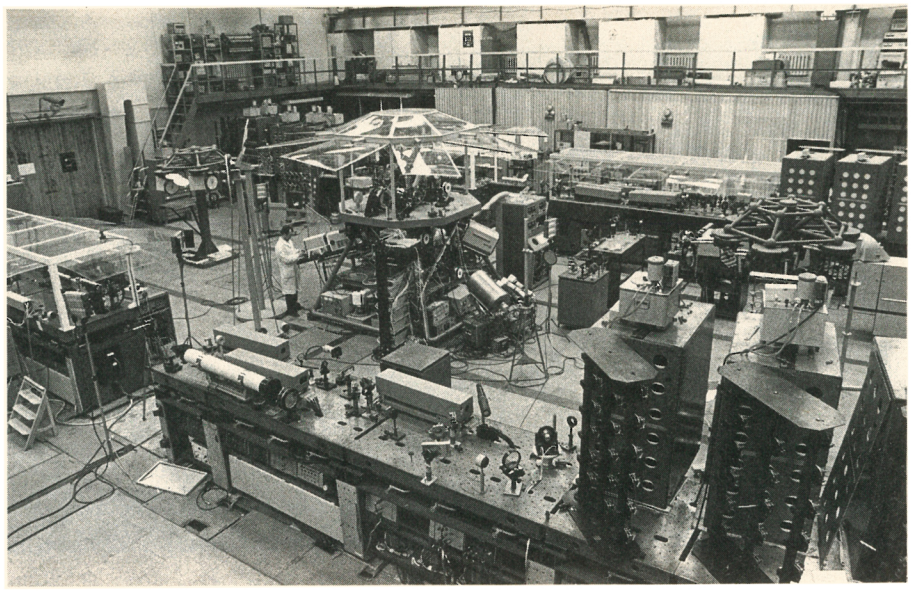
In contrast, fundamental science is truly international. All of its achievements belong to all nations and can be entirely understood by scientists anywhere on the globe. Likewise, any success of fundamental science in any country can benefit any other country. This is not entirely true of practical applications that are deduced from fundamental scientific discoveries to be used by one country against a rival. However, even in the development of the atomic bomb, it can be seen that all of the potentially dangerous secrets pertained only to the technological details of applied science. The "secrets" directly connected with fundamental science were rather easily and independently discovered in the USSR, the US, Germany, Great Britain and France.

Therefore, the development of fundamental science in any country is a blessing for all of humanity. Any nation has a real interest in the scientific successes of other countries, which allow it to save its own resources for the further development of research.

Living standard of Soviet scientists

No doubt the standard of living of scientists in the Soviet Union was always much lower than that of Western scientists of the same professional level. But this corresponded more or less to similar differences for other groups of society (except maybe the peasant population). And the standard was tolerable—there was no tendency for mass emigration among higher-level scientists (although, of course, emigration was not an easy enterprise).

When people characterize the current low Russian standard of living, they often simply convert the monthly salary in rubles into dollars, according to the official exchange rate—this January it was 110 rubles per dollar. (Except where noted, all figures are from January.) After approximately doubling in January, the typical salary of a scientist with a science degree at an institute of the



OLEG KUZMIN/ITAR-TASS-SOVFOTO

Dolphin-1 laser installation at the Lebedev Physical Institute, shown here in 1981. The device has been used for several years for research in controlled laser-induced thermonuclear fusion, and a somewhat modernized version is still in use. At one point it held the record for greatest volume compression, a factor of 3000.

Academy of Sciences became 1000–2000 rubles per month. One could therefore estimate it as about \$9–\$18 per month. This calculation is impressive but wrong.

In fact the conversion rate should differ depending on the kind of commodities you have in mind. For instance, although food prices increased by factors of 10–40 when prices were "liberalized" in January, they are still very low when converted to dollars at the official rate. For example, bread costs 3–8 cents per kilogram, and a dozen eggs costs 20 cents—about 10–20 times cheaper than in the US. Thus the "food conversion rate" is not 110 rubles per dollar but only about 15 rubles per dollar or less, depending on the food. Accordingly, the "food-based salary" of a scientist may be (extremely crudely) estimated as \$60–\$130 per month. Rent for a decent three-room apartment is currently incredibly low—less than a dollar per month—and so the "apartment-based salary" would be extremely high.

All this explains why people here are not dying from starvation, which would be inexplicable with the popular but wrong estimate of about \$10 per month. Of course, this is only surviving, not living. Constant malnutrition *is* a reality. In the special restaurant for members of the academy, a reasonable lunch (which corresponds to dinner in America) cost about 3 rubles a year ago but now costs about 10 times more. Rather few members of the academy now visit this restaurant regularly. Once always crowded, its hall is now half-empty.

The president of the academy, Yuri Osipov, said in a recent TV interview that a full member of the academy who is also the director of a large academic institute earns less than a bus driver. (In January a bus driver in Moscow earned about 2000 rubles per month.)

One should also take into account the inevitable further increase of prices. Indeed, in April the price of sugar jumped to 80 times the December 1991 price. Nevertheless, at the official exchange rate, it still costs less than \$1 per kilogram. However, scientists' salaries increased only by a factor of 2–4 in the same period.

What is the way out of this situation for scientists?

During these troubled times, the great majority of the population does not seek a way out but simply endures the situation and waits for better times. I have witnessed three periods of famine in this country, and I know from personal experience what a long-lasting feeling of hunger means. It was like that during the civil war of 1918–21, when industry was totally paralyzed. It was somewhat different during the "collectivization" of 1930–33: Townsfolk didn't suffer too much, but in villages millions died and cases of cannibalism were well known. Then there was the extreme famine during World War II, when hungry people labored hard and as a rule enthusiastically, and hungry scientists produced good work. In each case the country survived. But now, in peacetime, with industry, however backward, still capable of producing everything that is needed, famine is absurd. And many people do not want to accept it as inevitable.

Some scientists have found work on the side, giving lessons, repairing cars and the like. This of course tells negatively on their scientific activity and rarely helps substantially. The most tempting way out is to emigrate.

Emigration

In the past, emigration was difficult. KGB and local party officials carefully selected those scientists who they considered *vyezdnoi*, or "permitted to travel abroad." The criteria were numerous and often very cynical. For example, an unmarried and childless scientist had an extremely low chance of going to a scientific conference abroad because, according to KGB reasoning, he or she might remain abroad as there would be no "hostages" on whom the KGB could exact retribution.

Recent years have brought us freedom of travel, tremendous inflation and increasing instability in the country, all of which has created a wave of emigration. Some scientists of world reputation have been abroad since 1989. Officially many of them are on leaves of absence for two to three years, but there is little hope for their return. Among the emigrants are many Jews who have suffered from the accumulated humiliation of anti-Semitism condoned by the state and party since World War II. Although this has softened considerably in the last couple of years, it is being replaced by growing fascist elements and anti-Semitic movements in many states. Simplified conditions for Jewish emigration have further accelerated the exodus.

But the temptation to emigrate goes far beyond one ethnic group. The current wave includes people from all regions, including Russians.

There are still factors that inhibit emigration. Only

the best people can expect to find permanent professional scientific work abroad. Also, such a move is not so simple psychologically. Many were brought up in a very attractive Russian culture. Emigration means leaving behind friends who have formed one's inner spiritual world. Nevertheless, scientists of all ages are emigrating.

Different institutes suffer from different scales of emigration. Our mathematicians, theoretical physicists and molecular biologists include many "stars" with international reputations, and a number of them have already emigrated or are spending more than half of their time abroad. I do not know the exact figures but in some institutes the absence of these people is now definitely felt. This process will undoubtedly continue at a rapid pace.

At the same time, many scientists (mainly those of somewhat lower professional level but nevertheless also well known in Western scientific circles) satisfy themselves by spending some three months of each year abroad. As a rule, in Western Europe they receive smaller salaries than natives of the same or even lower qualifications, because it is well known that these Soviet scientists will readily agree to such conditions. After living abroad and spending some minimal sum for their personal needs, they return with enough savings to make essential improvements in their families' food supplies, making life more tolerable.

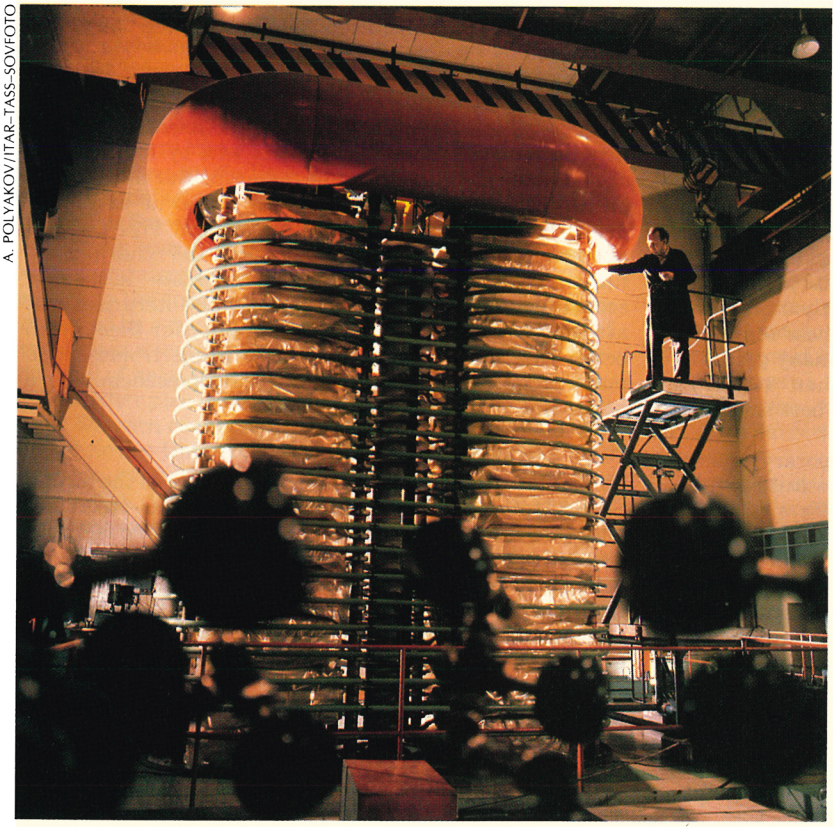
A talented young colleague told me that in a German institute in 1991 he earned 40 marks per day and received free accommodations. He managed to keep his daily living expenses under 20 marks and thus saved about 20 marks, or $12, each day. After returning home and converting his money at the official exchange rate, he had a sum equal to his official monthly salary at home for each day spent abroad. The head of the German institute openly told him that he earned about half as much as a typical young Western scientist of much less use to the institute.

However, such a regime of repeated travel is difficult for experimenters, whose general situation is much worse than that of theorists. Experimenters suffer not only from the very bad food situation but also from drastically increased prices for instruments and special installations and the everyday services necessary for their operation—power, heat, water and so on. In the past these were all rather cheap.

In January some dramatic incidents occurred. For example, at an academic chemical institute the bills for auxiliary services such as heat were directed to its bank and automatically paid. After these sums were subtracted from the institute's account, the institute had no money left to pay salaries. The administrators feverishly looked for money and with some additional credit paid the scientists' salaries after a one-month delay. This is in no way a rare situation.

Many institutes, trying to maintain the very existence of their staffs, raised salaries by a factor of four as compared with the previous year. This has been done at the expense of experimental work or by selling equipment

A. POLYAKOV/ITAR–TASS–SOVFOTO



Crimped Catch Three experimental installation at the Nuclear Physics Institute in Novosibirsk, Siberia. The device is used to study the properties of plasma, an important step in developing a thermonuclear power plant. The idea of a crimped "catch" for plasma was conceived almost 20 years ago by Gersh Budker and then-young physicists V. Mirnov and D. Ryutov.

that is not urgently needed. But it often leads to the paralysis of experimentation.

Brain drains

We can distinguish various types of brain drain that endanger our fundamental science.

First, there is permanent emigration. This includes people who are tired of poor living conditions, the regional conflicts that have recently become so frequent and bloody, and the general instability of social and international relations.

Second, there is what we may call temporary emigration—that is, when people spend a large part of their time abroad. They simply wish to wait in quiet conditions until the hard times in our country are over. As a rule, these people do not want to break their ties with their country. However, a comfortable life and the possibility of doing uninterrupted scientific work are tempting. The longer they live in such conditions, the less likely their return. It seems realistic to delete the names of many such individuals from the list of possible returnees.

However, the level of emigration essentially depends on the working atmosphere here. In the theory division of the Lebedev Physical Institute, there are some 55 scientists. Only 4 or 5 of them have emigrated—forever, we think. Some 5 to 7 others are abroad on contracts of one to two years, and about 40 more have been going abroad for periods of three months per year. When one of them was asked by a foreign correspondent why he does not stay abroad permanently, he answered: "How can I leave my institute? Here I have a weekly seminar on plasma, solids, superconductivity, cosmology and so on, headed by Vitaly L. Ginzburg and attended by at least 200 people. Moreover, there is a weekly seminar on the most fundamental and abstract problems of quantum field theory by Efim S. Fradkin with some 40 participants, and a fortnightly seminar headed by Leonid V. Keldysh on fundamental problems of field theory and solids, with some 50 participants. First-class theorists take part in discussions in these seminars. They are so interesting! I have worked in many places in western Germany—I never saw more than 10 to 15 participants at a seminar there. And the best scientists there are scattered over the entire country!"

The proportions of permanent and temporary emigration are similar to those for the Lebedev Institute at first-class institutions such as the Institute of Physical Problems, founded by the late Peter L. Kapitsa; the Landau Institute of Theoretical Physics in Chernogolovka, near Moscow; and the Institute of Theoretical and Experimental Physics in Moscow. At the Landau Institute the number of outstanding scientists who spend half or more of their time abroad is higher than at these other institutes.

This shows that emigration, be it permanent or temporary, has not yet ruined the best institutions; they still have outstanding scientists and are very attractive for their staffs. But how long will scientists' devotion to their work at their native institutes last when they can live instead in some peaceful democratic state with a well-developed system of scientific institutes? Which side will win?

Besides such "external" brain drains, our fundamental science faces another danger that we may call an "internal" brain drain. I have described above how in the Stalinist and post-Stalinist eras science as a profession had a special attraction for talented young people because they were not forced to make the everyday lies and compromises required of other professions. Their work was an honest pursuit.

In this respect the situation in science was much better than in many of the other spheres of activity open to an ambitious and talented individual. But new times open up new possibilities, such as commercial and political activities of various types. Young people are now finding new outlets for their abilities. I know at least four young men—three physicists and one chemist—who were dissatisfied with their work in science, even though three of them already had their candidate degrees. They turned to business—one works on the commodities exchange, one in a trading company and two in commercial enterprises producing new technology. Of course they now earn tens if not hundreds of times more income. But I am sure they were no less attracted by the very nature of the work. In business they have found new difficult problems to be solved, a spirit of competition and risky or even dangerous situations.

We should expect a rapid increase in internal migration. Of course, this process also has a positive aspect for science because it purifies the scientific community by removing those individuals who by their nature are not truly suited to scientific research. But the internal brain drain has a peculiarity that makes it extremely dangerous for the future of fundamental *experimental* research: It includes those technicians and other personnel who traditionally earn less than scientists. In the new economy there appear to be many private enterprises that are in need of these technicians and can offer them much better salaries. Already, specialists in electronics, computer programming and so on are leaving academia for a better life.

How can other countries help?

The problem of helping fundamental science in the former Soviet Union, of helping scientists survive, is vigorously discussed throughout the world by scientists who feel deep sympathy and respect for their colleagues here. We all belong to the kind of international community that inevitably arises among people who are devoted to a common noble aim and capable of understanding and evaluating each other's work. The presence of rather strong elements of competition does not belie the fact (and the feeling) that we are involved in a common pursuit, that we are mutually engaged in this work.

However touching these feelings, it is very difficult to transform them into money controlled by governments and business executives. What can be done?

V. ZININ/ITAR–TASS–SOVFOTO

A new magnetic detector called Kedr is under construction and will be used with the future VEPP4 collider for high-energy physics research at the Novosibirsk Nuclear Physics Institute. Here it is discussed by V. Peleganchuk (left), the technical director of the institute, and I. Protopopov, the head of the collider group.

Many essential attempts are now being developed. One of the most important is the declaration[1] issued by the heads of NATO in Rome in November 1991. It contained a section entitled "Relations with the Soviet Union and the Other Countries of Central and East Europe—a Qualitative Step Forward." No doubt this declaration is a "qualitative step forward" because it recognizes that the interests of Central and Eastern Europe are not inimical to those of NATO.

This document allows Central and Eastern European scientists for the first time to participate (with full payment of living and travel expenses) in the advanced study institutes and advanced study workshops held throughout the NATO member countries. It also permits a limited number of these meetings to be organized in Eastern Europe. The document also allows the granting of funds to laboratories in some Central and Eastern European countries for collaboration with NATO-member laboratories. No doubt this will help to establish lasting ties between researchers of both sides. The NATO document also expands to Eastern Europe another program known as the Expert Visit Program. The program will arrange for visits by experts from NATO nations, intensive courses at Eastern European universities given by eminent professors from NATO nations, and so on. A third program, the Laboratory Linkage Program, supports the organization of collaborations on concrete applied science problems like those that have been successfully operating since 1981 in Turkey, Greece and Portugal.

It is remarkable that NATO is ready to offer scientists in the former Soviet Union some of the privileges that until now were reserved for NATO members. But the approach of scientific liaisons endorsed by NATO is not entirely satisfactory. Seemingly, the basic idea is to help the former Soviet Union in the same way that NATO helps developing countries—that is, to spend NATO money without gaining any immediate profit. But the crisis in science in the former Soviet Union is very different from that faced by a developing nation, which has no heritage of world-class scientific achievements to build on. A different kind of help seems more appropriate.

Another plan is to open new workplaces in the US and other Western countries especially for scientists from the former Soviet Union. Here the approach is inverted, and the plan would increase emigration and intensify the brain drain. This would help many scientists to survive the hard times in comfort and would be a blessing for them. But it would help only the best scientists, while lowering the general level of scientific potential in the former Soviet Union.

No doubt these and other similar plans would be beneficial to a considerable extent. But they will not achieve the general goal of preserving the current level of fundamental science.

International research centers

Many of my colleagues and I prefer another approach: the large-scale collaboration of the West in organizing international scientific centers to be based at the best existing scientific research institutes in the former Soviet Union. Let us call them IRCs: international research centers.

This idea originates from our deep belief that despite the economic difficulties and the harm already inflicted by the brain drains, our science still has great potential. I shall illustrate this by the example of the Lebedev Institute because I am most familiar with it; naturally, there are many similar possibilities at other institutes. At the Lebedev Institute there are many very active older world-class physicists, including Keldysh, Nikolai G. Basov, Ginzburg and Fradkin, and about 200 younger professors, many of whom are also well known to the global scientific community. An IRC connected with this institute could have a prosperous future.

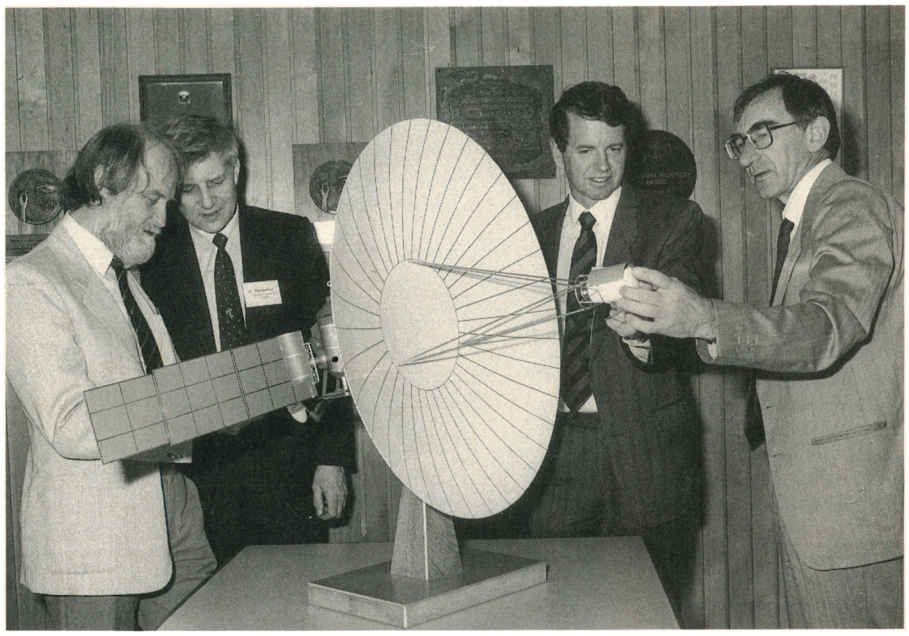
In general, an IRC would:

▷ Collaborate with countries outside Eastern Europe to organize large-scale research programs in fundamental physics.

▷ Organize intensive courses (like those of NATO) with lectures by eminent professors from Central and Eastern Europe (including those scientists who now spend their time abroad) and elsewhere, and with participants drawn from the former USSR and developing as well as industrialized countries.

▷ Organize advanced study institutes and workshops for a similar contingent of lecturers and audiences.

At least two such centers were organized in the USSR long ago. I have in mind the Dubna Joint Institute for Nuclear Research and the Serpukhov Institute for High Energy Physics. They were sponsored almost exclusively by the Soviet government and correspondingly acted within the old administrative system, which put numerous



Model of the Radioastron satellite that would form one end of the baseline of a radiointerferometer. Completion of the project is currently threatened by the economic situation in the former Soviet Union. The Radioastron project could form the basis of an international research center in Russia. Here, Nikolai Kardashev (second from left), chairman of the Radioastron International Scientific Committee and director of the Radioastronomy Center of the Lebedev Institute, discusses the project with scientists from the Australian National Telescope Facility and CSIRO at a meeting in Australia.

obstacles in the way of truly independent international cooperation. Nevertheless, they achieved many important scientific results.

Investment in an IRC by industrialized countries would be very efficient, both economically and politically.

The economic efficiency follows in part from the low living expenses in Russia when expressed in dollars. But it is also more efficient economically than many other plans because helping "on site" in Russia would eliminate the competition for scientific vacancies in the West created by the influx of foreigners.

I shall illustrate the plan with the example of one very impressive project. A few years ago the well-known Soviet radioastronomer Nikolai S. Kardashev put forward the idea of a radiointerferometer with one end of the baseline on Earth and the other on a satellite orbiting at, say, 60 000 km. Such an instrument would achieve angular resolution that is an order of magnitude better than anything possible with an interferometer with its baseline entirely on Earth. The opportunities for investigating the universe are correspondingly enhanced. For example, it becomes possible to study the global geometry of space.

The project was enthusiastically accepted by scientists. The collaboration, including participants from 14 nations with Kardashev heading the coordination committee, has worked for several years, and the contribution of each group has been agreed upon. Construction of many of the instruments is nearing completion. The US joined the project after a letter supporting the project and signed by the late Andrei D. Sakharov was sent to Vice President Dan Quayle in 1989. A large group of scientists and engineers is working on the project at the Lebedev Institute. Naturally, the main contribution of Russia was to be the construction of the satellite.

However, the new economic situation in this country has produced difficulties, and the danger of a considerable delay has arisen. The specially constructed satellite can be easily made in a Russian plant for a quarter of the cost in the US. A grant of about $2 million would allow completion of the project. World science would have an unprecedented new window on the universe, and the Russian institutes involved in the project could substantially improve the life of their scientists.

This is in no way a unique example. For instance, the late Gersh I. Budker many years ago proposed the elegant idea of a linear accelerator for unstable particles such as muons. (At high energy, relativistic time dilation makes acceleration possible.) Now at the Institute of Nuclear Physics in Novosibirsk, his pupils, headed by Aleksandr N. Skrinskii and Vladimir E. Balakin, have made considerable advances in realizing the idea. But they need help. This could be another IRC, and again international collaboration on site would be economically the most efficient.

For many reasons such investments would be extremely efficient politically, too. First, any act of international solidarity strengthens the friendly relations between nations, and this is essential in the contemporary world. For our country this is especially important because it would help quash the fascist reactionary movements, which are gaining popularity in regions where people feel helpless and suffer from lack of food. This is a crucial moment for the fate of humanity.

Second, the existence of international scientific centers would improve relations among the independent states that remain after the decay of the USSR, because IRCs can be established in states other than Russia. For instance, giant installations for cosmic-ray studies are under construction in Armenia and Kazakhstan. It is now clear that their construction can be finished only if they become international centers.

And third, but maybe most essential, is a fact of geography. When it becomes clear that Russia and other republics of the former Soviet Union have entered the world system of democratic states as dependable partners, they can play the important role of a bridge between the West and the East. Supporting the international status of their scientific centers is an important step toward the integration of Western and Eastern cultures, which is indeed a hope of humanity.

Reference

1. Newsletter of the NATO Science Committee and the Committee on the Challenges of Modern Society, issue N31, 4th quarter 1991, NATO Scientific Affairs Division, Brussels. ■