Murray Gell-Mann, Caltech professor of theoretical physics, is—at 27—one of the country's outstanding young physicists. His special field is the theory of atomic nuclei.

AN AMERICAN PHYSICIST IN MOSCOW

I WAS ONE of a group of about a dozen Americans invited to a conference on high-energy physics held in Moscow last May. The field we discussed there is a branch of nuclear physics. In the last ten years there have been applications of nuclear physics to technology —the so-called peaceful uses of atomic energy—and there have been applications to war. But there remains a field of research which is pure nuclear physics—just the efforts of scientists all over the world to try to find out something about the structure of the atomic nucleus. And it is this field of physics that we discussed at the conference in Moscow.

Specifically, we discussed a particular part of nuclear physics which is not the study of nuclei at rest, but the study of what happens to nuclei and their constituents when they collide at very high energies, producing new particles which are never seen otherwise. After a small fraction of a second these particles decay into electrons and light and such things. Such transformation processes of nuclear particles are, for the most part, what we discussed under the name of high-energy nuclear physics.

The sort of nuclear physics that has been applied to the making of bombs and the making of piles for electric power is entirely low-energy nuclear physics. The

A Caltech physicist attends an international conference in Moscow, and brings back an informal—and surprising—report on Soviet scientists and how they work.

A transcript of an extemporaneous talk

by MURRAY GELL-MANN

high energy field is so far without practical application.

At the Geneva Conference last year, Western and Soviet scientists had already discussed the applications of nuclear physics to atomic energy. From the point of veiw of secrecy, our conference was very much in the nature of an anti-climax since we were talking about pure physics. From another point of view, though, our conference was more interesting because we were visiting the Russians at home. We were meeting their families and seeing how they lived—we were talking to them over long periods of time. And they must have felt much more at ease at home than they did when they were travelling abroad.

The sixty foreigners who came to the conference were from the West and the East. There was our delegation of about a dozen from the United States, including five from California. There were some five or six from England, a few from France, and a couple from Italy. There were two reasonably good physicists from China, and there was a very famous one from Poland. There were a number of people from other countries—one from Roumania, one from Hungary, a couple from the "Korean People's Democratic Republic" and so on.

At the beginning, the Soviets practiced segregation in housing us. The Westerners were put in the Moscow, an old hotel in the center of town, literally a stone's throw from the Kremlin. The People's Democrats went into one of the new skyscraper buildings on the outskirts of the city. There were so many complaints from both sides about the fact that we were segregated that, after a week or so, the People's Democrats were moved in with us. We got along very well, all of us; we talked about physics, and we talked about touchier subjects too.

The official sessions lasted about ten days and were held at the various institute and university buildings in and near Moscow. After the first one, I didn't go back very much to these sessions. The principal purpose of the conference was to present Soviet work to the Westerners, rather than the other way around. The speeches were given in Russian by Russian experimental physicists talking about their work, and simultaneous translations came to us through earphones. This system, so successful at the UN, was less so here, because the translators were not physicists, and, although the Russians were clearly talking about physics, the translators were not. You don't have to know very much about science to know that it would create some difficulty when the speaker said, "We then applied perturbation theory, neglecting terms of higher order;" and the translator said, "We made use of the method of disturbances, ignoring members of higher rank." So if you wanted to listen you had to perform second translations in your head, and that wasn't very convenient.

What I did most of the time was to try to engage in informal discussions with small groups of Soviet physicists, discussing various parts of the frontier of physics and comparing their work with ours in particular fields.

I expected to see a great many women scientists at the sessions, because I had been told that women comprised over half the medical profession, and I thought that in physics too, perhaps, something like that was the case. But there were only a few in the audience—about the same number that would be found in a corresponding meeting in America.

Another thing that I had expected was a great deal of formality—a sort of "Herr Professor" attitude among the Soviet physicists. But when the meeting began I realized that there really wasn't very much formality. Before five minutes had elapsed the Soviet scientists were on their feet, screaming at one another and arguing desperately. In general, there was a great deal of emo-

tion and a great deal of heat generated as well as lots of light. So I find that the Soviet scientists are at least as informal as our American ones—perhaps more so.

Soviet research in physics is not run in any unified way. Although it is just about all financed by the National Academy of Science, which is a branch of the government, it is handled by many autonomous organizations and research institutes of the Academy. Aside from Moscow State University, the most important research is undertaken at these institutes. There are a great many of them, and, in or near Moscow, there must be about a dozen which are wholly or partially devoted to high-energy physics. These institutes cooperate with one another but they are also rivals, like the various universities in this country.

Soviet scientists are doing very good work. In almost all of the field of high-energy physics, their work was pretty much parallel to that going on in the United States and other countries. There is, however, one particular branch which we might call ultra-high-energy physics, or the physics of new unstable particles, in which there has been very little work in the Soviet Union. This is the physics of collisions at *extremely* high energies in which new kinds of particles—the so-called strange particles—are produced. These are investigated in one of two ways—by using cosmic radiation, which contains high-energy nuclear particles, or by generating high-energy nuclear particles in accelerating machines such as the Bevatron at Berkeley.

Bigger than the Bevatron

The Soviets have done very little with either of these methods. So this subject, which has been under investigation in the West for three to five years, is just in its infancy in the Soviet Union. However, they are now building a machine which will be bigger than the Berkeley Bevatron. It should be ready in about a year, and at that time they will presumably jump with all four feet into ultra-high-energy physics. They will, of course, be two or three years behind the Berkeley people, and they will have to start from scratch, but presumably after a little while they will be doing equally important work.

It is a little bit strange to find the Soviet Union, supposedly such a practical country, pouring so much money into a very abstract field. We asked one of their principal theoretical physicists how they got all this money from the government and he said, "Well, we just say to them, 'Look at the Americans'." It seems that, whereas we tell our government about the numbers of mathematicians and physicists and engineers that are being graduated by the Soviet universities—a figure which is in excess of the corresponding figure for the United States, possibly about double—they tell their government about our fundamental researches in pure science. And they apparently point out that scientists become discouraged if they can't do the most important frontier work in science, that they won't have the highest quality scientists if they can't train them by working on the most advanced and the most spectacular problems. And so they apparently get unlimited funds.

We took a trip to see the great new Russian accelerator that will be ready next year, and also their medium-energy accelerator which has been running for about seven years now. These are located in a new village, which was built for the purpose, about 70 miles from Moscow, on the Volga. The town is called Bolshaya Volga—the great Volga. The two laboratories there, each containing its gigantic accelerating machine, have just been donated by the Soviet Government to an international organization which consists of countries whose names you can guess—the Soviet Union, Poland, Bulgaria, Roumania, the "Korean People's Democratic Republic" and so forth. These are member countries. However, citizens from other countries will apparently be invited to come and visit and spend a year or more working at these laboratories. American physicists are to be invited too. Whether they will accept and whether the invitations will actually go through, no one can say at the moment.

The wrong side of the fence

It was an all-day trip that we took; we spent the morning looking at the existing accelerator, a large part of the afternoon (until most of us despaired of ever getting any lunch) looking over the other one. As we were walking around the grounds of the second accelerator, one of our physicists from Columbia was talking with Danysz, the Polish discoverer of the hyperfragments, and he said to Danysz, "Look, I see barbed wire over there and behind the barbed wire some people in fatigue clothes; don't you see them?" And Danysz looked over and said, "Yes, what about them?" And my friend said, "Well, they are digging trenches and throwing earth up into those trucks; who do you suppose they are—slave laborers?" Danysz looked at him for a little while, looked at the people, and looked at the fence. Then he said, "What you are faced with is a problem in topology; those people are *outside* the fence." Which was true. We were *inside*. The laboratories were enclosed in barbed wire and apparently had been top secret until just before our visit. We were the first Westerners to be shown them.

The contain, of course, the kind of equipment which, in the United States, has been pretty much open to the public ever since it was built. Physics of this sort—high-energy physics—has never been classified anywhere in the world except Russia. Some of the attitude of suspicion, naturally, still hangs over these installations. When I got tired walking around all the machines and looking at all the equipment and listening to the "Oohs" and "Ahs" of the American experimental physicists, I went out in back to look at birds. Bird-watching is a hobby of mine. After a minute I saw a woodpecker sitting on top of a pile of wood behind the Accelerator Building, and I was staring at it, fascinated, because I had

never seen a wryneck before, when the driver of our bus came running up and said (in Russian, which I had difficulty understanding), "No, no, no, you mustn't stay out here; you mustn't look over in that direction; you must go back in there and look at that atomic machinery."

So I went back in, and I found our American physicists staring rather open-mouthed at the accelerators. They are, of course, very much like ours; they were invented almost simultaneously in Russia and the United States. But what our physicists marveled at was the lavishness of the accelerators. They had apparently been built without any regard for money at all. The equipment was the best that one could get, no matter how expensive or difficult the method of manufacture. Luis Alvarez of Berkeley said that it reminded him of Los Alamos during the war where the motto was, "Why use lead when gold will do?"

Princely salaries

These people not only have money for their equipment but they also have lots of money for themselves. The scientists are among the best paid people in the whole country. The ruble, in which they are paid, costs the tourist a quarter. However, it is not worth a quarter; from what we could tell, it is worth more like ten cents. A professor of physics will make several salaries. He will be a professor at one of the institutes of the Academy of Science where he does his research. That will net him 6,000 rubles per month. He will be, at the same time, half a professor at the university, which means that he will teach a course there perhaps for half a year. He will get half a salary for this too, which is 3,000 more. Besides that he is likely to be an Academician, a member of the National Academy, and that honor carries with it a salary of 5,000 rubles per month for life. Such a man, then, will make 14,000 rubles a month, or $1,400. That is, even by American standards, quite a decent salary. In the Soviet Union, although there isn't very much to buy, it is, of course, a princely salary. But the thing that strikes one particularly is the contrast with the salaries of other people. A maintenance employee—a janitor or gardener—at the same Institute may be making 400 rubles a month, a ratio of something like 30 to 1. In the United States, the ratio would be perhaps 3 to 1.

Political pressure

Although Soviet scientists live very well they have been subject, at least until the recent change of regimes, to a considerable amount of political pressure. One of their very greatest physicists was under house arrest for almost eight years as a result of a fight he had with Beria. He was released only about a year ago. He had managed to do some work at his country estate during his long confinement. His son, who was also a physicist, brought him out some equipment and some books and he was able to do a little work, but it was on some rather unusual things; for example, he worked on the "Kugelblitz." This is a phenomenon which may or may not exist—spherical lightning. These balls of lightning, which have been seen by various people—often peasants—are supposed to come rolling down the chimney and go spinning around on the hearth rug. It is uncertain whether they exist at all, of course; they are somewhat in the same category as flying saucers.

However, the physicist wrote an excellent scientific paper showing how, if these things *do* exist, they might be explained by certain physical principles. It was an extremely ingenious piece of work—but the great man could certainly have been better employed during these 7 or 8 years. He is the director of one of the biggest institutes near Moscow, and he is back in his office now. His salary is 32,000 rubles a month and he has a Zis limousine with a chauffeur who is supposed to be the best driver in Moscow, and he has a fine town house and a country estate, and so on.

Other physicists didn't receive promotions which were obviously due to them, because of the political and even racial prejudices which were prevalent under the Stalin regime. There were political arrests and there was a feeling of uneasiness among the scientists. A lot of this seems to be changed.

Laughing at Stalin

Many of the people we met expressed a considerable amount of relief at the change of government, and they seemed happy that they were now free to laugh a little at the Stalin myth. And they do laugh at it. For example, in the home of one scientist—in the bathroom, where, let's say in rural America one might expect to find a Sears Roebuck catalog, one finds the *Official Biography of Stalin* and one tears out pages.

Pure physics, which was strangely classified until two years ago, is now declassified and the Russians have published their results and are now free to communicate with foreign scientists. Whether all of Russia's principal physicists will be able to visit foreign countries in the near future is another matter. Some of them are allowed to travel, but many of the important ones have not been allowed to do so. It will be interesting to see whether—in the next year or so—they will be able to accept the invitations they have received from the United States.

I expect that if things continue the way they have been going in the last year or two, the Soviet scientist will become an ordinary member of the world community of scientists, producing results which will be on the same level as ours, discussing them with us freely, and making trips—we hope—to the West, just as we were permitted to visit them. We should be delighted to have them, for they are very good scientists and very fine people.

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