Glasnost Comes to Soviet Physics

An article in the magazine Literaturnaya Gazeta *publicizes a decade-long misdirection of high-pressure physics research and has some barbed words for the way Soviet science works*

THE 25 June 1986 issue of the Soviet magazine *Literaturnaya Gazeta* contained a remarkable article with the awkward (in translation) title "Nothing, that pretended to be metal: Who held back development of an important direction in physics for a decade and how." Written in a mocking, melodramatic tone, the article blames primarily one man, Evgenii N. Yakovlev, for taking research at the Institute of High-Pressure Physics near Moscow down a blind alley during his 10-year tenure as acting director.

The article does not stop with Yakovlev. While noting the pressures to conform, it also criticizes the scientific staff of the high-pressure institute, whose members did not publicly proclaim their reservations when they privately questioned Yakovlev's research priorities. Almost everyone agrees these priorities were based on experiments whose results were wrongly interpreted. Finally, the article even takes on the Academy of Sciences of the U.S.S.R., which failed to act long after it understood the gravity of the situation at its high-pressure institute.

The intent of the article in the *Literaturnaya Gazeta*, which is read by several million university-educated citizens of the U.S.S.R., is clear. The *glasnost* or openness campaign now going on in the Soviet Union aims at a public airing of instances of the inefficiency and corruption that are said to be widespread in all sectors of Soviet society, including the scientific. The article plainly puts Yakovlev and the high-pressure institute in the class of sorry situations needing public exposure to help force change. "The important thing here is to create conditions in science under which unprincipled people simply do not survive as scientists," writes the author, S. Ushanov.

Interviews with several American physicists who know Yakovlev and have visited the high-pressure institute leave no doubt that the Soviets have fallen behind in the institute's specialty, so-called static high-pressure research, by neglecting to pursue the use of the diamond anvil cell. This device has caused a revolution in the field because it can apply pressures up to several million atmospheres, while allowing the physical properties and structure of a compressed sample to be monitored at the same time. Because the institute is *the* central laboratory for static high-pressure research in the U.S.S.R., this is a major omission.

The *Literaturnaya Gazeta* article tells its story with a wonderfully melodramatic flair, but the mocking tone leaves no doubt as to its intent, beginning with the title itself. "Nothing, that pretended to be a metal" refers to a joke said to be circulating in scientific circles to the effect that with his high-pressure apparatus "E. N. Yakovlev was able to make metal even out of absolute vacuum."

"The important thing here is to create conditions in science under which unprincipled people simply do not survive as scientists."

To appreciate the joke and also the events at the high-pressure institute recall that one of the great divisions in condensed-matter physics is that between electrically conducting metals and insulating nonmetals and that considerable effort has been devoted toward learning in detail how a material can change from insulator to metal and vice versa. High pressure enters the scene because, to paraphrase a 1926 contention of the late John D. Bernal of Birkbeck College (London), "anything will become metallic if you squeeze it hard enough."

Metallic hydrogen has been a particularly fascinating subject for speculation both in condensed-matter physics, as a possible possessor of room-temperature superconductivity and other remarkable properties, and in planetary science, as a likely constituent of the deep interiors of Jupiter and Saturn that could be responsible for their magnetic fields. A wave of contemporary interest among physicists began to surge in the late 1960s, starting with the theoretical work of Neil Ashcroft of Cornell University, who calculated some of the expected properties of metallic hydrogen.

In the Soviet Union, academician Vitalii L. Ginzburg of the P. N. Lebedev Physical Institute in Moscow included metallic hydrogen in his book *Key Problems in Physics and Astrophysics*. Well-known Soviet theorists who subsequently worked on the problem include Alexei A. Abrikosov of the L. D. Landau Institute of Theoretical Physics and Yuri M. Kagan of the I. V. Kurchatov Institute of Atomic Energy, both also in Moscow.

Events at the high-pressure institute trace back to academician Leonid F. Vereshchagin, the first Soviet researcher to make synthetic diamonds. Later, he spearheaded the establishment of the Institute of High-Pressure Physics and became its inaugural director in 1958. One of Vereshchagin's pet projects was the construction of an immense 50,000-ton press, which is still the largest in the world. The gigantic apparatus, built partly for the purpose of making metallic hydrogen, extends asymmetrically 28 meters above and 15 meters below the ground. As it turned out, the press was used mainly for other purposes, such as the production of synthetic diamond.

The *Literaturnaya Gazeta* article itself begins with the early 1970s, when it was not clear how high a pressure would be needed to make hydrogen metallic—estimates started at 1 million atmospheres—nor was it clear what kind of apparatus would be up to the job. Researchers at the high-pressure institute under Vereshchagin, including Yakovlev, tried a new approach, the indentor technique. They fashioned a flat plate and a sharp point of a synthetic, polycrystalline diamond material described in the article as "a synthetic diamond that bore the sonorous name 'Carbonado,' just as if it had come from the pages of a pirate novel."

Based on the relation pressure equals force divided by area, the idea was that an immense pressure would be generated because the force would be concentrated in the tiny area between the point and the plate. The use of carbonado also obviated the difficulty and expense of finding natural diamonds, as used in the then not-yet perfected diamond anvil apparatus, which squeezes samples between two tiny flat surfaces on gem-quality diamonds.

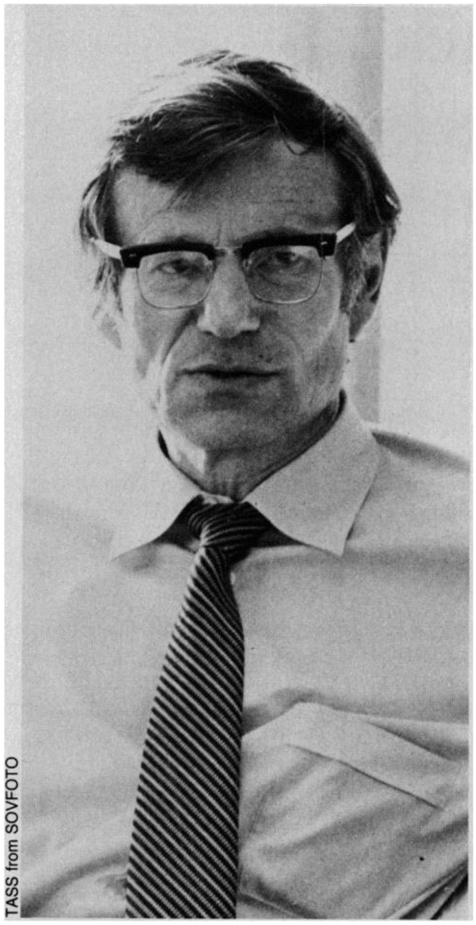
One difficulty with the indentor technique is measuring the pressure achieved. The researchers could only estimate the pressure by calculating the value needed to account for the indentation left in the plate by the point. A second problem is that carbonado, which is laced with metal particles as a result of the sintering process by which it is made, is opaque, so that there is no way to watch the sample while under pressure. The only measurement possible is to monitor the current between the tip and the plate, which would begin to flow when an insulating sample turned to metal under pressure. Despite these difficulties, preliminary tests with materials coated on the tip that made insulator-to-metal transitions at known pressures suggested the technique was workable.

Early on in 1972, the Soviet investigators achieved a major breakthrough, reaching a putative pressure of 1 million atmospheres, a figure not surpassed by American researchers for several more years. Thereafter, they began squeezing a wide variety of insulating substances, including hydrogen, and turned them *all* to metal (even a vacuum, as the joke would have it), as indicated by the appearance of an electrical current when the pressure was high enough. The article questions the honesty of the researchers, who wanted to demonstrate the existence of metallic hydrogen and verify its speculated wondrous properties. "And they wanted this so badly that, like at a telekinesis séance, the unsubmissive reality of the physical world yielded and obeyed the heedless desire of the experimenters."

Not mentioned in the article is that, as director of the high-pressure institute, Vereshchagin put his name on publications reporting these results, although Yakovlev seems to have been leading this particular effort. In any case, after Vereshchagin's death in 1976, Yakovlev was named acting director, presumably to continue this line of work. Contrary to the impression the article gives, all other research did not stop. In 1982, for example, Yakovlev won an award from the Council of Ministers of the U.S.S.R. for work on making synthetic diamond under high pressure.

The metallization reports appropriately generated much interest around the world, but the obvious alternative explanation that the current flowed because the point was punching through the samples and directly contacting the plate soon gained more credibility. "Solid hydrogen flows like butter," says one physicist, and because the sample is not confined, the point can easily push it aside and open a hole.

At one conference on high-pressure physics, for example, Yakovlev claimed that Soviet researchers had converted hydrogen into a metal at a pressure somewhat greater than 1 million atmospheres, and in another experi-


TASS from SOVFOTO

Evgenii N. Yakovlev. *A former award winner is now in hot water.*

ment had done the same for ruby at a pressure near 400,000 atmospheres. But, at the same meeting, a group from the Carnegie Institution of Washington's Geophysical Laboratory reported obtaining pressures well over 1 million atmospheres in a diamond anvil cell, which does confine the sample. The Carnegie group measured the pressure by the shift in the wavelength of fluorescence emitted by a tiny ruby chip, in the transparent natural diamond cell. The ruby was still red and not remotely like a metal.

After this revelation, Yakovlev refrained from reporting specific pressures, but did not withdraw any claims to have observed insulator-to-metal transitions. As acting director of the high-pressure institute, he has been free to travel frequently to meetings overseas, always repeating his belief that the observations were real, but also unable to provide any new supporting data.

If his colleagues from overseas felt he was sincere but mistaken, the *Literaturnaya Gazeta* article criticizes Yakovlev's motivations for sticking by his experiments when others were skeptical. "Did Evgenii Nikolaevich himself guess earlier of the fiasco that had befallen him? It is difficult to judge, although suspicions must have arisen in the depths of his soul. But suspicions are suspicions, and position is position, and life is life. . . . And so a mighty wave of popularization of the new 'achievement' in physics rolled through in 1974–80."

Eventually, considerable skepticism developed even in the Soviet Union, according to American visitors. Sergei M. Stishov, an eminent researcher at the rival Institute of Crystallography in Moscow, who now uses a diamond anvil cell in his research, questioned the claims in the Soviet scientific literature. However, until recent anonymous letters to the newspapers, there was no public comment from the institute staff.

Describing the institutional pressures that prevented skeptical co-workers from expressing their doubts, the article explains, "We know dozens of other big and little screws that the institute chiefs can turn to apply pressure to unruly subordinates—wages, dissertation approval, quarters. A loner who ventures to doubt the results of the research work of the chief openly is truly not to be envied: all of this force of pressure will immediately be concentrated on his small area, and a man, even a resolute one, still does not have the hardness of diamond."

At the end, the article fires a broadside at the Soviet academy. "One must ask: well, and what about the Academy of Sciences? How could it permit the profanation of science to go on for so many years? Did no one really see anything? They saw. . . . Even in 1978 the Bureau of the Division of General Physics and Astronomy adopted a decision to release E. N. Yakovlev from the post that he occupied. 1986 is here, and this decision still remains on paper."

All in all, according to American high-pressure physicists, the Soviet system is a more appropriate target than the alleged personal failings of Yakovlev, who followed the direction set under Vereshchagin but was unable or unwilling to adapt when circumstances changed. It was mainly the combination of a highly centralized research effort and a rigid, slow-moving bureaucracy that allowed the high-pressure institute, which employs several hundred scientists and technicians, to drift well out of the scientific mainstream while Yakovlev remained in charge, partly because of his preoccupation with the carbonado-based indentor technique and its limited capabilities. By contrast, Soviet laboratories active in a related field called dynamic high-pressure research, in which, for example, an explosive transiently generates a shock wave and an attendant high pressure in a target, have maintained a world-class reputation. ■

ARTHUR L. ROBINSON