gas in the primary loop.

Once the emergency core cooling system and auxiliary feedwater pumps were both back in operation, things still were not under control. About one hour into the incident, an operator shut off the primary circulation pumps, apparently out of concern that they were badly vibrating, perhaps because of the bubbles in the system. Without circulation and apparently with little convection (a large temperature difference prevailed between inlet and outlet over this time), the core overheated. During the ensuing hours, the temperatures on some thermocouples on the fuel rods went above the computer-readout cutoff point of about 750° F. A large portion of the core was apparently uncovered after this point for an unknown period of time.

Bubble. When the operators restarted the circulation pumps and closed the block valve on the pressurizer, a new trouble developed. A large volume—as much as 1000 cubic feet or more—of noncondensible gas was detected in the reactor. Although no reliable measurement could be made of the composition of the gas in the reactor vessel, it was suspected to contain hydrogen. Air samples from the containment building registered concentrations of hydrogen of about 2%, and some sharp spikes in the containment building pressure—one of 28 psi—were interpreted as possible small hydrogen explosions. The hydrogen within the reactor vessel would come largely from a high-temperature oxidation reaction between the water and the zircalloy cladding.

The highly publicized concern that a growth of oxygen concentration from the radiolytic disociation of water might produce an explosive mixture within the reactor vessel now seems unjustified. As explained to us by Milton Levenson of the Electric Power Research Institute, who led an Industrial Advisory Group at the site, the very presence of a hydrogen overpressure in a closed system helps the oxygen recombine with the hydrogen and remain in the water. In fact, PWR's normally operate with an extra charge of hydrogen in the water to scavenge oxygen.

Nevertheless, any noncondensible gas bubble (or bubbles?) within the reactor vessel posed a problem for the safe cooling of the reactor. If the pressure were reduced too low, the bubble would perhaps expand enough to expose the tops of the fuel rods again. The gas was removed by spraying it out of the pressurizer relief valve to the containment building. The procedure worked slowly, and by 4 April the process had virtually eliminated the bubble.

Within the containment building, the additional hydrogen in the atmosphere already present there *could* produce a flammable (at 4% hydrogen) or explosive (at 6 to 8%) mixture. These percentages could be slightly higher in the presence of water vapor, according to Levenson. To reduce this danger, two hydrogen recombiners were installed in the auxiliary building outside the containment.

The reactor continued to cool through most of the month of April with primary pumps and one steam generator in operation. (Steam Generator B had been isolated when primary-to-secondary leaks were suspected there.) On 27 April, the primary pumps were turned off and the core left to cool by convection, with both steam generators operating. After two days, Generator B was isolated and at this writing is being equipped to run with all water and no steam. The decay-heat removal system normally employed to cool the reactor is not being used, partly because it would pump the radioactive primary coolant into the auxiliary building and might cause leakage around the seal.

Radioactivity. The accident has resulted in some releases of radioactivity to the environment. With the fuel rods overheating and cracking, fission products such as iodine, xenon and krypton escaped. These elements contaminated the primary coolant while it was still flowing out of the stuck relief valve. When the seal ruptured on the quench drain tank (15 minutes into the accident), this hot liquid spilled onto the floor of the containment building. The pump sent this fluid into an auxiliary housing that is shielded and equipped with air filters. Releases occurred because the liquid volume was too large for the system to handle. The containment building was not designed to isolate automatically when the emergency core cooling system comes on. It was isolated only after five hours, when the pressure in the containment building rose above 4 psi over atmosphere.

The resulting cumulative dose equivalent from 28 March to 7 April is estimated to be from 2000 to 5000 person-rem (that is, the number of people exposed times the average dose per person) within a 50-mile radius and about half that in a 10-mile radius, according to an NRC spokesman. The average dose equivalent to a person in the smaller-radius region amounts to 10 millirem during that time, he said. This may be compared to the average dose equivalent per person per year from natural sources (in that region of Pennsylvania) of 85 to 90 millirem, according to Mark Mills of the Atomic Industrial Forum.

A massive cleanup job lies ahead to dispose of the radioactive water from the reactor core, and the estimated 400 000 gallons of liquid on the floor of the containment building. A more difficult task will be to decontaminate the inside of the building, where radioactive cesium may have been deposited. —BGL

Current response to Orlov jailing

A year after the trials and sentencings of high-energy physicist Yuri Orlov and computer scientist Anatoly Shcharansky, the US physics community is still grappling with the question of scientific exchange with the Soviet Union.

SOS. Over 2400 US scientists recently signed one of two statements—either withholding or severely restricting cooperation with the Soviet Union until Orlov and Shcharansky are released. The statements were circulated by a group known as Scientists for Orlov and Shcharansky, which a year ago took up the cause of those scientists and other oppressed scientists in the USSR. Of the six members of the SOS Executive Committee, three are physicists—Owen Chamberlain (University of California, Berkeley), Malcolm Derrick (Argonne National Laboratory), and Kurt Gottfried (Cornell University). While SOS does not feel that all contact between the US and Soviet scientific communities must cease, they are opposed to expanding involvement at this time and to the essentially one-way transfer of technology in areas in which the US enjoys a considerable lead.

An international radio broadcast from the Soviet Union recently attacked the SOS statements. According to the broadcast, SOS has been misinformed about the Orlov and Shcharansky cases by "American propaganda." It also went on to denounce the "chauvinism" implicit in the SOS statements, saying that American contributions are not essential to the advancement of Soviet science.

Cooperation. Many US physicists do not feel that prolonged isolation from the Soviet Union is the most productive form of protest. The Working Group on Physics of the US–USSR Joint Commission on Scientific and Technical Cooperation, for example, is continuing to encourage members of the US physics community to participate in its program of meetings, symposia, seminars and exchanges (see box). The activities of the working group fall under the purview of the National Academy of Sciences. David Pines (University of Illinois), US chairman of the working group, told us that although there is a "broad spectrum of opinion" within the group on what is the "most appropriate response," the entire group agreed that "organized boycotts are not the most suitable response" to the current situation. He noted that in the past several individuals in the group have attended, as individuals (not in an official capacity), dissident and re-

continued on page 80

Orlov jailing

continued from page 78

fusnik scientific meetings while in Russia with the Working Group (see Guest Comment, page 9, this issue).

The US–USSR Condensed-Matter Theory Research Group, which, in the wake of the Orlov trial last year, cancelled a symposium that was to have taken place in the Soviet Union (PHYSICS TODAY, July 1978, page 61), is now planning to participate in a three- to four-week workshop in Soviet Armenia this fall. As Elihu Abrahams (Rutgers University), one of the US coordinators of the group, explained to us, "It was not [the group's] intention to end all relations with the Soviets for an indefinite period of time . . . they were responding to a very dramatic moment." Or, as Leo Kadanoff (University of Chicago), a member of the group, put it, "At that time we felt that we had no choice but to express our dismay at what was then a fresh wound." Kadanoff added that, while he was still displeased with "many policies of the Soviet government, the value of scientific collaboration suggests that we should have normal scientific relations with our Soviet colleagues. We have to balance off the value of scientific contact with what is to be gained from scientific protest." Abrahams said that he did not expect everything to return to "pre-Orlov and Shcharansky conditions." He believes that the widespread protests of the past year "will influence Soviet-exchange participants' activities in the program and their expectations from it."

Emigré advice. Many physicists are turning to those who have experienced the Soviet system themselves for direction. While those who have emigrated generally hesitate to tell others what they must do, some have made their feelings known.

In 1976 Sergei Polikanov, a Soviet nuclear physicist working at Dubna, was planning to do an experiment at CERN and had requested permission to bring his family with him. His request was denied. In 1977 he disclosed his situation to Western correspondents and, although Polikanov did not lose his job, he felt isolated from scientific work. Last year he and V. M. Strutinsky were awarded the APS Tom W. Bonner Prize in Nuclear Physics for their discovery of isomeric fission, but Polikanov was not allowed to leave the USSR to attend the awards ceremony at the April 1978 APS meeting in Washington (Strutinsky did not attend either). Last summer, after the Orlov trial, Polikanov addressed a "not very polite" letter to Soviet President Leonid I. Brezhnev saying that he could no longer continue to live in a totalitarian system. In August his request was approved and he was granted a one-way exit visa in September. This April he was finally able to accept his award at the APS meeting in Washington. Polikanov is now seeking a position in the US. He told us that it is extremely important that we restrict cooperation with the Soviet Union on a large scale, but as to the precise nature of that restriction, "I leave that to American scientists."

DAVID KALSON

POLIKANOV

In addition to restricting scientific exchange, some emigrants feel that other forms of pressure should be put on the Soviet scientific community to come to the aid of their oppressed colleagues. Edward Lozansky, who emigrated in 1977 and is now at the University of Rochester department of physics and astronomy, explains in a letter to be published in a forthcoming issue of PHYSICS TODAY that those Soviet scientists who come to this country have been hand-picked by the Soviet government and as such carry more weight than many of their American hosts might suppose. Or, as one anonymous Soviet physicist said, "One must not underestimate the influence of the scientific oligarchy on the Soviet government."

—MEJ

US–USSR cooperation

At the present time, the Working Group on Physics of the US–USSR Joint Commission on Scientific and Technical Cooperation is planning events in the following fields with the US coordinators given in parentheses: condensed-matter theory (William Brinkman, Bell Labs and Elihu Abrahams, Rutgers University); relativistic astrophysics (Douglas Eardley, Yale University and Donald Lamb, University of Illinois); laser interactions with matter (Richard Morse, University of Arizona); particle physics (Peter Carruthers, Los Alamos Scientific Laboratory); mathematical physics (Martin Kruskal, Princeton University), and biomolecular physics (Hans Frauenfelder, University of Illinois and John J. Hopfield, Princeton University).

Among the events planned for the near future include a joint research group meeting in condensed-matter theory (see story on page 78); a joint research group meeting on dynamics of non-Abelian gauge fields, to be held in Aspen, Colorado for eight weeks during July and August with approximately 12 participants from each country; a joint workshop on absorption and transport phenomena in laser-produced plasmas, which will be held in the US for two weeks in September, with approximately 15 participants from each country; and a joint symposium on mathematical physics, to be held for three weeks this summer in the USSR, with approximately 10–15 participants from each country.

Interested physicists are urged to contact the Working Group's Secretariat at the Section on USSR and Eastern Europe, Commission on International Relations, National Academy of Sciences, 2101 Constitution Avenue, Washington, D.C. 20418.

in brief

A report by the National Science Foundation on its Science Development Program, a grant-making activity that was begun in 1964 and ended in 1972, is now available. The report, a two-volume set, provides a synopsis of funding programs operated under the SDP and also includes an evaluation made by SDP grant recipients. Copies can be obtained by writing: National Science Foundation Publications Office, Washington, D.C. 20550.

Gerald O. Barney has been appointed assistant director of the Office of Technology Assessment, to head its science, information and transportation division. Barney's most recent position was with the President's Council on Environmental Quality.

The Federal Republic of Germany has donated $700 000 to the Institute for Advanced Study in Princeton, New Jersey, for a senior research professorship and two five-year fellowships for work in fields in which Albert Einstein had been active. □