

In Ukraine, science will need rebuilding postwar; in Russia, its isolation could endure

The impulse to help Ukrainian scientists is widespread. But balancing sanctions against Russia while keeping open bridges of communication is tricky and controversial.

By unleashing war, Russia has condemned itself to international isolation, to the position of a pariah state. This means that we scientists will no longer be able to do our work properly: Scientific research is unthinkable without extensive cooperation with colleagues from other countries. . . . We demand the immediate cessation of all military actions against Ukraine.

So reads, in part, a statement signed by several thousand Russian scientists and science journalists in the days following their country's invasion of Ukraine on 24 February. Numerous other statements from the science community, including ones by Russian expatriate scientists, have condemned the war. Meanwhile, one with signatures of the heads of hundreds of Russian academic and research institutions expresses support for the war and Russian president Vladimir Putin ("Now more than ever, we must demonstrate confidence and resilience in the face of economic and information attacks, effectively rally around our President").

In early March, Russian missiles heavily damaged the Kharkiv Institute of Physics and Technology and its neutron source (see "Prominent Ukrainian physics institute imperiled by Russian attacks," *PHYSICS TODAY* online, 7 March 2022). By mid-April the war had displaced millions of Ukrainians. Among them were about 15 000 PhD scientists, or one-sixth of the country's total, many of whom have left the country, according to Vaughan Turekian, executive director for policy



DORMITORIES at the School of Physics and Technology (left) and the Central Scientific Library (right) at V. N. Karazin Kharkiv National University in Ukraine are among the casualties of repeated shelling by Russia.

and global affairs at the US National Academies of Sciences, Engineering, and Medicine (NASEM).

Around the world, ordinary citizens are taking in Ukrainian refugees and helping them settle in for stays of undetermined duration, donating money, providing childcare, and otherwise rallying to help. Scientists, too, are finding ways to help their colleagues in trouble—from offering jobs and distance courses to looking ahead to rebuilding science in Ukraine. (See "Q&A: Oleksandra Romanyshyn on helping Ukrainian scientists," *PHYSICS TODAY* online, 22 April 2022.)

Meanwhile, scientists and scientific institutions are struggling with how to navigate interactions with colleagues affiliated with Russian institutions. "I believe that scientific collaboration should transcend geopolitics and that open sci-

entific collaborations can serve as good examples of how international cooperation can benefit the global society," says David Reitze, director of the Laser Interferometer Gravitational-Wave Observatory, or LIGO, an international project that includes a few scientists in Russia. Yet, he adds, "it would be impossible for me to knowingly collaborate with scientists who support Putin's naked act of aggression against Ukraine and the Ukrainian people."

"You always hit innocent people with sanctions," says Helmut Dosch, chair of the board of directors of DESY, the German Electron Synchrotron Laboratory in Hamburg. Still, the day after Russia invaded Ukraine, DESY suspended cooperation with Russian institutions. "We wanted to radiate a clear signal," says Dosch. Such a move is new for DESY, he adds. "We have never before frozen sci-

entific cooperation for political reasons.” Dosch also returned the honorary doctorate he received in 2010 from the Kurchatov Institute in Moscow.

Dosch stresses that he and DESY are keeping contacts with individual scientists in Russia who have expressed opposition to the “aggressive war.” Such contacts must be handled carefully to protect the scientists, he says. “We assume the secret service is watching. If a scientist is accused of treason, they could disappear for good.” It’s complicated, he adds, “but we try to keep communication channels open.”

Offers outnumber takers

Early on 24 February, Mykola Semenyakin was awakened by his phone. His parents in Kyiv were calling him in Moscow to tell him that Russia had attacked Ukraine. Within an hour, Semenyakin had bought plane tickets, and that night he flew to the Netherlands. His decision to study in Russia had been hard because of the 2014 annexation of Crimea and the start of the conflict in Donbas, he says. “That made it controversial. But I thought the scientific cooperation with good people might be okay.” With the hot war, he continues, “it’s impossible. It wouldn’t be ethical for me to work there while people in Ukraine are dying from Russia’s attacks.”

Semenyakin had been months away from completing his PhD in mathematical physics at the Skolkovo Institute of Science and Technology (Skoltech), which was founded a decade ago with help from MIT and other Western institutions. (See *PHYSICS TODAY*, January 2013, page 20.) He is on track to finish his PhD this summer, now with Carlo Beenakker at the University of Leiden, with whom he connected through friends. Semenyakin says he’d like to recognize his Russian adviser, “but the issue of affiliations is tricky. I prefer not to have Skoltech on my thesis.”

Institutions around the world—in Europe and North America, and as far away as Australia and Japan—are offering Ukrainian physicists and other scholars temporary posts, typically for 3 to 12 months. The Polish Academy of Sciences, for example, placed 67 Ukrainian scientists at its various institutes within a day. NASEM is piggybacking on the Polish academy’s program, says Turekian; by mid-April NASEM had raised



UKRAINIAN SCHOLARS are joining the Leibniz Institute for Solid State and Materials Research Dresden, in Germany. Of the several dozen, 19 newcomers received six-month scholarships after the 24 February invasion of their country; others had their contracts extended. Women are disproportionately represented because men aged 18 to 60 cannot leave Ukraine.

\$2.5 million and placed 200 Ukrainian scientists around Poland. The Perimeter Institute in Waterloo, Ontario, Canada, is offering positions for master’s and doctoral studies and postdoctoral and visiting scientists.

After Russia annexed Crimea, the Kyiv branch of the Moscow Institute of Physics and Technology severed its ties with Russia and reinvented itself as Kyiv Academic University. It strengthened collaborations with institutions in Europe. Since the invasion in February, some 19 students and scientists, mostly physicists, have gone to the Leibniz Institute for Solid State and Materials Research Dresden, says Jeroen van den Brink, director of the German institute’s theoretical solid-state physics division. The institute also extended contracts for Ukrainians who were already there.

But many scientists either cannot or do not want to leave Ukraine. Men between the ages of 18 and 60 are barred from leaving the country. And women may have family or other reasons not to leave, notes Alexander Kordyuk, director of Kyiv Academic University.

“The number of offers greatly exceeds the number of our students and researchers who can and want to leave Ukraine,” he says.

Some institutions also welcome refugees from Russia. A statement by FAIR, the Facility for Antiproton and Ion Research in Darmstadt, Germany, for example, says it’s keeping its “doors open to researchers from Russia who face political persecution.”

Leonid Rybnikov, a Russian professor of mathematics at the Higher School of Economics in Moscow, landed a temporary post at the Institute of Higher Scientific Studies near Paris. He was arrested in Moscow on 1 March for writing slogans against the war and Putin and spent two weeks in jail. Now, he says, “for the same offense, you can go to prison for several years.”

Scientific sanctions

On 25 February, the day after the invasion, MIT ended its relationship with Skoltech. The same day, Germany’s Alliance of Science Organisations released a statement recommending that “academic

cooperation with state institutions and business enterprises in Russia be frozen.” On 2 March, Germany’s largest research funding agency, the German Research Foundation, suspended funding for German–Russian projects; over the past three years, the funding agency has invested some €110 million (\$116 million) in more than 300 such projects. For now, data, samples, and equipment may not be exchanged, and German scientists and their Russian counterparts cannot hold joint events.

On 1 March, the Polish Ministry of Education and Science quit the Joint Institute for Nuclear Research in Dubna, near Moscow, of which Poland was a founding member in 1956. “I was a member of the nuclear physics program advisory committee at Dubna,” says Adam Maj, who heads the division of nuclear physics and strong interactions at the Polish Academy of Sciences’ Institute of Nuclear Physics in Kraków, Poland. “I withdrew.” Other Polish scientists on Dubna committees and scientific boards did too, he says.

Some 40 to 50 Polish nuclear physicists had strong ties with Dubna and will have to reorient, Maj says, and 5 neutrino physicists in Kraków involved in the Baikal Deep Underwater Neutrino Telescope in southern Siberia will look to join different projects outside of Russia. “People are not happy to change experiments,” he says. “At first, opinions were split, but increasingly, people see that it’s not possible to work with Russia for now.”

The Large Hadron Collider (LHC) at CERN is coming back on line after a three-year shutdown; beams of protons circulated on 22 April, and experiments are set to start in June. Despite the excitement about new LHC experiments, the war in Ukraine and sanctions on Russia are “the biggest concern at the moment,” says Joachim Mnich, CERN’s director for research and computing.

About 140 scientists from institutions in Ukraine are involved in CERN, of which the country is an associate member. Some 1000 scientists from Russian institutions work at CERN, with roughly half of them spending at least half their time on site. At a special meeting on 8 March, the CERN Council suspended the observer status of the Russian Federation; observers—the others are the US and Japan—can attend council meetings where dis-



TAIGA, the Tunka Advanced Instrument for Cosmic Ray Physics and Gamma Astronomy, is being built in Siberia. The partners from outside of Russia have suspended their participation in the project in response to Russia’s invasion of Ukraine.

cussions on the LHC take place, but they do not have voting rights. The council also ruled out future joint projects involving Russian institutions. But the thorny issues of ongoing projects and publications are still in discussion.

Scientists affiliated with Russian institutes make up about 7% of the workforce on the LHC and its experiments, Mnich says. “In some key areas, it would not be easy to replace the Russian contributions.” For example, he says, the photon spectrometer in the ALICE detector “is entirely the responsibility of Russian institutes. It would be hard to train others to operate it.”

Scientists in Russia are also responsible for parts of the high-granularity calorimeter for the upgrade of the CMS experiment; the scintillator for the calorimeter is supposed to be milled in Ukraine, and institutions in Belarus (under sanctions for supporting Russia’s invasion of Ukraine) and the US also are con-

tributing to it. “The CERN Council has not yet suspended such ongoing collaborations,” says Mnich. “For now, we try to continue, but with sanctions, the difficulties in exchanging goods and money hinder progress.”

Suspending ongoing collaborations at CERN would mean a loss in expertise and in financial and in-kind contributions, likely causing delays and cost hikes. Russian scientists at CERN could lose their residence permits and salaries. And for those who have spoken out against the war, returning to Russia would be dangerous. CERN is evaluating implications and possible solutions to the fallout of a full suspension, says Mnich. The council is expected to decide how to proceed at its June meeting.

Meanwhile, publishing has become fraught. A preprint posted on arXiv.org on 26 April lists the authors as the “CMS Collaboration” instead of including the full list of authors (around 2350 names),

some of whom have Russian affiliations. Other LHC experiments are taking the same tack, and decisions on how authors are listed in final publications are still to come. Some members of the collaborations don't want Russian affiliations included on a publication, but for scientists with such associations, it could be risky to omit them.

For their part, publishers are mostly staying out of the fray. Ukrainian journals are an exception; they are rejecting authors with Russian affiliations.

Michael Thoennessen, editor-in-chief of the American Physical Society journals, says APS has not changed its publishing policies. "We continue to be committed to maintain open dialog and promote co-operation between scientists," he says. "We have no plans to impose sanctions or restrict scientific information." But, he adds, APS will list authors as they request—including with a home address or no affiliation. "The caveat is that all authors have to agree."

Collaboration versus condemnation

As a major partner in FAIR, Russia was responsible for providing magnets for the facility's accelerator. Having suspended Russia's participation, FAIR is seeking other sources for magnets. The change "will imply some delays and additional costs," says FAIR spokesperson Ingo Peter.

Razmik Mirzoyan is an astrophysicist at the Max Planck Institute for Physics in Munich, Germany. He has been a leader in TAIGA, the Tunka Advanced Instrument for Cosmic Ray Physics and Gamma Astronomy, since the project's start in 2013. Most of the collaboration's roughly 90 scientists are at Russian institutes, with a handful in Germany and Italy. The design consists of four telescopes and 120 large photomultiplier-based stations distributed over about 7 square kilometers near Lake Baikal. The instruments measure the direction and energy of impinging ultrahigh-energy cosmic rays, from teraelectron volts to hundreds of petaelectron volts.

Two of TAIGA's telescopes are operational. An imaging camera, mirrors, and other parts for the third telescope were due to arrive from Germany in late February or early March, but with the sanctions, Mirzoyan assumes the shipment was stalled. He is unaware of the exact status because on 9 March, he called a

video meeting and put the collaboration on hold. "With people dying and everyone around me doing things to help refugees from Ukraine, continuing the co-operation as if nothing had happened seemed unnatural," Mirzoyan says. "It's a pity for us—and a greater pity for our colleagues in Russia."

Achim Stahl is working with a team of about a dozen physicists—experimentalists at the University of Aachen and the Jülich Research Center in Germany

and theorists at two Russian institutions—who are looking for electric dipole moments in protons and deuterons. Funding for visits and networking from the German Research Foundation is frozen, and the agency recommends that the collaboration cease joint publications, says Stahl. "But they said it was our decision." For now, he says, "we won't publish or submit joint talks, but we will continue to email each other and keep our personal contacts. It's a balance between

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keeping open bridges of communication and not wanting to help a country that is aggressively invading another country.”

At the individual level, some scientists in the West continue to work with their Russian colleagues. That’s easiest for theorists, who can interact by email, telephone, and video. A physicist at the University of British Columbia in Vancouver, Canada, who requested anonymity to protect Russian colleagues, says that he and a half-dozen theorists scattered around the US, Europe, and Russia still meet regularly on Zoom to discuss quantum gravity and quantum cosmology. “We assume the FSB [Russian federal secret service] is listening, so people have become more careful about what they say,” he says. “As long as Russian scientists can access the internet, we can work together.”

But other scientists are uncomfortable working with people who keep their Russian affiliations. Oleksandr Gamayun is a Ukrainian condensed-matter theorist who has been at the University of Warsaw as a research fellow since 2021. He has long-standing close collaborations with Russian colleagues from when they were postdocs in the UK. “I know these

people well,” he says. “I would love to keep working with them. But because of their Russian affiliations, it’s hard. In my eyes, the affiliation is a representative of the regime. I hope they will move abroad.” Their joint work is on hold, he says, but “after peace, I wouldn’t have trouble reestablishing the connection.”

Alex Buchel is a Ukrainian string theorist who has been at the Perimeter Institute for nearly 20 years. “I have colleagues in Ukraine. They can’t do science right now,” he says. “They are looking for bulletproof vests.” Last fall he gave an online colloquium in Moscow, but he says that he wouldn’t give a talk in Russia now. “And if I receive an application from a Russian postdoc or student, I don’t look at it. I don’t want to have to second guess about their views.” To work with someone in Russia, he says, or to publish their papers, “there should be a litmus test. Someone who wants to benefit from funding, collaboration, and publishing must stand and say they do not support the war.” Mirzoyan agrees: “I came to the conclusion that one of the ugliest things in society is when people keep silent.”

Rybnikov, the Russian mathematician

currently in France, is looking for jobs in English-speaking countries. He is pessimistic about the future of science in Russia: “I expect that Russia will stop most international programs in mathematics and other sciences, and you can’t do science in a vacuum. It will work both ways—other countries will also stop working with Russia.”

“It’s very difficult to do physics when this criminal war is continuing,” says a theoretical physicist in Moscow who requested anonymity. Many Russian scientists, especially students, consider emigration to be “the most reasonable choice now,” he says. Other scientists, both inside and outside of Russia, also worry about the effects on science of Russia’s isolation. Alex Levchenko is a Ukrainian theoretical physicist at the University of Wisconsin–Madison. “The damage in Ukraine, including to science, is impossible to grasp,” he says. But because of the sanctions, international condemnation, and exodus of talent, “Russian science will inevitably suffer longer term.” The ripple effects will reach the rest of the community, he adds. “It’s negative for all sides.”

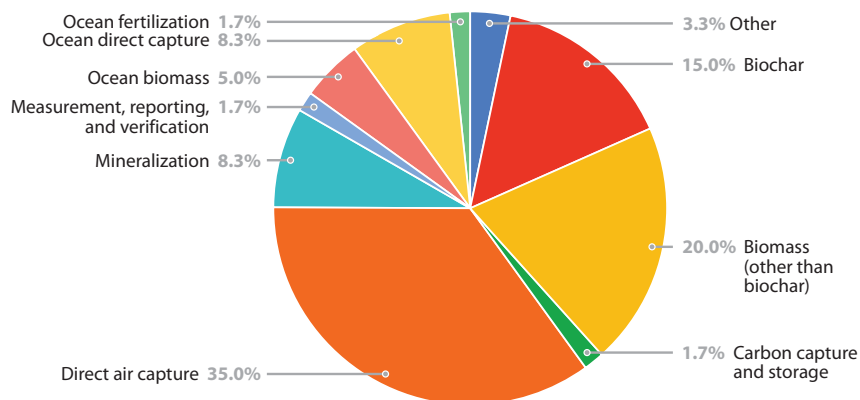
Toni Feder

Carbon dioxide removal is suddenly obtaining credibility and support

The question about carbon extraction is no longer if it will be needed, but whether it can be scaled up quickly enough.

As the likelihood of the world failing to decarbonize rapidly enough to avoid the worst effects of climate change grows, the interest in atmospheric carbon dioxide removal (CDR) has exploded.

April was an eventful month in CDR: A new privately backed nearly \$1 billion funding mechanism was unveiled. More than a dozen aspiring CDR startups received \$1 million prizes to help further develop their technologies. And the United Nations’ Intergovernmental Panel on Climate Change (IPCC) confirmed the necessity of CDR to achieve



ADAPTED FROM ROBERT HOGUND

TECHNOLOGIES PROPOSED by the 60 teams that were selected as finalists for the XPrize carbon-removal “milestone” prizes. Fifteen of the teams were awarded \$1 million prizes. Up to four prizes, worth a combined \$80 million, are to be awarded in 2025. Organizers say the milestone winners won’t necessarily be favored in that contest.

carbon neutrality by midcentury. The US Department of Energy continued finalizing plans on how it will spend the bil-

lions of dollars for direct air capture (DAC) that lawmakers appropriated in November.