Physicists need to be talking about nuclear weapons

At the beginning of the nuclear era, many of the leading physicists of the 20th century—including Albert Einstein, Niels Bohr, Enrico Fermi, Werner Heisenberg, Hans Bethe, and J. Robert Oppenheimer—and many of the younger physicists involved in the US's secret nuclear weapons project during World War II discussed the consequences of their work and issued warnings about the dangers of a nuclear arms race with the Soviet Union. Currently, however, despite Russia's threats of nuclear use and a developing nuclear arms race with China, the US physics community is having little such discussion.

That is, perhaps, because until recently and in contrast with the Cold War nuclear arms race, nuclear weapons work in the US has been focused primarily on maintaining and refurbishing the existing nuclear warhead stockpile. But the consequences of using a significant fraction of the global stock of nuclear weapons remain existential—on a par with the long-term consequences of climate change, which is attracting much more attention and debate. It is time for the physics community to renew its engagement with the nuclear weapons policy debate.

Today about 10 000 nuclear warheads are in military service in nine nations (and about 3000 more are waiting to be dismantled).[1] They have an average explosive energy an order of magnitude larger than that of the warhead that produced over 100 000 civilian deaths in Hiroshima, Japan (which had an energy equivalent to about 15 000 tons of chemical explosive).[2] Nearly 2000 warheads are on alert status, ready to be launched within minutes of an order being received.[3] They could kill hundreds of millions of people directly. Indirect effects, such as global famine from crop failures from a multiyear climate cooling due to a stratospheric smoke pall produced by nuclear-caused firestorms, could kill billions.[4]

It is difficult to grasp that humans have allowed themselves to be subject 24/7 to a potentially civilization-ending threat that a single political leader could trigger. Contrary to their commitment in the Treaty on the Non-Proliferation of Nuclear Weapons "to pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament," the five permanent, veto-wielding members of the United Nations Security Council—the US, Russia, the UK, France, and China—all of which are party to the treaty, are upgrading their nuclear arsenals.

MODEL OF MIRVS—multiple independently targeted reentry vehicles—around the third stage of a US Trident submarine-launched ballistic missile. Each cone-shaped reentry vehicle houses a nuclear warhead with a yield of up to 455 kt. The diameter of the Trident missile is 2.11 m.

Physicists are essential to the nuclear weapons complexes: They perform R&D to maintain and improve nuclear warheads and their delivery systems. Physicists are employed in the multibillion-dollar US Stockpile Stewardship Program (SSP), which aims to ensure "safety, security, reliability, and effectiveness" of the nuclear weapons stockpile.

Minimizing the possibilities of nuclear accident (safety) or unauthorized use (security) is essential. The SSP's large focus on nuclear weapons' reliability and effectiveness deflects attention, however, from the fact that the weapons are unusable by responsible leaders. It is difficult to imagine that a rational adversary would ever take an action because they believed that a significant fraction of US nuclear weapons would not work reliably. Similarly, nuclear weapons have been proven more than effective for excessive destruction. The focus should be on reducing their numbers and explosive power.

A prominent example of an SSP project involving many physicists is the National Ignition Facility, which is funded to advance understanding of nuclear-warhead physics in the absence of nuclear testing. It is also used to understand the behavior of materials in the centers of stars and planets, and it might open a new path to fusion energy. But like other aspects of the SSP, it could have counterproductive results in addition to the beneficial ones.

There are questions physicists must ask themselves. For example, does work on laser implosion encourage the proliferation of thermonuclear-weapons science to other nations? More generally, could improved understanding of weapons physics, in the US or elsewhere, inspire proposals to introduce design changes that would encourage nuclear testing in order to verify that the changed designs still work?

A central justification for nuclear weapons is deterrence. The premise is that wars between major powers are prevented by the danger of catastrophic nuclear use. Nuclear weapons surely deter the expansion of local wars such as the one in Ukraine. But it may be too much to credit nuclear deterrence exclusively, as is often done, for the absence of direct war between the leading military powers since World War II. Many other changes in the international system have also contributed, including the formation of supranational organizations such as the European Union and the United Nations, an increase in the number of democracies, and increased global trade and international scientific collaboration.

In any case, nuclear deterrence risks global catastrophe. Including the Cold War confrontations over West Berlin, the Cuban missile crisis, and multiple close calls from launch-on-warning postures, humanity has escaped a nuclear Armageddon by many strokes of luck. Physicists, familiar with instabilities in physical systems, should be explaining the instabilities of the current nuclear postures and how to reduce them—especially incentives for first use.

In the early years of the nuclear age, eminent physicists working on nuclear weapons in the national labs struggled over the ethics of their work. Hans Bethe once called the hydrogen bomb "the greatest menace to civilization."[5] He later explained his decision to work on it nonetheless: "If I didn't work on the bomb somebody else would—and I had the thought if I were around Los Alamos I might still be a force for disarmament. So I agreed to join in developing the H-bomb. It seemed quite logical. But sometimes I wish I were more consistent an idealist."[6]

Such self-questioning within the physics community, including within nuclear weapons laboratories, currently seems muted. It is time for the renewal of vigorous discussions of how to reduce the dangers from nuclear weapons and of the consequences of research on nuclear weapons. To suggest one route for participation, we invite physical scientists to join the Physicists Coalition for Nuclear Threat Reduction (https://physicistscoalition.org), which the two of us recently cofounded with others. Physicists must act now, for the sake of everyone.

References

1. M. Roser, B. Herre, J. Hassel, *Nuclear Weapons*, Our World in Data (2013).
2. H. M. Kristensen, M. Korda, *Nuclear Notebook*, *Bulletin of the Atomic Scientists* (2023).
3. H. M. Kristensen, *Alert Status of Nuclear Weapons*, Federation of American Scientists (2017).
4. L. Xia et al., *Nat. Food* **3**, 586 (2022).
5. H. A. Bethe, *Sci. Am.* **182**, 18 (1950).
6. S. S. Schweber, *In the Shadow of the Bomb: Oppenheimer, Bethe, and the Moral Responsibility of the Scientist*, Princeton U. Press (2000), p. 166.

Stewart Prager
(sprager@princeton.edu)
Frank N. von Hippel
(fvhippel@princeton.edu)
Princeton University
Princeton, New Jersey

Revisiting science and colonialism

Being a history buff, I have read all sorts of "justifications" for colonialism, including Niall Ferguson's book *Empire*, in which he claims British imperialism modernized the world,[1] and Bruce Gilley's controversial article "The case for colonialism," in which he presents a full-throated justification for the practice.[2] But the commentary by Suman Seth (Physics Today, December 2022, page 10) is the first piece that I've read that seems to glorify colonialism by linking it to scientific advances.

Seth states, "It is hard to imagine what much of modern science would have looked like without colonialism." Such a statement should be accompanied by a mention of the fact that under colonialism hundreds of millions of people lost their lives, many colonies were looted, and slavery flourished—the consequences of which we still live with today.

Are we supposed to look more fondly on colonialism because some scientific advances may have been delayed a bit in its absence? Before considering where science would be without colonialism, one should consider colonialism's devastating impacts. Colonialism killed more than 50 million native people in the

CONTACT PHYSICS TODAY

Letters and commentary are encouraged and should be sent by email to **ptletters@aip.org** (using your surname as the Subject line), or by standard mail to Letters, Physics Today, American Center for Physics, One Physics Ellipse, College Park, MD 20740-3842. Please include your name, work affiliation, mailing address, email address, and daytime phone number on your letter and attachments. You can also contact us online at **https://contact.physicstoday.org**. We reserve the right to edit submissions.