Sakharov In Arms Control:
Much for Us Still to Do

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I am pleased to help celebrate Andrei Sakharov's contributions to science and humanity, recognizing that Sakharov contributed substantially to our not having had a nuclear war. His contributions to fusion energy and to astrophysics have served as the foundation for the contributions by scientists the world over. His remarkable contributions to peace, as will be detailed by Frank von Hippel, are fragile and in peril, as is the existence of systems of government capable of managing the powerful tools for destruction that we have built, and that can be rebuilt even if they are largely eliminated.

Some background may help to indicate the scope of the problem and the uncertain path forward.

My personal involvement with Sakharov was primarily in meetings of the U.S. National Academy's Committee on International Security and Arms Control – CISAC – but my friend and colleague Sid Drell was closer with him and helped disseminate some of his works.

From Sakharov's 1968 book, ***"Progress, coexistence, and intellectual freedom",*** and some of his later writings, I see that he felt that even though peaceful coexistence was of critical importance, he believed also that it would not be achieved by a monopoly on nuclear weapons on the part of one power, and he played a major role in contributing to the Soviet Union's ability to burn thermonuclear fuel – deuterium – in powerful thermonuclear explosives for which it could be cheaply and inexhaustibly produced.

My own parallel involvement was initially purely technical. Appearing for my second summer as a consultant at Los Alamos in May, 1951, I asked Edward Teller what was new; I heard from him the idea of radiation implosion that he and Stanislaw Ulam had published in a secret Los Alamos report on March 9, 1951. He asked me to devise an experiment that would persuade any skeptic that radiation implosion by an auxiliary fission explosion – a "primary" in current terms – could burn large amounts of thermonuclear fuel. On July 25, 1951, I published a four-page secret report with a large foldout sketch of what would be tested as the MIKE shot of the Ivy series on November 1, 1952, with a yield of 11 megatons – more than 500 times the explosive yield of the weapon used against Hiroshima or Nagasaki.

This realization of the design and its test in16 months was a spectacular success organized by Los Alamos director Norris Bradbury and largely assigned to Marshall Holloway to produce the 80-plus ton MIKE design itself. The development of the U.S. "hydrogen bomb" was motivated by the fear that the Soviet Union would accomplish that first; the Ivy MIKE

test ensured that our Soviet colleagues would test their own true solid-fuel thermonuclear weapon in November, 1955 – the RDS-37 at 1.6 MT yield. The U.S. had demonstrated staged lithium-deuteride-fueled thermonuclear weapons in Castle BRAVO – 15 MT on March 1, 1954.

In addition to a line of fusion weapons that include the hundred-megaton *Tsar Bomba* (tested on October 30, 1961, with a lead fusion tamper at 50 megatons), Sakharov also proposed a powerful tsunami-inducing torpedo that has been revived in recent years by Russian leadership, on which I don't comment further.

Immediately after the use of the two nuclear weapons against Hiroshima and Nagasaki in August, 1945, and the conclusion to World War II, many scientists involved in the Manhattan Project turned their efforts to the control and limitation of nuclear weapons, reinforced a decade later -- July 9, 1955 -- by Bertrand Russell's issuing the "Russell-Einstein Manifesto" warning of the consequences of nuclear war. The Pugwash Conferences on Science and World Affairs, from its first meeting in Pugwash, Nova Scotia, July 1957, created the opportunity for scientists of various states to present papers and to discuss what might be done to reduce the likelihood of nuclear war, among other existential concerns. Pugwash provided the opportunity for Track 1.5 and Track II dialogues extending far beyond the problem of thermonuclear war.

We need to understand and work to counter the perils not only to governments and to populations, but also to civilization – by physical destruction but also by pandemics and by the potential advent of a dark age – the rejection of fact and science. Long available to anyone in the world are reliable assessments of the effect of nuclear weapons, first published in 1950 by the U.S. Atomic Energy Commission, with the most recent version[1] in 1977. Although the scientists involved in creating the first nuclear weapons, and then the thermonuclear weapons of essentially unlimited yield, could be heard in their views of the essentiality of control and limitation of weapons and ultimately to the effect that "A nuclear war cannot be won and must not be fought," that group has passed on, and other concerns and opportunities compete for public attention.

[1] https://www.dtra.mil/Portals/61/Documents/NTPR/4-Rad_Exp_Rpts/36_The_Effects_of_Nuclear_Weapons.pdf (searchable)

The effect of a single nuclear weapon is not the whole story on a finite Earth, and the impact of multiple detonations and resultant fires can largely block sunlight, producing "nuclear winter" for months or years. In recent years, research has provided evidence that the detonation of even tens of Hiroshima-yield weapon in the tropics, e.g., in a nuclear war between Pakistan and India, with strong insolation, could loft fire-produced black carbon (BC) to the stratosphere, where it would persist for months, while spreading through the northern hemisphere[2] – a topic that has not received the attention it deserves by those with experimental and computing resources to investigate quantitatively the individual steps involved. Sakharov himself discussed one of the global effects of nuclear weapons detonations – that of radioactive fallout, especially of C-14.

Many people might contribute to the next steps to avoid nuclear war. These are difficult times in formal relations between the United States and Russia, and between the United States and China. Nevertheless, individuals in each country continue to try to understand the hazard to the peoples of the world and how these may be abated by individual or joint efforts.

In particular, I welcome China as a competitor in building semiconductors, in designing advanced automobiles, in space exploration, in countering global warming, and in work in medicine and public health. I think that the United States has lagged for the last 20 years or more in some of these fields. But I do not welcome the near-automatic classification of China as "enemy" of the United States, rather than as a competitor. In sports, fair competition brings a gradual improvement of human performance. We should be doing the same in industrial and scientific competition; with free publication of results, the resulting improvement need not be so gradual, as exemplified by the mRNA COVID-19 vaccines by Moderna and Pfizer-BioNTech achieving initial mass vaccinations in December, 2020.

SURVIVING THE COVID-19 PANDEMIC AND FUTURE DISEASE THREATS TO HUMANITY

An example: after initial months of confusion and secrecy, China has protected its people against the COVID-19 coronavirus pandemic, and the United States has already lost more than half a million people to the coronavirus, in part

[2] https://science.sciencemag.org/content/365/6453/587.full (A 2019 publication dealing with the self-lofting of BC and other wild-fire smoke in 2017)

because of unwillingness to learn from China's experience. Chinese scientists published the full genome of the SARS-CoV-2 virus on January 11, 2020, facilitating the production of vaccines all over the world. Both the determination of the viral genome and the creation of vaccines by those who had no sample of the virus itself were possible only because of the scientific progress over the past decades, in many countries.

Part of the problem in battling COVID-19 appears to be organizations that are unable to move rapidly in response to opportunities or threats, such as the U.S. Centers for Disease Control and Prevention – CDC – and the World Health Organization – WHO. The problem is compounded by the ascendancy of "fake news" that drowns out analysis by recognized experts and innovators alike.

Another great physicist, in January 1946, at a conference in Princeton, commented,

"Dr. Einstein, why is it that when the mind of man has stretched so far as to discover the structure of the atom, we have been unable to devise the political means to keep the atom from destroying us?"

"That is simple, my friend. It is because politics is more difficult than physics." — Albert Einstein

But it is a deadly serious question with many aspects. Relatively few can contribute to the evolution of nuclear weapons or to the technical defenses against them, but scientists don't have a monopoly on potential solutions in the political realm. Especially in democratic societies, many people must share a viewpoint in order to make effective decisions. The doubling time of COVID-19 in the normal society of New York State in March 2020 was less than 3 days; real-time control of such an epidemic, especially one for which there is no antiviral therapy, is possible only by following (and modifying) a pre-determined plan, which we did not have.

WHO CAN CONTRIBUTE TO THE CONTROL OF NUCLEAR WEAPONS AND THE PREVENTION OF NUCLEAR WAR?

The Pugwash Conferences have contributed, not only in their international nature but especially in providing an umbrella that facilitated bilateral meetings between a small group of Soviet scientists and one of Americans – the latter led for many years by Paul Doty of Harvard. Some details of the "Pugwash" background to the 1972 ABM Treaty have been reported. Although I was not at that Pugwash Conference in Udaipur, India, January 1962, I was well acquainted with the

issues and the American participants. Persistence and mutual respect, honesty and effort were key to the advances in understanding the non-intuitive influence of imperfect missile defense on eroding deterrence.

Key to such assessments are detailed analyses such as that referred to by Sakharov[3] in his 1968 *"Progress ..."* work. Such technical publications are essential to the understanding of weapons and countermeasures and to defining agreements that might limit them. If attention is paid, they can also support a major tool of arms control – the defense planning and investment process. A few centers in the United States, Germany, Sweden, China, and Russia, including the American Physical Society, have published technical studies that illuminate a field. This work should be valued and expanded.

Our familiarity with Zoom and other remote conferencing systems, widespread access to the internet, and the experience of the past pandemic year that largely prevented physical meetings, have provided new tools for proposing and considering new means of arms control. They need to be adopted by negotiators and decision makers, with appropriate attention to information security on the necessary time scale consistent with the urgency of the problems. Other aspects of political innovation seem unchanged – the necessity for significant group endorsement and discussion of specific approaches, and the reporting of several such channels to governments.

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[3] "Anti-Ballistic-Missile Systems," by R.L. Garwin and H.A. Bethe in *Scientific American*, Vol. 218, No. 3, pp. 21-31, March 1968.