The Midlife Crisis of the Nuclear Nonproliferation Treaty

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Peter Pella
Professor of Physics Emeritus, Gettysburg College, PA, USA

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To Eleanor for her unending love and support.

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Preface

The Nuclear Nonproliferation Treaty (NPT) has been the principle legal barrier to prevent the spread of nuclear weapons for the past forty-five years. It promotes the peaceful uses of nuclear technology and insures, through the application of safeguards inspections conducted by the International Atomic Energy Agency (IAEA), that those technologies are not being diverted toward the production of nuclear weapons. It is also the only multinational treaty that obligates the five nuclear weapons states that are party to the treaty (China, France, Great Britain, Russia, and the United States) to pursue nuclear disarmament measures.

Though there have been many challenges over the years, most would agree that the treaty has largely been successful. However many are concerned about the continued viability of the NPT. The perceived slow pace of nuclear disarmament, the interest by some countries to consider a weapons program while party to the treaty, and the funding and staffing issues at the IAEA, are all putting considerable strain on the treaty. This book explores those issues and offers some possible solutions to insure that the NPT will survive effectively for many years to come.

Acknowledgments

There have been many people who have made significant contributions in my life who deserve to be remembered. I want to thank John Winhold and John Watson for instilling in me a love for Physics, and Hendrix College and Gettysburg College for nurturing my love of teaching. I am forever indebted to Ambassadors Susan Burk and Norm Wulf for mentoring me in the ways of nuclear nonproliferation, and along with others in the former Arms Control and Disarmament Agency for giving me a truly memorable experience as we worked tirelessly in 1994 and 1995 to secure the indefinite extension of the Nuclear Nonproliferation Treaty.

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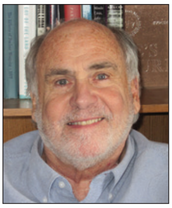
Lastly and most importantly, I want to thank my dear wife Eleanor, whose love and tireless support makes everything else possible.

Author biography

Peter Pella



Dr Pella has just retired after being a Physics professor for over 35 years. He spent the last 28 years at Gettysburg College where he was the W K T Sahm Professor of Physics. His research included the study of the spin response of the nuclear force and fundamental properties of the neutron. He has participated in research at the Indiana University Cyclotron Facility, the Bates Linear Accelerator Facility and the Thomas Jefferson Continuous Electron Beam Accelerator facility in medium-energy nuclear physics. He is also involved in issues related to nuclear weapons. His expertise focuses on nuclear nonproliferation, the Nuclear Nonproliferation Treaty, The International Atomic Energy Agency, and nuclear issues involving North Korea and Iran.

As a William Foster Fellow from 1994 to 1995, he worked at the United States Arms Control and Disarmament Agency, from which he received a Meritorious Honor Award for his service in helping to achieve the indefinite extension of the Treaty on the Non-Proliferation of Nuclear Weapons. He also worked at the Bureau of Nonproliferation, US Department of State, from 2000 to 2001 on issues relating to Iraq, North Korea, and The International Atomic Energy Agency. He contributed two chapters (Nuclear Nonproliferation and The International Atomic Energy Agency) to the Oxford International Encyclopedia of Peace published by Oxford University Press in October 2009. He also authored a textbook, *Nuclear Weapons, Policy, and Strategy, The Uses of Atomic Energy in an Increasingly Complex World*, for a nuclear weapons policy course he had taught for over 30 years.

He holds a bachelor's degree in nuclear engineering from the United States Military Academy at West Point; a master's degree in experimental nuclear physics from Rensselaer Polytechnic Institute; and a doctorate in experimental nuclear physics from Kent State University.

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Chapter 1

Introduction

The nuclear age officially began seventy years ago in the desert outside of Alamogordo, New Mexico. A weapon test, called 'Trinity', demonstrated the feasibility of constructing nuclear weapons, with their awesome power. Two more explosions quickly followed that test. They were detonated over the cities of Hiroshima and Nagasaki and ended World War II. Thankfully those are the only times that such weapons have been used in anger, but the effects of those explosions left an indelible mark on the psyche of the world's population.

The sense of idealism felt by the victorious countries after World War II ended quickly eroded due to the constant friction between the United States and the then Soviet Union (also known as the Union of Soviet Socialist Republics or USSR). The term 'Cold War' was coined in 1947 to describe the continuing conflict between the countries. The world became divided between those states controlled by the Soviet Union (the Warsaw Pact) and those allied with the US (NATO).

The first detailed nuclear doctrine for the United States was issued in 1948. It stated that US national security and international stability depended on containing any Soviet expansion. To do so, the US needed to develop a retaliatory nuclear force in case it was attacked first by nuclear weapons, and to build more weapons for a pre-emptive strike. Because of the large advantage that the Warsaw Pact had over NATO in conventional forces, it also recommended that nuclear forces be used in any conventional war, if the US found itself at a disadvantage. This was an effective policy at the time because of the US monopoly on nuclear weapons and was called 'massive retaliation'.

During the late 1950s, the policy began to shift. In 1957 the US had some 4000 weapons and the USSR had about 500. The US realized that the USSR would soon have a sizeable bomber and intercontinental ballistic missile (ICBM) capability. The massive retaliation policy was no longer effective. If the US tried to destroy the USSR, the USSR would surely do the same to the US with its surviving nuclear weapons.

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Only a few weapons detonated over major US cities would be disastrous. Therefore a different policy of deterrence was developed.

This new doctrine became known as mutual assured destruction (MAD). It was designed to deter a nuclear attack against the US and provide the same deterrence for the USSR. MAD would prevent a surprise nuclear attack against the US in the following way. The US would ensure that if they were attacked first (in a 'first strike') and some of their nuclear weapons capability were destroyed, there would be enough survivable nuclear forces left to be able to effectively destroy the USSR. Such a retaliatory capability (used for a 'second strike') would deter the USSR from striking first. Because of Soviet nuclear forces, the same deterrence would work to prevent the US from launching a first strike against the USSR. Deterrence would be mutual.

This doctrine required two components that were particularly worrisome to civilian populations around the globe. First of all, it required nuclear forces that were on hair-trigger alert, so that a second strike could be carried out in 30 min or less. It also required the US to publicly proclaim that it not only had the capability, but also the will to carry out such a second strike. The fear that a catastrophic nuclear war between the US and the USSR could be started by accident or by a rogue military commander was palpable.

Hollywood and popular literature addressed these fears. Two movies were particularly effective, though there were many others that followed suit. *Fail Safe* was about a lone nuclear-armed bomber that attacked Moscow because of a technical accident, and the black comedy *Dr Strangelove or: How I Learned to Stop Worrying and Love the Bomb,* starring Peter Sellers, was about a nuclear attack against the USSR launched by a rogue commander. In addition, atmospheric testing by the US and USSR as they worked to develop hydrogen weapons and perfect their fission bombs raised concerns about the effects of the fallout produced from such tests. A popular book at the time by Neville Shute, called *On the Beach*, later made into a movie of the same name, depicted the last days of humanity after a catastrophic nuclear war. The last survivors on Earth were in Australia, and they were waiting for the lethal radioactivity that was moving their way.

It became clear to the international community that nuclear weapons were becoming a significant threat to international security. Nuclear reactor technology was rapidly spreading around the globe, thanks in part to the Eisenhower administration's 'Atoms for Peace' program. Some countries were then using those technologies to develop nuclear weapons and forecasters estimated that within the next several years there could be as many as 20 or 30 nuclear weapons states. The Nuclear Nonproliferation Treaty (NPT) was formulated to respond to that threat.

The NPT entered into force 46 years ago with 45 original signatories, including the nuclear-armed states Russia (then known as the Soviet Union), the United Kingdom and the United States. This was preceded by three years of tense negotiations among 18 nations in Geneva and two more years of waiting while the world watched to see if other countries would sign and ratify the treaty. Finally, on 5 March 1970 the treaty became part of the international landscape.

The NPT represents one of the most important bargains ever negotiated. States without nuclear weapons pledged not to acquire them, while nuclear-armed states committed to eventually give them up. At the same time, the NPT allowed the peaceful use of nuclear technology by non-nuclear-weapon states under strict and verifiable control. It is the most widely subscribed arms control treaty and represents an international norm against nuclear weapons proliferation.

The existence of the NPT has led several states to abandon their nuclear weapons ambitions and it has made it far more difficult for other non-nuclear-weapon states to acquire the materials and technology needed to build them. The NPT process has also encouraged action on several nuclear arms control initiatives. It has helped promote regional security by giving assurances to countries within a certain region that their neighbors are not developing nuclear weapons. This helps to reduce the incentives for others to seek nuclear arms for prestige or defense.

Although the NPT has survived for over 45 years, and has dealt with such issues as the Cold War, the dissolution of the former Soviet Union, a clandestine nuclear weapons program in Iraq, and a nuclear-armed North Korea (Democratic People's Republic of Korea), there are even more stresses on it today. There need to be even stronger and more comprehensive efforts on nuclear nonproliferation. The NPT's future success depends on universal compliance with stricter procedures to prevent the spread of nuclear weapons, more effective regional security strategies, especially in the Middle East, and renewed progress toward fulfillment of the nuclear-weapon states' NPT disarmament obligations.

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Chapter 2

Scientific background

To understand the concerns raised by the proliferation of nuclear weapons and the details of nuclear nonproliferation efforts, one must have a basic understanding of some of the scientific principles involved. The intention of this chapter is to introduce the most important scientific principles in a manner accessible to most readers. Those with a more scientific background will realize that much has been left out, though hopefully not enough to affect one's understanding of the rest of the material in this book.

2.1 Fundamental forces

There are four naturally occurring forces in the Universe: (1) the gravitational force, (2) the electric force, (3) the strong nuclear force, and (4) the weak nuclear force. They are called the four fundamental forces and are responsible for all that exists in nature and for life itself.

(1) The gravitational force is an attractive force between two objects that have mass. It is the force responsible for holding the Earth in its orbit around the Sun, allowing the Earth to receive the appropriate temperature for life to exist. Gravity is responsible for attracting the elements together, forming the Earth and Sun. It also governs the motions of all the Universe's stars, planets, and galaxies.

(2) The electric force is a force between two objects that have a property called charge. There are two kinds of charges and Benjamin Franklin labeled them positive and negative. If the two objects possess the same sign of charge (both positively or negatively charged), then the force is a repulsive one. If the two objects have charges of opposite sign, then the force is an attractive one. When an object contains an excess of positive (negative) charge, we say that it is positively (negatively) charged. If an object contains equal amounts of positive and negative charges, we say that the object has zero net charge or is neutrally charged. The electric force is responsible for holding atoms together. It is the force responsible for interactions between

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molecules, and hence all chemical reactions. Since life itself is a process of chemical reactions, the electric force is responsible for life.

(3) There are two types of nuclear forces. The first type is the strong nuclear force. It is responsible for holding the nuclei of atoms together, for fission reactions, and for fusion reactions. Fission alone, or both fission and fusion together, are responsible for the energy released in nuclear weapons. Fission is also the process by which the energy is released in a nuclear reactor. Fusion is responsible for the Sun's heat generation, which provides the Earth with the proper temperature and light to sustain life. Finally, fusion in stars is also responsible for producing elements within the periodic table up to iron.

(4) The second type of nuclear force is called the weak nuclear force. This force is responsible for, among other things, a type of radioactive decay called beta decay. Beta decay is responsible for producing all the elements in the periodic table from iron up to uranium. These elements are crucial for the formation of planets, and are necessary to support life on Earth.

2.2 Model of the atom

An atom is the smallest piece of an element that contains all that element's properties. The electric force between the negatively charged electrons orbiting the atom and the positively charged protons in the nucleus holds it together. A neutral atom is one in which there are equal positive and negative charges.

The nucleus contains most of the atom's mass. The size of the nucleus is on the order of 10^{-15} m, while the size of the atom itself is on the order of 10^{-10} m. The nucleus, therefore is 1/100 000th the size of the whole atom. To put that in perspective, if the nucleus were magnified to be the size of a small marble, and we placed that marble at second base in the Royals Stadium[1], the outer electrons would be flying around in the bleachers and outside the stadium. An atom is mostly empty space.

The nucleus is made up of two kinds of particles: the proton and the neutron. The proton has a positive charge equal in magnitude to the negative charge on an electron. A neutral atom, therefore, contains equal numbers of protons and electrons. The neutron has zero net charge. Table 2.1 summarizes the characteristics of an atom's three types of particles. Note that the masses are listed in both

Table 2.1. Particle masses.

Particle	Mass (kg)	Mass (μ)
Electron	9.11×10^{-31}	5.485×10^{-4}
Proton	1.672623×10^{-27}	1.0072765
Neutron	1.674928×10^{-27}	1.0086649

[1] A baseball park in Kansas City, Missouri, USA.