

\[ E = mc^2, \Delta H = D(H - H), \] and the end of civilization

J. E. Hirsch
Department of Physics, University of California, San Diego
La Jolla, CA 92093-0319
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100 years ago Einstein discovered \( E = mc^2 \), the secret energy stored in ordinary mass. \( \Delta H = D(H - H) \) is the chemical energy released in chemical bond formation between two H atoms. The failure to recognize the enormously different energy scales in those two equations reflected in current events may start a chain reaction this very year, on the one-hundredths anniversary of Einstein’s discovery, that leads to the end of civilization. Due to the confluence of a particular set of circumstances, this particular moment is more dangerous than any other in the history of nuclear weapons. Physicists have a special responsibility to do their utmost to prevent this from happening. This paper is a call to arms. A principle to underpin nuclear non-proliferation and enhance stability is advocated.

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I. EINSTEIN’S LEGACY

100 years ago, on September 27, 1905, A. Einstein wrote “It is not impossible that with bodies whose energy-content is variable to a high degree (e.g. with radium salts) the theory may be successfully put to the test”, in connection with the equation \( E = mc^2 \) that he had just discovered[1] . Today, Einstein is revered by scientists as well as the world at large as the greatest scientist of all times, and this full year has been dedicated to honor him and his momentous contributions. Yet there is an imminent danger that this will also be the year where Einstein’s famous equation sets out a chain of events that leads to the destruction of civilization. This chain of events will be triggered by the disregard of politicians to the vastly different energy scales involved in nuclear and chemical reactions[2], and the failure of scientists to call this fact forcefully enough to theirs and the public’s attention.

It is the responsibility of all humans, but especially of physicists, to do their utmost to preserve Einstein’s legacy and prevent developments that could lead survivors of a nuclear holocaust to remember Einstein as the greatest criminal of all times. A set of confluent circumstances makes this particular moment more dangerous than any other in the history of nuclear weapons. This paper is a call to arms.

II. EINSTEIN AND NUCLEAR WEAPONS

It took 14 years after Einstein’s discovery of \( E = mc^2 \) for the world at large to discover Einstein. On the morning of November 7, 1919, newspapers all over the world reported that Einstein’s prediction of gravitational deflection of light had just been verified in a solar eclipse, making Einstein from then on a celebrity throughout the civilized world.

It would only take 6 years after another action of Einstein for the world to learn about its consequences. On August 2nd, 1939, Einstein wrote a letter to US President Roosevelt to point out that the newly discovered phenomenon of nuclear fission “would also lead to the construction of bombs”, and urged Roosevelt to support the work that would lead to nuclear bombs. The concerted work of many theoretical and applied physicists in the ensuing years under the Manhattan project led to the first controlled nuclear chain reaction in December 1942, and shortly thereafter to the first nuclear explosion in July 1945. The world woke up on August 6, 1945, to discover the horrors of a nuclear bomb used in an act of war. The full extent of the devastation caused by the nuclear explosions in Hiroshima and Nagasaki would only become clear several years later, as the long term effects of the unleashed radioactivity were making their way through the molecules, cells and tissue of the human bodies that had been exposed.

Einstein himself was of course fully conscious of the enormous responsibility on his shoulders, and in fact in the years after his fateful letter to Roosevelt he opposed the use of nuclear bombs in World War II. After the war, he devoted large efforts to work for international cooperation and spoke out fervently in favor of nuclear disarmament. In Einstein’s own words: “I believe America may totally succumb to the fearful militarisation which engulfed Germany at the beginning of the 20th century.”, and “In all countries power lies in the hands of ambitious power-hungry men. This is true whether the political system is dictatorial or democratic. Power relies not only on coercion, but on subtle persuasion and deception through the educational system and the media of public information.” These words ring fully true today.

III. WEAPONS OF MASS DESTRUCTION

The term ‘weapons of mass destruction (WMD’s)’ is used to describe chemical, biological, radiological and nuclear weapons. Here we will focus on chemical weapons and nuclear weapons because they present the starkest...
contrast, and discuss what is the significance that they are lumped into the common concept of WMD in the formulation of policy.

Chemical weapons were first used on a wide scale in World War I. Chlorine gas was first used by Germany against French forces on April 1915, and by British against German forces shortly thereafter[3]. Later, phosgene and mustard gas were used. Protection methods against poison gases were however quickly developed, and proved highly effective. The total number of deaths from chemical weapons in WWI is estimated to be around 90,000[3], approximately 1% of the total number of casualties on the battlefield. Thus, 100-times more 'mass destruction' was caused by conventional weapons than by chemical weapons in a conflict where chemical weapons were used almost from the beginning. As scientists that deal with objective reality we should object to the label 'weapon of mass destruction' being applied to weapons that cause 100 times fewer casualties than weapons of non-mass-destruction, unless all weapons are made to fall under such category.

The term 'weapons of mass destruction (WMD’s) has become a central element in the formulation of United States policy in recent years, especially since Iraq’s invasion of Kuwait in 1990. The US invasion of Iraq in March 2003 was launched with the stated purpose of rid- ing Iraq of chemical and possibly biological weapons that Iraq was known to possess before 1990. At the same time the point was made that Iraq one day would possess nuclear weapons, which would heighten the dangers more. This could appear to be a logical inference if there was a logical link between different WMD’s, in particular chemical and nuclear weapons. There is however no scientific nor technological link between chemical weapons and nuclear weapons, nor as discussed above is there any relation between their destructive power that would not also include conventional weapons. Consequently there should not be a link in policy decisions or statements, unless one accepts a premise that policy can be discon- nected from reality. Scientists should be at the forefront in exposing the flaw of such statements, but their voices have not been heard.

IV. PHYSICS AND CHEMISTRY

Chemical weapons involve chemical reactions, nuclear weapons involve nuclear fission or fusion reactions. The energy stored in the H-H chemical bond is of order $5eV$, while the energy stored in a H atom through $E = mc^2$ is of order $10^9$ eV. Even though only a tiny fraction of the mass of the atoms involved is released as energy in a nuclear fission reaction, the fission reaction is over a million times more powerful than the most potent chemical reaction[2], and even higher for a fusion reaction.

The detailed processes by which chemical weapons and nuclear weapons cause harm to human tissue and ultimately death need not concern us here. The single scal-
from the arms control organizations nor professional scientific societies deploiring the characterization of nuclear and chemical weapons under the same label of 'WMD'.

We need to make a renewed effort to feel the urge that the older generation felt to combat the potential destructive use of nuclear weapons, otherwise we may be engulfed in events that once started will be impossible to stop. In Einstein’s powerful words, "In our time, scientists and engineers carry a particularly heavy burden of moral responsibility, because the development of military means of mass destruction is dependent on their work."

True, but let the chemists worry about chemical weapons and biologists about biological weapons; physicists should focus and continue taking the lead in worrying about the nuclear weapons that their profession created!

VI. CHAIN REACTIONS

Einstein’s 1905 paper set off a chain reaction that led in a series of many steps to the nuclear arsenals of today. Chain reaction is what leads in a nuclear device from ignition where a few Uranium 235 atoms split to the full explosion. Once a chain reaction is set into motion it is very difficult or impossible to stop. That is why it is essential to stop a chain reaction before it starts or at its very early stages.

I do not see a point where the chain reaction that led from 1905 to today could have been stopped. Once \( E = mc^2 \) was revealed, the discovery of fission and fusion had to happen, and there has never been a time in history where scientific progress has not been exploited for military application. Even if WW2 had ended before Hiroshima, a nuclear device would have been used in a military action eventually to test its awesome power, and humanity was fortunate that this happened when only one nation had achieved that technology. However I argue here that a specific imminent event will trigger a chain reaction that will lead with very high probability to the destruction of civilization: a new use of a nuclear bomb by a nuclear nation against a non-nuclear one. I furthermore argue that we are still at a point where this chain of events can be stopped.

Some may argue that the point of no return has already been crossed, when the first nuclear weapons were created or used, and that their large scale use is inevitable in the long run. While impossible to prove wrong, this may also be a self-fulfilling prophecy. After the horrors of Hiroshima and Nagasaki the world has relied on a universally agreed-upon taboo against the use of all nuclear weapons, no matter how small, and on the Nuclear Non-Proliferation Treaty (NPT). Nations have been encouraged to abandon nuclear weapons ambitions under the promise of a general effort towards nuclear disarmament. Once that taboo is broken the trend will be reversed, and nations will race to acquire nuclear weapons for protection, deterrence and retaliation. Any regional conflict will have a high potential to explode into all-out nuclear war, with untold consequences.

VII. THE WAY TO STOP IT

There is no rational reason why nonnuclear nations will choose to forego the development of nuclear weapons technology if a nuclear nation today uses a nuclear bomb against a non-nuclear adversary, other than the fear to be attacked before it reaches the goal. Once a nation acquires a few nuclear bombs, it possesses a powerful deterrent against nuclear attack even by a far superior adversary: the fact that it can retaliate even with one hit. Hence even if all nations had nuclear weapons today it would be a relatively more stable situation. Of course the probability that an unidentified terrorist group acquires and uses a nuclear weapon increases, but nuclear nations no matter how ‘rogue’ have every incentive to avoid such an event. If a nuclear nation nukes a non-nuclear nation however, terrorist groups that are sympathetic to the victim nation will have infinitely more incentive to find a way to retaliate in the same kind, and eventually will succeed.

It is also inconceivable that the United States and other nuclear countries today will be able to stop the 182 non-nuclear nations from developing nuclear weapons solely by provoking fear of military action. The NPT relies on voluntary compliance by nations following a rational goal, and will become untenable if the goal is no longer rational because it leaves the nation exposed to a nuclear attack by the nuclear nations. Such reasoning is likely to be used even by nations that today are friendly to the United States and other nuclear nations.

Even in the current situation, the NPT is not providing a strong incentive for non-proliferation, because nuclear nations are dragging their feet in fulfilling their promises of arms reduction. Instead, a much more stable equilibrium would be achieved if all nuclear nations pledged today never to use a nuclear weapon against a non-nuclear adversary (by non-nuclear adversary it is meant an adversary that does not possess nuclear weapons, even if it is in full control of civilian nuclear technology). Similar proposals, such as "no first use" pledge[4] have been discussed in the past. The pledge discussed here is more restricted than ‘no first use’ since it would allow nuclear nations to strike first at other nuclear nations.

It is difficult to imagine sequences of events where such a pledge would leave a nuclear nation in a situation where it would need to break the pledge for its survival or even to gain significant advantages. If nuclear nations made such a pledge and planned their military policy with the intent of abiding by the pledge, they could make sure that their other military resources allow them adequate protection and even adequate offensive capability against non-nuclear countries that possess any other weapon capability, including other "WMD’s". I realize that powerful nation may have geopolitical goals that would require
use of military force in an offensive way[5]. However this does not have to involve nuclear weapons.

Such a pledge by nuclear nations would provide a powerful incentive for non-nuclear nations to not develop nuclear weapons, providing them with a powerful shield in the form of the assurance that no nation would ever use nuclear weapons against them. Instead, nuclear nations would not enjoy such a privileged status, which in turn would provide a strong incentive for nuclear nations with small arsenals to voluntarily disarm. Non-nuclear nations would become nuclear at their own risk.

By the same token, in the absence of such a pledge, if military policy and planning of a nation relies on the use of nuclear weapons against non-nuclear adversaries, events will eventually lead that nation to a situation where it will become essentially impossible not to use a nuclear weapon against a non-nuclear country. I argue that we are almost at that point today.

VIII. THE UNITED STATES NUCLEAR WEAPON POLICY

Nuclear weapons policy in the United States has steadily evolved in recent years towards integration of conventional and nuclear forces for military operations in restricted theaters. The United States has never renounced first use of nuclear weapons against conventional forces, citing as example a Soviet invasion of Western Europe. However recent changes indicate that the United States is now prepared to use nuclear weapons, even in a pre-emptive way, against enemies that do not possess nuclear weapons and do not represent a threat to the survival of the United States nor of any ally of the United States.

The document "Nuclear Posture Review"[6] from the Department of Defense was delivered to Congress in December 2001 and represents official United States policy. Not all of its contents have been made public, but the ones that have reveal the essence of the new US nuclear weapons policy. It envisages a "new mix" of nuclear and non-nuclear capabilities for a "diverse set of potential adversaries", to provide "flexible, pre-planned non-nuclear and nuclear options". For example, it states "Composed of both non-nuclear systems and nuclear weapons, the strike element of the New Triad can provide greater flexibility in the design and conduct of military campaigns to defeat opponents decisively. Non-nuclear strike capabilities may be particularly useful to limit collateral damage and conflict escalation. Nuclear weapons could be employed against targets able to withstand non-nuclear attack, (for example, deep underground bunkers or bio-weapon facilities)." Classified presidential directives spell out further the policies contained in that document[7].

A draft document "Doctrine for Joint Nuclear Operations" from the U.S. Joint Chiefs of Staff has been made public and is available on the world wide web, one version dated September 2003[8] and a revised one dated March 2005[7, 9]. This document is not yet official US policy but it is reported that its adoption is imminent[10]. The document describes in chilling detail scenarios under which nuclear weapons will be used against non-nuclear nations. Even if some changes are made before final adoption, because the document reflects the essentials of the policy contained in "Nuclear Posture Review" such changes will only be cosmetic (there is no substantial difference between the 2003 and 2005 versions in the issues of concern here). The scenarios described apply literally to events about to unfold.

In the following I describe a series of events that will lead with near certainty in the immediate future to implementation of this new nuclear policy and use of a nuclear weapon against a non-nuclear nation: Iran.

IX. IRAN: THE IMMINENT DANGER

A tense situation has developed with Iran due to the stated desire of Iran to implement the uranium enrichment cycle for use in nuclear reactors. The US opposes this due to stated fears that Iran would eventually divert material to build nuclear weapons. It has put pressure on European nations members of the IAEA (International Atomic Energy Agency) to refer Iran to the UN Security Council (SC) for the consideration of sanctions. Russia and China have explicitly stated that they would veto any SC resolution to impose sanctions on Iran, as they consider Iran’s desire to be legitimate and allowed under the Nuclear Non-Proliferation treaty of which Iran is signatory. When the issue reaches the Security Council and a sanctions resolution is vetoed, the US will be left with no diplomatic options, only military ones.

The US has not engaged in direct negotiations with Iran and other concerned nations to attempt to reach a mutually acceptable agreement. The fact that it has pushed for the IAEA resolution to refer Iran to the Security Council on the face of explicit opposition by China and Russia is puzzling, since such referral will not put additional pressure on Iran, given the promised veto of those two SC members. It ceases to be puzzling however if a US decision to resort to a military option has already been made and the purpose of diplomacy is only to provide cover for planned military action. US President George Bush has explicitly refused to take the military option off the table[11]. The only realistic military option for the US is aerial bombing of Iranian installations, since a ground attack would likely be met with fierce Iranian resistance that an overstretched US military would not be able to overcome.

X. SEQUENCE OF EVENTS TO COME

Assuming Iran is referred to the UN Security Council and no sanctions are imposed, US military action appears unavoidable. Such action is likely to include the use of
low-yield nuclear weapons, for the reasons discussed in what follows.

Iran has signed and ratified the Chemical Weapons Convention (in 1993 and 1997 respectively) that requires it to terminate production and eliminate stockpiles over a period of years, however it is likely to still have supplies[12–14]. Proof that Iran still possesses some chemical weapons should not be difficult for the Bush administration to present, together with arguments that Iran has used chemical weapons in the Iran-Iraq war (conveniently omitting the fact that it was responding to chemical attacks by Iraq) and that it could use them again against US and British forces in Iraq. The Pentagon document "Doctrine for Joint Nuclear Operations"[9] explicitly states that "Geographic combatant commanders may request Presidential approval for use of nuclear weapons for a variety of purposes that include "To demonstrate US intent and capability to use nuclear weapons to deter adversary use of WMD".

If only conventional bombs are used in an unprovoked US attack on Iran, Iran is likely to retaliate with a barrage of missiles against US and British forces in Iraq, and possibly Israel, as well as possibly a ground invasion of Iraq, that the 150,000 US troops in Iraq would not be able to withstand. Iranian missiles could potentially include chemical warheads, and it certainly would be impossible to rule out such possibility. The Pentagon document "Doctrine for Joint Nuclear Operations"[9] explicitly states that nuclear weapons may be used by the US in the following situations: "Against an adversary using or intending to use WMD against US, multinational or alliance forces or civilian populations", "To counter potentially overwhelming adversary conventional forces including mobile and area target (troop concentration)", "Attacks on adversary installations including WMD, deep, hardened bunkers containing chemical or biological weapons or the C2 infrastructure required for the adversary to execute a WMD attack against the United States or its friends and allies", "For rapid and favorable war termination on US terms", "To ensure success of US and multinational operations". Each of these scenarios applies literally to the Iran situation under discussion.

Early use by the US of low-yield nuclear bombs with equal or better bunker-busting ability than conventional bombs targeting Iranian nuclear, chemical and missile installations would be fully rational under the conditions described above, and would have the added benefit of sending a clear message to Iran that any response would be answered by an immensely more devastating nuclear attack. The US Senate is likely to have already approved the deployment of tactical nuclear weapons in the Persian Gulf, given that Iran has missiles that it can equip with chemical warheads at a moments notice. Such a grave measure could be carried out without public disclosure, with the argument that disclosing it would endanger coalition troops in Iraq. Once military action starts the US Senate and a large part of the American public are likely to support the use of low yield nuclear weapons to destroy Iranian installations, since this would protect the lives of 150,000 US soldiers that would otherwise be at great risk.

XI. SUMMARY

The points discussed in this paper have been separately discussed by other authors in different contexts. Still I believe that given the current situation it is of extreme urgency to consider the totality of arguments given in this paper, that lead either to a rational course of action or an irrational one. I argue that never before, including the Cuban missile crisis, have we been so close to a point where a probable sequence of events about to unfold would lead to the destruction of humanity. Unlike the Cuban missile crisis, if this chain of events gets started this time it is not likely to lead to total destruction in a matter of days or months; nevertheless we will have entered a different world, and even if the time scale of retaliation and escalation is years rather than days, the chain reaction that will follow will be unstoppable. Furthermore, this moment is far more dangerous than the Cuban missile crisis because there is no immediate deterrent to the initial event that will get this chain reaction started.

We have discussed in this paper the following points: (i) Chemical weapons are qualitatively different from nuclear weapons. Nuclear weapons are in a class by themselves and it is extremely dangerous to lump them into the same category with other so-called "WMD's"; (ii) A country using a nuclear weapon against a non-nuclear country will start a chain of events that will lead unavoidably to the destruction of civilization; (iii) Physicists have a special responsibility to care about these issues and devote effort to help the public understand them and to influence government policy; (iv) The situation with Iran is extremely close to a point of no return, beyond which the use of nuclear weapons will become unavoidable; (v) A rational strategy does exist to create a substantially more stable situation regarding nuclear weapons and provide a real incentive for non-proliferation, that nuclear countries pledge to under no circumstances use a nuclear weapon against a non-nuclear adversary.

XII. A CALL TO ARMS

As argued above, physicists have an enormous responsibility on their shoulders as the creators of nuclear weapons. A petition by physicists opposing pre-emptive nuclear strikes against non-nuclear countries is currently on the world wide web[15], URL http://physics.ucsd.edu/petition/. All physicists should consider signing this petition.

In connection with the dangerous Iran situation, US physicists should make their voices be heard urgently and loudly, communicating with Congresspeople and lead-
ing figures which can influence government policy, and writing letters to local and national media demanding full disclosure of government actions and plans regarding the use of nuclear weapons, retraction of the policies described in the documents "Nuclear Posture Review" and "Doctrine for Joint Nuclear Operations", and stating vehemently their opposition to any course of action that would lead to the necessity of using nuclear weapons imminently against any non-nuclear nation and in particular Iran. European physicists should likewise attempt to influence the upcoming actions of the "European partners" in the IAEA to avoid further escalation of the Iran situation.

Assuming the Iran question is resolved in the next few months without leading to nuclear war, physicists should be at the forefront of a world-wide effort, that may extend over several years, to get humanity to demand that all governments of nuclear countries pledge absolute renunciation of the use of nuclear weapons against non-nuclear countries. Such pledge should be individually made and incorporated in the law and the constitution of each nuclear country, and it should not be put as condition by any one country that all nuclear countries subscribe to the pledge. However, nuclear countries that do not sign the pledge would become pariahs in the world community. Citizens of the world should actively boycott all products and services of nuclear nations that have not signed the pledge. It is likely that the United States will be reluctant to sign, however even a country as powerful as the United States will feel the pressure of citizens of all other countries as well as their own boycotting all American-made products and services. Foregoing the enjoyment of American productivity is a small price to pay when the survival of humanity is at stake.

Let us all take some time out of our everyday scientific activities to work towards ensuring that we and our descendants will be around to enjoy the fruits of our labor, relish the benefits that flowed from Einstein’s discovery of $E = mc^2$, and prevent that the world ever regrets that $E = mc^2$ was discovered.

Acknowledgments

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