Star Wars Forever? — A Cosmic Perspective

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Abstract: Many philosophers argue that one cannot derive an "ought" from an "is", but sometimes science tells us things that should lead most people to the same conclusion about what ought to be done. The current debate over missile defense has failed to emphasize a crucial point: even one war in space will create a battlefield that will last forever, encasing the entire planet in a shell of whizzing debris that will thereafter make space near the earth highly hazardous for peaceful as well as military purposes. With enough orbiting debris, pieces will begin to hit other pieces, whose fragments will in turn hit more pieces, setting off a chain reaction of destruction that will leave a lethal halo around the Earth. No actual space war even has to be fought to create this catastrophe; any country that felt threatened by America's starting to place lasers or other weapons into space would only have to launch the equivalent of gravel to destroy the sophisticated weaponry. Wise people have pointed out that missile defense will waste hundreds of billions of dollars that could be spent combating the real threats in the modern world. Short term political interests pale before the overwhelming, eternal immorality of imprisoning Earth for all future generations in a halo of bullets. This horrible crime would dishonor our ancestors, plant and animal alike, who bequeathed this beautiful blue planet to us, and cripple our descendents, who would never forgive us.

The depth of our moral understanding depends on our perspective. The view of the Earth changes from flat at a shallow perspective to spherical at a larger perspective. So should our unwillingness as a species to make permanent deleterious changes in the entire Earth, when we view the present epoch in the history of our planet in cosmic perspective. Such considerations arise in connection with issues such as global warming and species extinction. The example of space debris from star wars is a particularly clear case, because the possible benefits to any nation from militarizing space are so obviously short-lived, and the political issues in space are particularly stark, with no pre-existing territorial divides to complicate things as always happens on Earth.

Space is the most fragile environment that exists because it has the least ability to repair itself. Only the Earth's atmosphere can remove satellites from orbit. When the sun flares up in its eleven year cycle, it heats the upper atmosphere and makes it expand so that debris and spacecraft in low orbits are subjected to increased drag. But the higher the original orbit, the less air there is to collide with.

Near-Earth space is already at risk from human activities, and it is in great need of protection by scientists and humanity at large.[1] We scientists should be especially concerned, both because we place many crucial scientific instruments in near-Earth space, and also because we are in a unique position to foresee the problems human activities are causing and to propose measures to mitigate or avoid them. In particular, scientists need to emphasize that a war in space could create a battlefield that will last forever, encasing our entire planet in a shell of whizzing debris that will thereafter make space near the Earth highly hazardous for peaceful as well as military purposes. Millions of land mines left from earlier wars in Afghanistan and other countries can eventually be removed, but debris in orbit higher than about 800 km above the Earth's surface will be up there for decades, above 1000 km for centuries, and above 1500 km effectively forever. Over 9000 objects larger than 10 cm in diameter are currently tracked, and there are probably more than 100,000 pieces of orbiting debris larger than a marble. But crowded near-Earth orbits are where the Bush administration wants to put parts of its proposed missile defense system such as Space-Based Lasers and thousands of "Brilliant Pebbles" space-based interceptor missiles. Such weapons are forbidden by the 1972 Anti-Ballistic Missile (ABM) Treaty, but on 13 December 2001 President George W. Bush unilaterally announced his intention to withdraw from this treaty.

Maybe the reason missile defense has gotten as far as it has is that so few people understand the laws of physics. But these laws, unlike human laws, are immutable. We can ignore them, but we cannot escape them. The nickname "Star Wars" for missile defense all too accurately reflects the popular fantasy impression of how things work in space. In the Star Wars movies and in hundreds of other popular science fiction films, we see things blow up in space and the fragments quickly dissipate, leaving space clear again. But in reality, space never clears after an explosion near our planet. The fragments continue circling the Earth, their orbits crossing those of other objects. Paint chips, lost bolts, pieces of exploded rockets—all have already become tiny satellites, traveling about 17,000 miles per hour, ten times faster than a high-powered rifle bullet. There is no bucket we could ever put up there to catch them. Anything they hit will be destroyed and only increase the debris. A marble traveling at that speed would hit with the energy of a one-ton safe dropped from a three-story building. With enough orbiting debris, pieces will begin to hit other pieces, fragmenting them into pieces, which will in turn hit more pieces, setting off a chain reaction of destruction that will leave a lethal halo around the Earth. To operate a satellite within this cloud of millions of tiny missiles would become impossible: no more Hubble Space Telescopes or International Space Stations. Even the higher communications and GPS satellites would be endangered. Every person who cares about the human future in space should also realize that militarizing space jeopardizes the possibility of space exploration.

As a scientist whose research has benefited enormously from space observations, these prospects horrify me. Most of the important astronomical satellites have been placed in the Low-Earth Orbit (LEO) region (from the lowest practical orbits, about 300 km altitude, up to about 2000 km). The Cosmic Background Explorer (COBE) satellite, in a polar orbit at 900 km altitude, allowed the discovery in 1992 of the fluctuations in the first light of the universe—the heat radiation that was emitted as the hot primordial plasma first cooled and became transparent about 300,000 years after the origin, long before the first stars formed. The temperature fluctuations COBE detected are relics of ancient differences in the density of the primordial universe from place to place. These initial conditions are what led over billions of years to the formation of galaxies and larger-scale structures in the universe, according to popular but—before COBE—unconfirmed theories such as Cold Dark Matter.[2]

The Hubble Space Telescope (HST), in a 600 km orbit, has observed many Cepheid variable stars in about 20 nearby galaxies, which has finally allowed accurate measurement of the expansion rate of the universe and thus, indirectly, the time since the Big Bang.[3] The Hubble Deep Fields—the longest time exposures with HST—have given us unprecedented images of the first galaxies, which are helping us to understand the history of our own cosmic home, the Milky Way galaxy.[4]

In the seventeenth century, Newton's separation of physics into universal laws and special initial conditions provided a paradigm that still guides the field, even though the universal laws themselves have been revised several times. Darwinian evolution plays a similar central role in biology, connecting the structures of organisms and of ecological communities with the underlying molecular genetics. Geology just advanced tremendously a few decades ago with the confirmation of the plate tectonics paradigm. Now it is cosmology's turn, with the crucial help of observations from astronomical satellites. The data from COBE, HST, and other new observatories should at last give astrophysicists a solid foundation on which to construct an overarching theory of the origin and evolution of the universe, an achievement that is also bound to have deep implications for the development of human culture.

But such satellites are already at increasing risk from space debris. At any moment, only about 200 kg of meteoroid mass is within 2000 km of the Earth's surface. Within this same altitude range there is roughly 3,000,000 kg of orbiting debris introduced by human activities. Most of this mass is about 3000 spent rocket stages and inactive payloads. Approximately 40,000 kg of debris is in some 4000 additional objects several cm in size or larger, most of which resulted from more than 90 satellite fragmentations. The main threat to satellites near Earth is from the 1000 kg of 1 cm or smaller debris particles, especially the approximately 300 kg of debris smaller than 1 mm.[5] Such BB-size fragments of debris have the same destructive energy as a bowling ball moving at 100 km/hr. An average small satellite in an 800 km orbit now has about a one percent chance per year of failure due to collision with a BB-size piece of debris.[6] The danger to a large satellite such as Hubble Space Telescope is even greater. And the amount of small debris is increasing. Random collisions between man-made objects in LEO are still relatively rare, but the density of such objects may already be sufficiently great at 900-1000 km and 1500-1700 km that a chain reaction or cascade of collisions can be sustained.[7] Further growth of the debris population will increase the threat at even lower orbital altitudes. The resulting debris environment will obviously be very hostile to satellites in LEO.

Offensive weapons in space pose the worst threat to satellites in LEO. Fortunately, offensive weapons have not yet been introduced into space—except for a few tests such as a Soviet space mine explosion, or the intentional destruction in 1985 of the still-operating Solwind satellite in a demonstration by the U.S. military. Each of these tests generated hundreds of pieces of trackable debris. But kinetic kill vehicles such as the proposed thousands of "Brilliant Pebbles" are sure to generate great quantities of space debris just during their initial deployment, and far more if they are ever used. Any kind of space warfare will put all satellites at risk. The explosion of nuclear weapons in space (prohibited by the Outer Space Treaty, but routinely considered by military planners) would indiscriminately destroy unprotected satellites by electromagnetic pulse (EMP) or nuclear radiation.[8] Perhaps worst of all would be the deliberate injection into LEO of large numbers of particles as a cheap but effective anti-satellite measure. Any country that felt threatened by America's starting to place lasers or other weapons into space would only have to launch the equivalent of gravel to destroy the sophisticated weaponry. Many of these pieces of metallic gravel and fragments of broken weaponry would join all the other debris in orbit. It would hasten the fragmentation of the 3,000,000 kg of dead satellites and rocket bodies now in LEO, and thus produce an enormous cloud of debris that would threaten all satellites in LEO.

Who can imagine that someone like Saddam Hussein, who set fire to the oil wells in Kuwait and caused an environmental disaster with no military purpose, would hesitate to launch gravel if he felt it was in his interest? And whose fault would it really be, once America has taken the decisive step alone to put offensive weapons in space, against the wishes of even our closest allies? Our planet, so beautiful as seen from space now, would be blanketed in a cloud of metallic garbage that would be a sign of our cosmic arrogance and stupidity forever.

Scientists can foresee problems of which others are unaware. Our dual role in helping to avert a space "tragedy of the commons"[10] is to increase the understanding of relevant basic science, and to define and advocate needed policies, such as the following:

- Do not introduce attack weapons into space.

- Avoid fragmentation of satellites from explosions due to accidents and anti-satellite weapons tests, the main cause of space debris. Prohibit explosions of any kind in space.

- Design boost and deployment systems for satellites that minimize the production of space debris. Require all satellites in LEO to carry a mechanism, such as rockets or inflatable devices to increase drag, that will cause them to reenter when their useful life is over.

- Ban nuclear reactors in orbit.[11]

- Minimize light pollution from orbit.

The space age is only 45 years old, yet we humans may already have placed so many artificial objects in the near-Earth environment that random collisions between them can produce a cascading number of debris fragments that will threaten and eventually prevent scientific and other uses of low Earth orbit. Such a debris belt would have other unfortunate consequences: for example, fragmentation of this debris by further collisions can eventually produce enough dust to cause a lingering twilight as it is illuminated by sunlight, a new and particularly unpleasant sort of light pollution.[12] It will without doubt be necessary for all space agencies to take active steps to prevent the buildup of debris, and it is an encouraging first step that NASA and ESA have succeeded in eliminating the Delta and Ariane upper stage explosions that were a major source of orbital debris. But much more effort will be needed, and it may even be necessary to deploy special spacecraft to remove some of the space debris at the altitudes where the critical density for a cascade have already been reached. Designing such devices will be a useful exercise, not least because it will help to impress on public officials the cost of space debris.

Morality has a lot to do with power—we can't be morally responsible for something over which we have no power. Power without moral responsibility is evil, and it is probably also evolutionarily self-destructive. A sense of morality balancing power is what makes it possible for us humans to use power productively to improve the world. Our sense of morality must expand as we acquire the concepts and perspective to understand the long tentacles of our power throughout the Earth and—in this case of star wars—into cosmic-scale time.

National political leaders usually take a short-range view, hardly ever stretching past the next change of government; astronomers measure time in millions and billions of years. We must help to educate the general public to think with at least an intermediate perspective of centuries and millenia about the environmental degradation that our increasingly powerful technology is causing on and near our beautiful but fragile planet—the only one like it that we know in the entire universe.

Wise people have pointed out that missile defense can't work, will harm U.S. national security more than enhance it, and will waste hundreds of billions of dollars that could be spent defending ourselves against the real threats of the modern world.[13] These truths are expressed on a scale of political debate to which the public is accustomed, and often cynically ignores. The true cost of Star Wars is on another scale entirely—a cosmic scale. Short term political interests pale before the overwhelming, eternal immorality of imprisoning Earth for all future generations in a halo of bullets. Even Nazi officers chose to disregard Hitler's orders to destroy Paris. The American people must stop our short-sighted government from destroying something incomparably more valuable—the sky itself. This horrible crime would dishonor our ancestors, plant and animal alike, who bequeathed this beautiful blue planet to us, and cripple our descendents, who will never forgive us.

It has become customary for U.S. presidents to end speeches by saying "God bless America." It's about time for people to start saying instead "God bless the Earth!"

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