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Viewpoint

Measures proposed for planetary defence: Obstacles in existing international law and implications for space arms control

Jinyuan Su [a], [b], *

[a] Associate Professor & Distinguished Research Fellow, School of Law, Xi'an Jiaotong University, 28 Xianning West Road, Xi'an, Shaanxi 710049, China

[b] Erin J.C. Arsenault Fellow, Institute of Air and Space Law, McGill University, 3690 Peel Street, Montreal, Quebec H3A 1W9, Canada

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ABSTRACT

Whereas the Earth is showered by extraterrestrial matters on a constant basis, most of them cannot survive the very high heat produced in their entry into the atmosphere to make a terrestrial impact. Impacts that are capable of inflicting terrestrial casualties and damages are even rarer. However, their consequences can be high, and even so nowadays with the change of human settlement patterns on the Earth. With the development of space science and technology, human beings are now capable of predicting possible impacts with some accuracy, and even minimizing the chance of actual collision. For the later purpose, many proposals have been put forward, which either employ weapons readily found on the Earth, or envisage newly developed technologies that could nevertheless be used for military purposes. This short note applies existent international law to these measures, and attempts to shed some light on their implications for ongoing discussions of space arms control.

1. Introduction

Many hypotheses have been put forward to explain the K-Pg extinction that wiped out the dinosaurs and destroyed 75% of all species on the Earth some 65 million years ago. The extraterrestrial impact theory, proposed by Professor Walter Alvarez and his colleagues in 1980 [1], stands out as the one credited with the most merits today. Whereas the theory is not without challenge, now it is at least evident that due to gravitational perturbations from nearby planets, asteroids that reside in the Asteroid Belt between the Mars and the Jupiter, and comets in the Kuiper Belt and/or the Oort Cloud may come close to the Earth and even enter its atmosphere. According to United Nations Committee on the Peaceful Uses of Outer Space (COPUOS), asteroids and comets whose trajectories bring them within 1.3 astronomical units (AU, 1 AU is equal to the distance between the Sun and the Earth) of the Sun, hence within 0.3 AU (or approximately 45 million km) of the Earth's orbit, are categorized as Near-Earth Objects (NEOs) [2]. NEOs also include objects that will come close to the Earth at some point in their future orbital evolution. The vast majority of NEOs are asteroids, referred to as Near-Earth Asteroids (NEAs). Those that get closer to the Earth than 0.05 AU (or roughly 7,480,000 km) and are larger than about 150 m in diameter are considered by the National Aeronautics and Space Administration (NASA) of the United States as Potentially Hazardous Asteroids (PHAs). NASA further restricts Near-Earth Comets (NECs) to include only short period comets, i.e. those with orbital period less than 200 years, among NEOs [3].

The risks that NEOs pose to the humanity have become much better known in the scientific world in recent decades, but public awareness and policy makers' attentions in this regard are limited at best, largely because no impact resulting in large-scale casualties is recorded in human history. However, it should be noted that the notion of risk, i.e. the expected value of an undesirable outcome, relates not only to the probability of an accident occurring, but also to the expected loss in case of the accident. NEO impacts are “low-probability, high-consequence” events. In other words, while the odds of an impact are small, the number of people who would be killed or wounded and the amount of property loss are high. Although extinction-level impacts are estimated to happen only every billion years, there is a much higher possibility of lower-level impacts, and the expansion of urban settlements throughout the last century has increased the chance of large-scale casualties in the event of an impact. The *Tunguska* impact of 1908, in which an extraterrestrial object of 60–190 m in diameter exploded at an altitude of 5–10 km and levelled 2,000 square kilometers of trees in Siberia, caused no casualties. However, if a *Tunguska*-sized asteroid

* School of Law, Xi'an Jiaotong University, 28 Xianning West Road, Xi'an, Shaanxi 710049, China.
E-mail address: jinyuan.su@hotmail.com.

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were to enter the Earth's atmosphere at the same velocity today, there would have been significantly higher chances of striking an inhabited area, thus producing significant casualties. An impact on critical infrastructures such as nuclear power plants and dams could also lead to catastrophes, as evidenced by the *Fukushima Daini* nuclear disaster of 2011. *Tunguska* events are predicted to happen once every 300 years [4]. On June 14, 2002, Asteroid 2002 MN, which has a similar mass and relative velocity, missed the Earth by a closest approach distance of 0.000797 AU or 119,229 km. The same object is estimated to have a 1 in 50,000 chance of impact with the Earth on June 16, 2100 [5]. The scientific world remains alerted of this object. As a matter of fact, it could no longer be claimed that no injuries to life or damages to properties have resulted from the impact of extraterrestrial objects. On February 15, 2013, the *Chelyabinsk* meteor crashed over a major Russian town, injuring 1,200 persons and damaging 4,000 buildings [6].

The optimistic side is that developments in space science and technology have made it possible to predict with some accuracy whether a NEO may present a serious threat to the Earth, and enabled us in many cases to undertake successful efforts to minimize the chance of actual collision, according to the Association of Space Explorers [7]. International mechanisms dealing with the issue are also coming into shape, thanks to constant mobilizations from scientists, academics, NGOs, and etc. In 2001, the COPUOS established the Action Team on NEOs (AT-14). In 2013, the AT-14 recommended the establishment of an international asteroid warning network (IAWN) and a space mission planning advisory group (SMPAG), which were subsequently approved by the Scientific and Technical Subcommittee of COPUOS during its 50th session in February 2013, and formally endorsed by the Committee at its 56th session in June 2013 and by the UN General Assembly at its 68th session in December 2013 [8]. States and even private entities continue to ramp up their efforts to map asteroids and seek ways of mitigation, notably NASA's Near Earth Object Program and B16 Foundation's Sentinel mission.

Various proposals have been put forward for the mitigation of NEO impacts, or "planetary defence", ranging from deflection to fragmentation. By deflection, the trajectory of a dangerous NEO is altered, with rocket engines, giant sails, "gravity tractors", kinetic energy impact, or even nuclear explosive radiations, to avoid collision with the Earth. Fragmentation needs to be done by burying and detonating conventional or nuclear explosives therein. In general, deflection methods are regarded as preferable to fragmentation approaches [9]. These options, however, are surrounded by legal and political controversies, either because they employ weapons readily found on the Earth, or because the newly developed technologies have military implications.

2. The application of existing international law to measures of planetary defence

Various approaches have been proposed for planetary defence. For many of them, in particular those by fragmentation, the use of nuclear or conventional weapons readily found on the Earth is conceived. The same happens to deflection — some scientists are of the view that for small (100 m) asteroids, deflection using a kinetic energy impact is technically feasible, while for those in the 1–10-km range only nuclear-based options are practical [10]. There are other proposals which rely on creating a small change in a NEO's trajectory so as to avoid a collision. Such measures would need the identification of the threat decades in advance. To NASA, the use of nuclear explosives is far more effective than others, according to its 2007 report to the US Congress [11]. However, the nuclear scenario has encountered substantial skepticisms, e.g. that due to the uncontrollable nature nuclear reflections risk sending the NEO into another orbit that threatens the Earth, and even fragmenting it without changing its trajectory, which increases its capacity to inflict harm [12]. The National Resource Council, in its 2010 report, calls for the use of nuclear weapons as a means of last resort in planetary defence [13]. The use of weapons in planetary defence is potentially hindered by existing international space law, which imposes partial restrictions on military activities in outer space.

The use of nuclear weapons in planetary defence is *prima facie* prohibited by international space law. First, the placement of any objects carrying weapons of mass destruction (WMDs) in orbit, the installation of such weapons on celestial bodies, and the stationing of them in outer space in any other manner is prohibited by Article IV, para. 1 of the Outer Space Treaty. This provision proscribes the placement of nuclear weapons in outer space, which is regarded as an important measure for the mitigation of NEOs that have very short warning time such as long-period comets [14]. One may argue that nuclear devices deployed in outer space for the purpose of planetary defence are not nuclear weapons, because they do not fulfill the defined subjective requirement of "weapon" in the first place, i.e. "an instrument used or designed to be used to injure or kill someone" [15]. However, this argument will probably encounter substantial disagreements, as it would weaken norms of existing international space law significantly and run the risk of a nuclear race in outer space. Second, even if no placement in outer space is required, nuclear explosions in outer space are nevertheless prohibited by the Partial Test Ban Treaty (PTBT). States Parties to the PTBT, according to its Article I, para. 1, undertake "not to carry out any nuclear weapon test explosion, or any other nuclear explosion" in the atmosphere, under water, or in outer space, or in any other environment if the explosion would cause radioactive debris to be present outside the borders of the State conducting the explosion. The phrase "any other nuclear explosion" includes explosions for peaceful purposes, as explained by then U.S. Acting Secretary of State Ball in a subsequent report to President Kennedy [16].

As to the legality of using conventional weapons, such as kinetic energy impacts, in planetary defence, international space law presents a mixed picture. Article IV, para. 2 of Outer Space Treaty only non-militarizes celestial bodies. It follows that States are not banned from deploying and using conventional weapons in outer void space for the purpose of planetary defence. Thus, the use of conventional weapons in planetary defence is partially constrained by existing international space law. In this connection, it is noteworthy that the term of "conventional weapons" is more riddled with ambiguities in outer space than on the Earth. Many of the newly developed technologies for planetary defence, which employ rocket engines, giant sails, "gravity tractors", and etc., are not typical weapons, but may be converted for hostile uses. Whereas they are un-prohibited in outer void space, it is a matter of dispute as to whether they could be legally stationed on celestial bodies.

The above outcomes pertaining to the legality of measures available for planetary defence, based on the application of existing international space law, seem rather absurd. But it may be relieved if it is viewed in the broader context of general international law. As provided by Article III of the Outer Space Treaty, States Parties shall carry on activities in the exploration and use of outer space in accordance with international law, including the Charter of the United Nations. General international law thus becomes applicable in outer space. One may wonder whether the use of force for planetary defence, which is very often indispensable therein, constitutes a violation of the non-use of force principle enshrined in Article 2(4) of the Charter. However, the term of "use of force" shall be distinguished in the two different contexts. One is a terminology that is in the general knowledge sense and may be better understood as the "use of weapons", while the other is in the legal sense.