TECHNICAL NOTE

DELIBERATE DESTRUCTION OF PLANETS AND BIOSPHERES

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Science fiction offers scenarios in which a planet is destroyed in combat. However, these are often impractical. Instead of supplying all the energy required, more plausible attacks may use leverage in order to damage or destroy the planet or its biosphere. In order to study the conduct, observation, or defence associated with such attacks, a range of potentially practical weapon and defence technologies are discussed. These are: altering the radiation budget of a planet so as to substantially change its temperature; introducing invasive species to transform the biogeochemistry; and using orbital perturbations of comets and asteroids to cause collisions, or to move the planet to an unstable or uninhabitable orbit. Weapon transit and effect times associated with these technologies render them suitable only for extreme slow-motion warfare, assuming near-term technologies.

Keywords: Exoplanet, solar radiation management, terraforming, directed panspermia, space warfare

1. INTRODUCTION

A discussion of planetary destruction technologies is necessary to enable the observation of any interplanetary warfare which may be conducted by these techniques. Additionally, consideration of potential hostile technologies may assist in the development of countermeasures.

Science fiction discusses the direct destruction of planets. However, an initial assessment of the physics of planetary destruction suggests implausible energy inputs are required. This is confirmed by Boulderstone et al. [1] who find that the “Death Star” would require power levels well beyond current technology (albeit consistent with the fictional power output of

the weapon). By contrast there is little systematic study of practical methods of destroying planets, or alternatively of rendering them uninhabitable.

Other fiction writers consider the destruction of the biosphere by terraforming-like interventions [2]. "Terraform" is defined as to transform a planet so as to resemble the Earth, especially so that it can support human life [3]. Terraforming is therefore typically discussed as a method of rendering an uninhabitable planet habitable. Proposals for the modification of inner solar system planets exist [4, 5]. An alternative use for comparable technologies exists, which intends the opposite effect – i.e. the deliberate destruction of the capacity of a planet to support life. By modifying the planetary radiation budget, destruction of the biosphere can be achieved with far less engineering effort and energy input than the direct destruction of the planet.

At the edges of a star's habitable zone, tipping points exist where Earth-like planets quickly enter a stable 'snowball' condition [6], as on the early Earth. This occurs where ice-albedo feedback quickly cools a planet, rendering it indefinitely ice-bound and devoid of a large and diverse biosphere. Alternatively, a runaway greenhouse effect may commence, (as on Venus [7]) where the oceans boil to give a steam atmosphere. The efficacy of steam as a greenhouse gas then drives planetary temperatures up by several hundred degrees Kelvin to form a new, stable climate. Such heating practically ensures the destruction of all life.

Panspermia describes a model of life propagation throughout space from a single origin, defined as "The theory that life on the Earth originated from microorganisms or chemical precursors of life present in outer space and able to initiate life on reaching a suitable environment" [3]. A terraforming approach of directed panspermia has been proposed [8], which seeks to deliberately propagate simple life to other planets.

Human history is marked by periods, in which highly-destructive offensive military techniques are developed using new technologies, and then later prohibited or abandoned. Nuclear weapons were fired in World War II, and not in anger since. Centuries before, disease-carrying carcasses were used as weapons [9]. Destruction of crop plants was conducted millennia ago, being so controversial as to be prohibited in ancient religious texts [10], as well as the modern Geneva Convention [11]. The restriction and prohibition of such techniques in later years suggests a potentially consistent pattern of early technological excess followed by a later period of restraint. Such a pattern may be detectable elsewhere in the galaxy.

Likewise, a 'scorched Earth' policy has previously been widely used in warfare to create a defensive barrier, e.g. in Stalin's retreat from Hitler [12]. A similar approach of rendering planets uninhabitable may be used to create a sterile zone to protect an alien civilisation.

2. DESTRUCTION TECHNIQUES

Various technologies are available to enable the destruction of planets, without relying on the discovery of new physics (warp drives, etc.), or on improbable engineering endeavours (e.g. Dyson spheres). These fall into three basic groups.

1) Terraforming - to induce snowball conditions, or a runaway greenhouse effect.
2) Introducing an invasive species, or community - to outcompete or destroy the natural lifeforms of the planet, such as by altering the atmospheric chemistry.
3) Causing orbital perturbations - which result in a major impact, or the planet leaving its habitable orbit (and then potentially entering either deep space, or a star).

3. TERRAFORMING

Terraforming by climatic adjustment relies on inserting greenhouse gases [13] or scattering aerosols [14] into the atmosphere of a planet, or placing mirrors or material into the planet's orbit [15] so as to concentrate or block incoming starlight (sunlight). Such attacks are most likely to be effective if the planet is at the edge of the star's habitable zone. The necessary materials may be produced on or near the attacking planet, and sent through interstellar space in a weaponised form. They may alternatively be produced in target solar system, or even on the surface of the target planet. A scenario depicted in "Aliens" [16] is similar to the latter case, albeit without directly hostile intent. Alternatively, other aspects of planetary biogeochemical function could be disrupted, e.g. the deposition of a large volume of ozone-destroying chemicals. Such perturbations need not be long lasting, as they may trigger planetary feedbacks (e.g. snowballing), or may result in the destruction of the target civilisation or species. This approach requires only very basic spacefaring technology – the ability to send large volumes of material through deep space, and to impact a target planet. If flight times of centuries or millennia were deemed acceptable, this technology may be accessible to mankind on decadal timescales, and presumably also to other technological civilisations. This approach is relatively easy to defend against, as the inbound weapon would be large and relatively slow moving, to prevent excessive heating on descent and impact. Such a weapon could be destroyed in space, or diverted to a parking orbit by means of a chemical rocket 'tugboat' or nuclear weapons (for discussion of diversion methods, see [17]. However, early detection would be critical, as even a damaged weapon could still release dangerous payload.

4. INVASIVE SPECIES

It is possible that advanced civilisations may emerge on planets which are vulnerable to colonization by species found on Earth, or those found on other planets. Such colonisations may similarly result in the destruction of the biosphere, ecosystem, or of key species of the target planet. In a more extreme case, the prehistory of Earth shows at least one example of an organism which profoundly changed the biogeochemistry of the planet:

cyanobacteria. Their evolution resulted in an oxygenated atmosphere [18] and consequentially an ozone layer. This triggered snowballing [19], as well as broad chemical environmental change. At the opposite end of the scale, a terrestrial example of a narrow-impact extinction event is the destruction of Dodo nests by introduced species [20]. There is a blurred line between hostile dispersion of invasive species and 'benign' directed panspermia – which also risks similar outcomes. Similarly, there is a blurred line between biosphere destruction and mere biological warfare. The invasive species technique is potentially accessible to mankind using near-term technologies, particularly if a large swarm of spaceships could be launched, in order to maximise the chance of an impact. Transfer of large masses would not be required, and even dust-grain-sized payloads may eventually be more than enough to destroy a planet's entire biosphere. However, survival and colonization by the intended species would largely be a matter of luck. This technique has the benefit of being exceptionally hard to defend against, as a swarm of tiny payloads would be difficult to reliably intercept.

5. ORITAL PERTURBATIONS

It has been proposed that asteroids could be steered [17] (e.g. using nuclear bombs or lasers). This process has been suggested as a means of moving planets into different orbits, particularly to escape an expanding red giant star [21]. Such techniques could also be used to destroy planets in a number of ways. The most obviously practical would be to cause a series of collisions with comets or asteroids. Direct damage from smaller asteroids could be used to destroy cities, which has been considered as a terrestrial weapon of mass destruction [22]. However, more generalised damage could be caused by using asteroids to induce climatic catastrophes, as has been seen during flood basalt eruptions in Earth's prehistory [23]. More challenging would be to cause a catastrophic collision between two planets, such as that which is believed to have formed the Earth's moon [24]. Alternatively, a planet's oceans could be frozen or boiled by making a series of orbital adjustments which serve to gradually move the planet out of the habitable zone. This technological approach would require the interstellar transfer of complex technologies, which would have to work reliably to survey and manipulate large bodies after centuries or millennia in deep space. Such technologies are likely accessible to mankind only on centurial timescales, or longer. Defending against such attacks would be technologically difficult, due to the fact that small craft stationed far from the target planet could be used to conduct the attack. However, the attack process itself may take centuries or millennia, and so defenders would potentially have a long time to detect and destroy the hostile craft.

6. DETECTION

Detecting warfare successfully conducted by such methods may be conceivable at interstellar distances, due to the large changes in observable planetary temperature [25]

and potentially in atmospheric chemistry [26] which may be expected as a result of an attack. Adjustments to orbital timings would be easily detectable by the transit method.

CONCLUSIONS

Various technologies are conceivable which could be used to destroy planets or their biospheres. The detection of events consistent with such military activities would aid the search for alien civilisations. The basic nature of some of these technologies may mean that such weaponry is commonplace in the galaxy. Accordingly, near-term vigilance for such attacks is warranted – particularly bearing in mind the ease with which large, 'dumb' bulk carriers could be diverted or destroyed. The ease with which such weapons may be developed by humans in coming decades poses serious ethical and governance challenges.

REFERENCES

[1] D.Boulderstone, C.Meredith, S.Clapton, "That's No Moon", *Journal of Special Topics*, Vol 9, No 1, 2010.

[2] B.Cooper, L.Niven, "Ice and Mirrors" ISFDB Title Record # 91948, Asimov's Science Fiction, Dell Magazines, February 2001

[3] "art, n.1". OED Online. September 2015. Oxford University Press. http://www.oed.com/viewdictionaryentry/Entry/11125 (accessed October 13, 2015)

[4] M.F.Gerstell, J.S.Francisco, Y.L.Yung, C. Boxe, E.T.Aaltonee, "Keeping Mars warm with new super greenhouse gases*", Proceedings of the National Academy of Sciences,* 98 (5): 2154–2157. 2001.

[5] P.Birch, "Terraforming Venus Quickly", *Journal of the British Interplanetary Society*, Vol 44, 157-167 1991.

[6] P.F.Hoffman, A.J.Kaufman, G.P.Halverson, D.P.Schrag, "A Neoproterozoic Snowball Earth", *Science*, 281 (5381): 1342-1346. 1998.

[7] I.Rasool, C.De Bergh, "The Runaway Greenhouse and the Accumulation of CO2 in the Venus Atmosphere", *Nature*, 226 (5250): 1037–1039. June 1970.

[8] F.H.Crick, L.E.Orgel, "Directed Panspermia", *Icarus*, 19 (3): 341–348. 1973.

[9] M.Wheelis, "Biological warfare at the 1346 siege of Caffa", Emerg Infect Dis (Center for Disease Control), 2002.

[10] Deuteronomy Ch. 20: Vs 19,20 ; Zondervan NIV Study Bible. Fully rev. ed. Kenneth L. Barker, gen. ed. Grand Rapids: Zondervan, 2002. Print

[11] International Committee of the Red Cross (ICRC), Protocol Additional to the Geneva Conventions of 12 August 1949, and relating to the Protection of Victims of International Armed Conflicts (Protocol I), 8 June 1977, 1125 UNTS 3, available at: http://www.refworld.org/docid/3ae6b36b4.html [accessed 14 October 2015]

[12] P.Carroll, “Hitler Moves East”, Bantam Books, 1966.

[13] M.F.Gerstell, J.S.Francisco, Y.L.Yung, C.Boxe, E.T.Aaltonee, "Keeping Mars warm with new super greenhouse gases", *Proceedings of the National Academy of Sciences*, 98 (5): 2154–2157. 2001.

[14] P.J.Crutzen, "Albedo Enhancement by Stratospheric Sulfur Injections: A Contribution to Resolve a Policy Dilemma?", *Climatic Change*, 77 (3–4): 211–220. 2006.

[15] J. T. Early, "Space-Based Solar Shield To Offset Greenhouse Effect", *Journal of the British Interplanetary Society*, 42. pp. 567–569, 1989.

[16] J.Cameron, “Aliens”, 20th Century Fox, 1986

[17] NASA, “Near-Earth Object Survey and Deflection Analysis of Alternatives”, Report to Congress March 2007, http://neo.jpl.nasa.gov/neo/report2007.html (accessed October 13, 2015)

[18] D.T.Flannery, R.M. Walter, "Archean tufted microbial mats and the Great Oxidation Event: new insights into an ancient problem", *Australian Journal of Earth Sciences*, 59 (1): 1–11. 2012.

[19] R.E.Kopp, J.L.Kirschvink, I.A.Hilburn, and C.Z.Nash, "The Paleoproterozoic snowball Earth: A climate disaster triggered by the evolution of oxygenic photosynthesis", *Proc. Natl. Acad. Sci*, U.S.A.102 (32): 11131–6. 2005.

[20] J. Hume & M. Walters, “Extinct Birds”, pp. 134–136, Poyser, 2012.

[21] D.G.Korycansky, G.Laughlin, F.C.Adams, "Astronomical Engineering: A Strategy For Modifying Planetary Orbits", *Astrophysics and Space Science*, 275 (4): 349-366. http://hdl.handle.net/2027.42/41972, 2001 (accessed October 13, 2015)

[22] C.Sagan, “*Pale Blue Dot: A Vision of the Human Future in Space*”, New York: Random House, 1994.

[23] J.G.Negi, P.K.Agrawal, O.P.Pandey, A.P.Singh, "A possible K-T boundary bolide impact site offshore near Bombay and triggering of rapid Deccan volcanism", Physics of the Earth and Planetary Interiors. 76 (3–4): 189. 1993.

[24] G.J.Taylor, "Origin of the Earth and Moon", Planetary Science Research Discoveries, 31 December 1998.

[25] H.Knutson, D.Charbonneau, L. Allen, et al, "A Map of the Day-Night Contrast of the Exosolar Planet HD 189733b", *Nature*, 447 (7141): 183–186. 2007 (accessed October 13, 2015)

[26] H.W.Lin et al, “Detecting Industrial Pollution in the Atmospheres of Earth-like Exoplanets”, ApJ, 792 L7, 2014.