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WHAT ABOUT COMETS?

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Abstract

Current planetary defense policy is like the sound of one hand clapping: It omits one of two essential components, namely, comets, and in particular long-period comets, whose appearance on Earth's cosmic doorstep will not have been anticipated. Such an apparition has the potential to end human civilization, and the threat is ever-present. Yet current policy favors addressing the threat from asteroids, which, while certainly also real and ever-present, does not, I shall argue, merit the relative exclusion from consideration of the cometary threat. I believe they are equally urgent, each in its own way. Further, meeting the cometary threat will call for a greater investment of resources, and hence requires even more attention, education, and political will than the asteroidal threat.

Introduction

Despite the recent impressive strides in surveying near-Earth objects and developing technologies of deflection, planetary defense is currently hobbled by an inadequate conception of, and hence policy (here I use the term for the de facto consensus, since there doesn't seem to be any de jure planetary defense policy) regarding the total threat of impact by extraterrestrial bodies. For various reasons, plausible in themselves, the focus has become asteroids, to the relative neglect of comets, and in particular long-period comets (and in this paper I shall use "comets" as shorthand for these).

Asteroids are seen to be both more threatening and more manageable. They are more threatening because there are so many of them that could cross Earth's orbit; they are more manageable because we will soon be able to track almost all of the ones that could do us serious harm, and their closing speed might well provide us with the decades of advance time we would need to prepare an adequate defense against them. Comets, to the contrary, are relatively rare visitors to the inner solar system; and when a new one does arrive from the Oort Cloud, should it happen to be headed our way, it is not likely to be detected in time to deflect it.

My contention is that these considerations do not lead to the conclusion that comets may be safely ignored for the time being, but, quite the opposite, lead to the conclusion that an adequate defense against comets needs to be pursued with a sense of urgency. More particularly, detection capacity needs to be extended to the outer solar system, and a deflection infrastructure needs to be put in place, not after but prior to detection of a specific threat (cf. Chapman, Durda, & Gold 2001).

It is curious that the cometary threat has fallen by the wayside, given the great amount of attention comets have garnered historically and even just in the past year. It is also ironic because comets were once superstitiously dreaded as harbingers of some Earthly catastrophe, whereas today we understand that the comets themselves constitute the threat. But whereas the Chelyabinsk meteor/asteroid was universally hailed as a wake-up call, the response to Comet ISON, Comet Siding Spring, and Comet 67P has been entirely in terms of photo-ops and scientific investigation of the origins of life on Earth. And who among us could ever forget Shoemaker-Levy 9? Thus, there have been cometary wake-up calls galore, but (to slightly mix the metaphor) we keep hitting the snooze button. When it comes to comets, we have been positively cometose (to coin a term).

I assign the root cause of this asymmetrical response to a misplaced emphasis on the rarity of cometary apparitions to the neglect of their randomness. And this too is ironic, given that asteroid impacts are also rare; yet the standard response by the planetary defense community has been that this rarity is compensated for by the magnitude of the possible catastrophe. But is that not also true of cometary impacts?

History and Terminology

It is only very recently that comets have fallen into relative oblivion. At the beginning of the serious planetary defense era, asteroids and comets shared top billing. Thus, the seminal Spacewatch Workshop held in Snowmass, Colorado, in July 1981, was devoted to the impact hazard of both kinds of small bodies, as testified by Clark Chapman's firsthand account (Chapman 1998) and by Chairman Eugene Shoemaker's review article, "Asteroid and Comet Bombardment of the Earth" (Shoemaker 1983). Later the same year in October the first Snowbird (Utah) Conference on the Alvarez hypothesis considered the "Geological Implications of Large Asteroids and Comets on the Earth" (Silver and Schultz 1982). Other notable examples from subsequent years include a mammoth collection of articles edited by Tom Gehrels on *Hazards due to Comets and Asteroids* (Gehrels 1994) and an early study of the legal implications of dealing with the impact hazard, titled "Asteroids and Comets" (Gerrard and Barber 1997). Popular treatments of the subject were also evenhanded, as testified by well-regarded trade books by astronomers such as John S. Lewis's *Rain of Iron and Ice* (1995), Duncan Steel's *Rogue Asteroids and Doomsday Comets* (1995), and Gerrit L. Verschuur's *Impact: The Threat of Comets and Asteroids* (1996), and by two hit movies of summer 1998, *Armageddon*, about an asteroid, and *Deep Impact*, about a comet.

Yet also, from the very first, there has been a near-haphazard use of the terms “asteroid” and “comet,” among others, in discussions of the impact hazard. Sometimes there seems to be no rhyme or reason for which term is chosen, even in the same text. Here is an example from Carl Pilcher’s testimony to Congress in 1998 (Stokes 2003, Appendix 1, with emphases added):

> While the threat of a catastrophic collision is statistically small, NASA has a vigorous program of exploration of NEOs planned, including *both asteroids and comets*. … In the unlikely event that a *potentially hazardous object* is detected, the Office would coordinate the notification of both the observing community and the public of any *Potentially Hazardous Asteroids* discovered.

The testimony moves from “both” asteroids and comets to the generic “object” to just “asteroids.” All told it contains four terms, including “NEOs.”

Perhaps it would be helpful, therefore, to review a number of such terms that appear in the literature, with an eye to exposing their differences and also to choosing the one or ones that are most apt for discussions of a comprehensive planetary defense:

asteroid or comet: This is the most explicit, but it has proved unwieldy to speak on all occasions. Also, it becomes even more unwieldy when the term is expanded to qualify the type of body that most concerns planetary defense, namely, one which might do us harm.

minor planet: Quaint, but confusing in the era of (so-called!) dwarf planets. Also, again, omits reference to hazard.

dangerous celestial body (DCB): This might be all right, although strictly speaking even a nearby potential supernova, etc., could be conceived as a DCB.

hazardous space object (HSO): Same as for DCB.

hazardous space rock (HSR): This might do, but I fear it may suggest only an asteroid to those who conceive of comets as “dirty snowballs.”

near-Earth object (NEO): This has become the term of choice because objects that are near Earth are the only ones we can do anything about or sometimes even detect. But I see two problems. One is that the technical definition – a minor body in the solar system having a perihelion of less than 1.3 AU – would include a long-period comet that happened to be heading in our direction but was still vastly far beyond the orbit of Neptune; but to call such an object “near-Earth” is counterintuitive. On the other hand, if “near-Earth object” were restricted to objects that actually are near Earth – even if “near” were extended to include anything closer than, say, Jupiter’s orbit – by the time a long-period comet heading our way became a near-Earth object in this sense, it would most likely be too late to defend ourselves against it. So I find the term not helpful for designating the target of a comprehensive planetary defense.

near-Earth asteroid (NEA): Same as for “near-Earth object” but more so since it explicitly omits the other “half” of planetary defense.

Earth-crossing object (ECO) or asteroid (ECA): Superior to “near-Earth” designations in that a potential hazard is more clearly presented by an object that would actually cross Earth’s orbit. But still the problems mentioned for “NEO” or “NEA.”

potentially hazardous object (PHO): This terms gets a lot right. Note the (perhaps benign) ambiguity regarding “potentially hazardous.” It could be referring either to our not having yet ascertained whether the object in question is barreling down on Earth, or to our possibly being able to destroy or divert an object that definitely does have us in its crosshairs. Both are concerns of planetary defense.

potentially hazardous asteroid (PHA): Same objection as to “NEA.”

potential impactor (PI): Short and to the point.

extinction-size potential impactor (EPI or ESPI): This is my personal favorite, which I coined because I wish to return planetary defense to its original concern with global catastrophe (which has largely gone by the wayside along with comets). “EPI” may be preferable to “ESPI” if only because the latter ambiguously sounds like “SP.” (I also recommend the term “NEPI” for the object that most concerns planetary defense, namely, the *next* EPI to appear on our cosmic doorstep.)

Hegemony

While it would be convenient to have a uniform term for the target of a comprehensive planetary defense, what especially concerns me is the collusion of inadequate terminology with the current hegemony of an asteroid regime. This may have begun as a merely terminological matter, with “asteroids” being used as shorthand for “asteroids and comets” spoken in the usual alphabetic order. But more recently the significance has become substantive. And the reasons are clear: Potentially threatening asteroids are more numerous than potentially threatening comets (at least if Scholz's star did not significantly perturb the Oort Cloud! [Mamajek 2015]), and present technology and/or political/economic priorities would not enable us to do much if anything to protect ourselves against a potentially threatening comet. The latter is so because such a comet would typically be discovered only at the orbit of Jupiter and would be traveling at tremendous speed in our direction, allowing insufficient time to mount an effective defense under present circumstances.

However, I myself draw exactly the opposite conclusion from these acknowledged facts. Given our present relative inadequacy to counter the cometary threat, I urge a redoubled effort to deal with it. Instead there has developed a kind of confidence that “heaven can wait” – that is, no comet will threaten Earth until such time as our technology has developed, of its own accord or due to more mundane pressures (or “as

if by an invisible hand" – laissez-faire planetary defense?), to the point at which we now find ourselves with respect to the asteroidal threat. For the latter is something that we appear more justly confident about, given (1) the remarkable strides being taken to inventory NEAs, such as the upcoming Sentinel mission, (2) the apparent preponderance of smaller objects that current technology could plausibly deflect, and (3) the longer time we could expect to have to prepare a defense against larger objects whose orbits lie within the inner solar system.

But, I submit, this is the tail wagging the dog, and it has led to a very curious and almost (?) self-contradictory attitude in the planetary defense community regarding the urgency of response that is appropriate to asteroids and comets, respectively. For while it is universally acknowledged that the asteroidal threat impels us to, in Donald Yeomans' words, "Find 'em early; Find 'em early; Find 'em early," since this … and only this … approach would, in the standard case, give us adequate time to deflect an incoming asteroid, the approach to comets has become, in effect, "They can wait; They can wait; They can wait." Thus, today one sees book after article after news story after magazine column with "asteroid" alone in the title and even in the text, when it purports to be about planetary defense as such. Similarly one finds that the United Nations initiative for global coordination of planetary defense (now housed at the IAU Minor Planet Center) is called the "International Asteroid Warning Network," and the White House/NASA Grand Challenge on planetary defense is called the "Asteroid Initiative," and the premier NGO devoted to planetary defense is promoting both an Asteroid Declaration and an Asteroid Day, and even this very meeting is billed in its logo as the "Planetary Defense Conference: Protecting Earth from Asteroids."

This makes no sense. There is a difference only in degree and not in kind between the asteroidal and cometary threats. Both involve statistically rare events that could have catastrophic consequences. Both require early detection, and both require devising new applications of existing technology and possibly also new technologies to detect and deflect them. Both require more investment of political will and federal budget than currently obtains. So the two threats are alike. But, yes, the difference of degree is significant; and that is why comets cannot be safely subsumed under the rubric of "Asteroid." For while various initiatives to protect against asteroids do indeed have implications for cometary defense, the latter requires in addition a more extensive monitoring of the outer solar system and, especially, a greater degree of advance preparedness to meet a threat once one has been identified. This all means even more expense than the already inadequately funded asteroidal defense initiatives currently on the table. So comets cannot be sidestepped or treated as free riders on asteroids. Their distinctive potential for wreaking havoc needs to be explicitly recognized.

Correlative Issues

While my discussion has focused on the relative neglect of comets in planetary defense, comets have really served as proxy for two broader issues, namely, short warning times and large (that is, "extinction-size") objects. For asteroids too can give us little advance notice, and asteroids too can be extinction-size. Current planetary defense policy has, in

these regards, been just as neglectful of the asteroidal threat as of the cometary threat. The reason I have chosen to emphasize the latter is that it makes the case more clearly, since in their very nature, (long-period) comets heading towards us will, because of their closing speed, give us short notice and, for the same reason, pose a high likelihood of global catastrophe. Asteroids, on the other hand, are likely to be discovered far ahead of impact time and to be "small." Yet this does not preclude the possibility of a large asteroid's being discovered very close to impact time. And no calculations are needed to discern the wisdom of a policy of "better safe than sorry," especially when the survival of our species is on the line.

The prevailing attitude toward both the cometary and the asteroidal threats fails to appreciate their essential nature as *random*. Specifically, although standard ways of articulating the impact threat make it sound like a regular, clockwork occurrence – for example, "*once every* 10,000 years" – the next apparition of an Earth-threatening asteroid or comet could occur at any time. It could occur today. To think otherwise is to commit a fallacy. And it would be cold consolation, when that fatal rock was finally bearing down upon us, to be able to exclaim, "This is highly unlikely!" (Marks forthcoming)

Conclusion

The chief absurdity of our time (a time of many absurdities) is that, in the decades since the shutdown of the Apollo program, the United States, and perhaps other spacefaring nations as well, has been floundering in search of a grand new space initiative, while, with ever-increasing conspicuousness, the most compelling undertaking imaginable has been staring us in the face: saving our species from an avertable extinction. We are becoming aware of this now, but in fits and starts, and with pendulum swings. For in addition to the waxing and waning of consciousness of the general threat from potential impactors, there has also been a switch of emphasis from the civilization-ending threat to the city- or regional-level threat. This has gone hand in hand with a shift away from equal concern about asteroids and comets to the almost total neglect of comets as also possibly imminent threats. The reasons have been the growing knowledge of the relatively large number and predominantly small sizes of near-Earth asteroids and the relatively high cost of preparing an adequate defense against long-period comets. The latter would presumably involve extending detection efforts into the outer solar system, as well as preparing a deflection infrastructure, not subsequent to but well in advance of any detection of an incoming comet. But asteroids too can pose analogous challenges.

I therefore close with these recommendations:

(1) that the expert planetary defense community as well as science journalists and popularizers strive to correct the imbalance of attention being paid by policymakers to asteroids over comets;

and

(2) that a new guiding principle of planetary defense be adopted – to replace “Find ’em early” (or really to expand it, since “Find ’em early” states a necessary condition of planetary defense but not a sufficient one) – to wit: Assume that the next potential impactor, of whatever size from city-killer to species extinction, will be discovered the day after we have prepared an adequate defense against it, were we to be planning, testing, building, and deploying both the requisite detection and deflection infrastructures, in earnest, today and forever.

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