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Pulverizing a Planet Killer

WARNING: SPOILERS AHEAD

In the recent Oscar-nominated film "*Don't Look Up,"* stars Jennifer Lawrence and Leonardo DiCaprio play astronomers who struggle to get the world to take seriously the threat of a 9-km-diameter comet headed directly for Earth. In the sci-fi satire, the horror of the planet-killing comet is second only to the bigger tragedy of human apathy and misplaced values; it is a driver of the plot, but the science behind humanity's approach to the doomsday rock is given a light treatment.

For UC Santa Barbara physicist Philip Lubin, who conducts research in a wide variety of fields from cosmology to planetary defense, however, the science hits home. To him, the *how* to actually protect Earth from cosmic collisions is key. Could humanity save itself in such a scenario of a "planet killer" with short term notice?

"While the movie is great comedy, the science depicted in mitigating the threat is lacking in credibility and would not work," he said. "However, there is a path forward that could allow humanity to survive and not have the ending shown in the movie."

For Lubin, the movie posed an intriguing question: Could we save ourselves from going the path of the dinosaurs?

"In the back of my mind the idea of existential threats was always bouncing around, starting when I was a graduate student at Berkeley and listening to the lunch discussion with Luis Alvarez at the Lawrence Berkeley Lab in his search to find out what killed the dinosaurs 65 million years ago," he said. Alvarez concluded that the

most likely cause of their extinction was a 10-km-diameter asteroid.

“I thought this was a perfect opportunity to talk about what humanity could do that the dinosaurs couldn’t,” said Lubin, who with researcher Alexander Cohen is an author of a paper currently in preprint on the Arxiv server.

Once in a While...We All Die

Planetary defense research thus far has considered asteroids and comets mostly in the range of tens of meters in diameter — such as 2012 DA14 (50m) that whizzed by on February 15, 2013, the same day that Chelyabinsk (20 m) exploded over a relatively sparsely populated area of Russia — to those of hundreds of meters in diameter, such as Apophis, a 370 m diameter behemoth that will come within Earth’s geosynchronous belt on Friday, April 13, 2029. Asteroid threats are more common than comet threats but both could end our species.

“'Planet killer’ events from asteroids and comets have happened to the Earth before and will happen again,” Lubin said. “We live in a dangerous cosmic neighborhood with frequent drive-by shootings that happen every day, though most simply burn up harmlessly in Earth’s atmosphere. But once in a while…we all die.”

An example most people slept through was a 1-km-diameter asteroid that passed close to the Earth on Jan. 18 of this year. Had it hit, the impact would have far exceeded the energy release of all of Earth’s nuclear arsenal. “Not a planet killer but a really bad day,” he said.

In his own research, Lubin and his group had submitted a set of papers on the defense of the planet from 20-1,000-meter asteroids mere weeks before the Netflix film’s Dec. 2021 release. The movie’s apocalyptic premise — a roughly 9-km-diameter comet with a six month window for humanity to save itself — got their gears turning.

“We applied the same basic technological basis for dealing with smaller threats and upscaled them to see if we could mitigate the much harder problem of an imminent existential threat that was depicted in the movie,” Lubin said. “For simplicity, we address a 10-km case for both a comet (fast and low density) and an asteroid (slower and higher density). Both cases would result in the extinction of the human race.”

Gonna Need a Bigger Bat

To defend the planet, one popular strategy has been to deflect these rocks in the hopes that they fall out of their trajectories and miss Earth, a scheme that would take years to centuries of warning to deploy any effective mitigation via deflection.

But we're not guaranteed a long warning period. Such was the case with NEOWISE, a 5-km-diameter comet that in July 2020 came close enough to see with the naked eye and which, due to its Sun-skimming orbit, was detected only four months earlier.

"That was actually the basis for the movie," Lubin said. "So this is not such a crazy scenario at all."

Ultimately, any effective strategy for defending the planet against cosmic rocks comes down to physics.

"Imagine you're playing baseball and someone throws a normal-sized baseball at you," Lubin said. "You have a bat and a way of protecting yourself." That would be analogous to our current asteroid deflection strategies.

"But now someone ups the game on the other side and says, 'I'm going to throw a bowling ball at you. But you have to use the same bat,'" he said. "And that's the problem with large threats if you try to use deflection. You need a really, really big bat to deflect the object." Add to that the very short timescale for response, and even with a big bat, deflection is not feasible, he said.

The strategy initially employed by the film's planetary defense space agency is one of deploying nuclear weapons, a plan you might remember from the 1998 films "*Armageddon"* and "*Deep Impact,"* in which bombs are sent into the incoming comet or asteroid in hopes that the explosion would both break up the cosmic colliders and send them careening away from Earth.

Such a strategy could work, but not as depicted in those movies, Lubin said.

For smaller asteroids (less than one km in diameter), Lubin's newest strategy, called PI (short for Pulverize It) sends penetrator rods to break the asteroid into fragments small enough (less than 15m diameter each) for the Earth's atmosphere to take the hit and vaporize the debris before it hits the ground. It is a very effective way of

neutralizing those cosmic threats, but is not a solution for the short warning time existential threats such as in "Don't Look Up."

What would work, Lubin said, would be to Pulverize It, utilizing the same penetrator rod strategy he developed for the smaller threats, but enhanced with nuclear explosive penetrators. Because the method can be deployed under very short response times, we'd have both the bigger bat and more precious time to deploy it far enough from Earth to give us a chance to survive.

"In cases like the one in the movie, what you want to do is intercept, fragment and disperse, but have the fragments miss the Earth completely," he said. An array of these nuclear enabled penetrator rods would be launched toward the asteroid or comet, fragmenting the outer layers first and working in toward the center, like peeling an onion.

"We start with the outer layers and break them apart, disperse them," he said. "And then we work inward until the whole object is fragmented…so they are dispersed with enough speed, and early enough so that they miss the Earth completely." In a situation such as the one in the movie, an interceptor mission *launched* four months before impact and actually intercepting one month before impact would be sufficient to disperse fragments away from Earth.

The Real Threat?

While we theoretically have the technology to defend ourselves from existential threats from 10 km comets and asteroids, getting our act together well in time to conduct this global concerted effort is another story — one hilariously told by the film. One obstacle would involve our uneasiness around nuclear weapons.

"This is a scenario where nuclear weapons could be used to actually save humanity rather than to destroy humanity," Lubin said. "What we often perceive as humanity's greatest threats (nuclear war) could be the salvation of humanity." Another potential quagmire would lie in the policy arena, in which we would have to face our own trust issues and priorities as we codify the use of nuclear explosives in space.

"I'm looking at it from a purely physics point of view," Lubin said. "Do we possess the technology to mitigate a threat like the comet NEOWISE, which could appear rapidly upon us? It's not so unrealistic. It's just that the idea of humanity going nuts

is probably also not unrealistic. But humanity does possess the ability to prevent our extinction by this threat if we were to handle it properly. Wisdom and crisis often do not go well together, however — we see this virtually every day where we are literally our own existential threat.”

For more information, see: www.deepspace.ucsb.edu/projects/pi-terminal-planetary-defense

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