Is Earth ready for an asteroid collision?

A space rock discovered in December 2024 caused quite some panic early this year as its likelihood of hitting the Earth rose to around 3%, the highest in the era of modern forecasting.

This asteroid named YR4 2024, was first detected by an observatory in Chile as it neared Earth. Asteroids, also known as minor planets, are rocky solar system bodies left over from the time when the Sun and planets formed some 4.5 billion years ago. While most asteroids revolve around the Sun in between the orbits of Mars and Jupiter, occasionally one of them can stray off course.

The chances of YR4 hitting Earth in December 2032 rose sharply and then dwindled down to practically 0 as astronomers collected more data on this space rock, which is estimated to be 40 to 90 metres wide. But even if this wasn't the case, experts believe we are now capable of averting such a disaster.

The only technique actually ever tested to deflect an asteroid involves smashing a spacecraft into the rock directly. Back in 2022, NASA demonstrated its ability to change the course of an asteroid by hitting Dimorphos, a moon rock orbiting another, larger minor planet.

When the Double Asteroid Redirection Test (DART) hit Dimorphos, the Hubble space telescope and several ground-based observatories saw material streaming out from it. The 160 metre-wide Dimorphos experienced a stronger push from the outflowing rubble, than the actual impact by DART. The mission successfully changed the orbit of Dimorphos by a significant 33 minutes, promising success in future endeavours of this nature.

But despite the initial success, scientists are aware of the extreme precision required to carry out such a task, because the smaller, disintegrated pieces from the asteroid may still turn towards Earth. Furthermore, complicated geopolitical trouble may be caused back home if the trajectory of the asteroid is changed, but just enough to alter its impact site from, say, New York to Moscow.

It may be possible to fly a spacecraft in close proximity of the asteroid, so it can use its own gravity to slowly tug the rock away from Earth, without making any contact. Since the mass of the spacecraft and asteroid are very different, this may require making several small changes to the orbit over a period of several months.

Graffiti and Mirrors

How about painting the rock? Astronomers have toyed with the idea of spray painting one side of the asteroid bright white to increase its reflectivity, which will slowly change its course. But this will require a long lead time of several months to years so that we can reach it in time to take necessary action.

That's why keeping an eye out for the potentially hazardous "near earth objects", solar system bodies such as comets and asteroids, which come closer than 50 million kilometres is so important.

Another technique following a similar concept is to fly a spacecraft close to the asteroid, such that the mirrors on the spacecraft can reflect excessive sunlight on one of its sides.

Image credit: nasa.gov

Lasers and Ion Beam

Shooting the asteroid with a spacecraft's thruster to slowly push it away is another method being examined. Rockets fly off from the Earth's surface using the same mechanism. In this case, though, an engine will be used to throw a beam of charged particles on the asteroid for a long time to push it away from Earth. A second engine will be required to prevent the spacecraft from moving too far from the rock as a reaction to the thrust.

Scientists are experimenting on how to use laser beams from one or more spacecraft to vaporise the surface of an asteroid. The underlying idea is that the ejected plumes will push away the asteroid in the opposite direction. Experiments conducted on marble-sized asteroids in the lab show that such a defence mechanism is feasible, and even more effective than a gravity thruster.

Nuclear Blast

Sending nukes into space may not be an ideal solution on various grounds, but possibly the last resort if an approaching asteroid is not detected soon enough, or, if all else fails. Demonstrations in the lab show that the X-rays from a strategically planned nuclear explosion near an asteroid will vaporise part of its surface, and move the rest of the mass away from Earth. Scientists are certainly not planning an extreme attack such as the one shown in the sci-fi movie "*Armageddon*", where a nuclear bomb is buried deep into the ground before detonation to maximise impact.

The downside of this violent defence technique is that there may still be active nuclear matter from the explosion, or the asteroid's ejecta, which turns towards Earth and causes further distress.

While scientists brainstorm, experiment and make suggestions, the final decision on strategies appointed for averting such a disaster depends upon the world leaders. It helps though to be well informed of the options at hand, as well as their shortcomings. NASA's database currently lists over 1.4 million asteroids ranging from over 500 kilometres to barely 10 metres in diameter. So in order to strengthen our planetary defence system, it is important to study the surface — composition, if it is rocky or amorphous, etc., along with the orbit and size of near-Earth objects.

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