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# Research on New Asteroid Defense Methods

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**Abstract:**

Asteroid Defense is the greatest challenge to the survival of mankind. The study of asteroid defense began in recent decades, and as more and more asteroids are found to have the potential to hit the Earth, humans are feeling the threat to their survival. This paper aims to propose a new method of asteroid defense. This paper discusses the dangers posed by near-Earth asteroids, such as thermal radiation, airbursts, earthquakes, and tsunamis. This paper outlines current defense methods, including changing the orbit of asteroids or destroying them. This paper discusses technologies such as dynamic pushback, kinetic impactors, and nuclear interception. In addition, the results of this paper show that particle accelerators are considered a potential solution to release huge amounts of energy to destroy asteroids. Building particle accelerators in space has advantages, but it also brings significant challenges. It needs to start doing it. It can't just leave the technology we have on paper.

**Keywords:** Asteroid defense; Building particle accelerators; New asteroid defense methods.

## 1. Introduction

The importance of asteroid defense goes without saying. About 65 million years ago, an asteroid slammed into the Mexican Yucatán Peninsula and Chicxulub crater, a violent collision that wiped out the dinosaurs. On February 15, 2013, an asteroid crashed into the Russian Chelyabinsk Oblast, an asteroid with a diameter of about 18 m and a mass of about 7,000 t exploded at a speed of 18.6 km/s at an altitude of about 30 km in the region, more than 1,200 people were injured and some $33 million was lost (based on national currency exchange rates as of 6 February 2013) [1].

This article discusses the advantages of building a particle accelerator in space and using the energy generated by particle collisions to intercept asteroids in Lenovo.

## 2. The Importance of Defense

### 2.1 Near-Earth Asteroid

In astronomy, asteroids with perihelion orbit within 1.3 AU (1 AU = 1.496 x 108 km) are known as near-Earth asteroids (NEA). As of March 7,2022,28,464, near-Earth asteroids have been found, including 10,024 more than 140m in diameter, 887 more than 1km, and 2,263 potentially dangerous. The near-Earth asteroids are dim, widespread, and difficult to detect, and the pull of large planets can easily change

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their orbits, and they may rendezvous with the Earth and impact it with a certain suddenness.

### 2.2 The Dangers of Near-Earth Asteroid

The near-Earth asteroid impacts will have different degrees of subsequent impacts, mainly involving three components: regional damage caused by air explosions or ground impacts, tsunami damage caused by ocean impacts, and global climate disruption caused by large-scale impacts. The specific forms of destruction are as follows:

1) Thermal radiation: An impact over a certain speed usually causes an explosion. There is a dissipation of energy as the near-Earth asteroid enters the atmosphere, and this energy releases heat radiation as it interacts with the Earth's atmosphere, potentially igniting material close to the point of impact, but its strength decreases rapidly as the distance increases. Thermal radiation comes in two forms: an opaque fireball and a more intense fireball when the intrinsic radiation of the fireball is released. On June 6, 2002, an asteroid approximately 10 meters in diameter struck the Mediterranean region and ignited in the atmosphere, releasing an energy equivalent to 26,000 tons of TNT, the energy from the impact was released as heat radiation [2].

2) Air Blast: The air explosion caused by an impact explosion can be divided into two phenomena: one is the pressure shock wave caused by the rapid expansion and compression of air during the explosion, and the other is the wind following the pressure wave, although most damage is caused by overpressure, objects with high resistance are particularly susceptible to strong winds. A Chelyabinsk event is 28-35 times more powerful than a Little Boy explosion.

3) Earthquake Impact: Large near-earth objects (Neos) larger than several hundred meters in diameter can cause significant seismic effects, which can be described by seismic measurements. Volcanic effects are also possible, although highly unlikely. The extinction of the dinosaurs.

4) Craters and spatters: Two different types of craters are defined, the so-called transient craters formed at the impact point and the final craters formed by the transient craters that subsequently collapse. Eligotegen crater, Russia.

5) Air Burst: the impactor reaches the ground as a whole, the impactor disintegrates and reaches the ground in several pieces, and the impactor disintegrates and explodes in the atmosphere. Whether and to what extent the impactor breaks up depends to a large extent on its composition. The existing models are complex and lack data, so it is difficult to predict (The Chelyabinsk incident).

5) Tsunami: More than 70 percent of the Earth's surface is water, so the chances of an impact occurring in the ocean are greater. Tsunamis can be characterized by 2 parameters, the height of the coastal tsunami wave and the distance from the coast to inland propagation. Since no global tsunamis have been recorded, all known models of the interaction of impactors with water at different depths are purely theoretical and contain many uncertainties. (The Chicxumberu Asteroid Impact: the impact triggered a tsunami about 1,600m high in the Gulf of Mexico).

6) Atmospheric pollution: large neos may affect dust and water vapour, ranging from local ozone depletion to conditions similar to the well-known"Nuclear winter", leading to mass extinction events. (The extinction of dinosaurs).

## 3. Defense Methods

Currently, there are two effective ways for humans to defend against asteroids: 1. Change the orbit of an asteroid away from the Earth. 2. Destroy the asteroid and break it up. Strategies for deflecting an asteroid include hitting it with a spacecraft (a kinetic impactor), pulling it with the gravity of a large spacecraft (a gravity tractor), exploiting the shock wave of a nearby nuclear explosion, and altering the surface or ablating it in various ways, including lasers or particle beams. Pulse methods, kinetic impacts, and shock wave deflections that alter the asteroid's orbit can have an immediate effect, whereas non-pulse methods may take years to accumulate sufficient deflections, so they need to find a dangerous object years before it threatens to collide with the Earth [3].

### 3.1 The First Scenario

1. There is a method called dynamic push-off, which is to anchor a thruster to the asteroid and push off through the asteroid's center of mass. There are three ways to deflect: 1. Spin and thrust 2. Direct propulsion 3. With precession and thrust, the thrusters can be used to spin the asteroid, but this can cause the asteroid to roll slowly, and this will require more control of the asteroid. In the case of rocky asteroids, they are made up of many small fragments that are loosely held together by weak gravity. When the thruster exerts a force on the rocky asteroid, as its rotation rate changes, its internal structure changes and it forms an extremely unstable object, there is a high risk that surface disturbances will damage the thrusters. In addition, when the asteroid re-enters equilibrium, due to morphological changes, the thrusters need to reposition the asteroid's center of mass and moment of inertia, this process may be more difficult for a non-rotating object (it is harder to find the center of mass of an inhomogeneous asteroid when it is not rotating). When the asteroid rotates, the direct propulsion at the poles of the axis of rotation is the constant

propulsion of the asteroid in inertial space in the same direction, although the total rotation rate of the asteroid will not change, its propulsion efficiency will be relatively small; When the rotation mode of precession and thrust is adopted, there will be a rotational moment acting on the whole spacecraft, so the attachment device is required to prevent the thruster from swaying.

2. Dynamic impactors are an easy way to mitigate asteroid damage: Objects transfer their momentum to asteroids by hitting them, and the collisions are modeled as simple Inelastic collisions. The change in the velocity of the asteroid resulting from the collision needs to be multiplied by a momentum enhancement factor resulting from the explosion of the material expelled during the impact. Using dynamic impactors to change the orbit of asteroids has its unique advantages: it can be launched quickly and has a high probability of success, in addition, this scheme must be the only one that has been verified in orbit, strategy. Therefore, for asteroids with long warning times, the dynamic impactor strategy is probably the most mature asteroid defense strategy. Of course, there are some problems with this strategy: 1 The necessary conditions for an effective impact are that the asteroid should not be too large or the warning time should be long enough, consideration should also be given to the fact that the rotation of the asteroid results in the convergence of the forces and the uncertainty in the direction of the forces; 2 medium-sized asteroids need to provide sufficient impact force and large dynamic impactors need to be sufficient to send them into an impact orbit, and advanced space technology, and the financial costs involved, and the need for a global monitoring network and international cooperation to respond to asteroids on time, it's going to take a long time to coordinate, and it's going to take a long time to put in place a comprehensive global monitoring system.

For example, NASA's dual asteroid reorientation test (Dart) mission (Figure [1]) will test the kinetic impactor concept for the first time. Although many studies have been conducted on asteroid reorientation and impact mitigation, none of the proposed concepts have been tested by missions to date. Impact studies of representative objects allow for the measurement of effects on target orbits and physical structures. To this end, the goal of DART is to validate the kinetic impact concept for planetary defense. The spacecraft used solar-powered electric propulsion to escape Earth, fly over (138971)2001 CB21 for maneuvers, and impact (65803) the Didymos system's secondary objects [4].

### 3.2 The Second Option

Nuclear interception technology is a relatively straightforward defense strategy, typically using nuclear devices to alter the trajectory of earth-threatening near-Earth asteroids, rather than destroying them directly through a nuclear blast. A direct nuclear attack on an incoming small body might shatter it, but the resulting mass of debris would still hit Earth on its original impact trajectory, setting off an even more catastrophic event.

The approach involves a series of small, ultra-high-speed kinetic energy penetrators (Fig. 1) that can break up and break up asteroids or small comets (commonly referred to as"Fireballs"). The material produced by decomposition is called"Debris". This method effectively reduces the threat by using the Earth's atmosphere to dissipate the energy of debris. It can intercept both in a short time and in a long time and can effectively deal with the great threat. Interceptor armour-piercing projectiles are deployed from land to outer space and then track the asteroid to smash it.

**Fig. 1 Potential approaches for dealing with asteroids [3]**

Existing methods of asteroid defense still have some limitations, so this paper proposes a new, more efficient, and potentially experimental way to intercept larger asteroids, this method not only makes up for the fact that it takes years to detect an asteroid with a nuclear bomb, unlike the emergency response with an electron beam or a laser, but also achieves a much greater impact than a nuclear bomb, the advantage of starting and firing at speeds comparable to lasers is particle collisions.

The largest explosive known to man is the Tsar H-bomb, which exploded with a force of 55 million tons of TNT, releasing an energy of about 2.1 x 1017 J of TNT and a temperature of 350 million degrees Celsius [5].

Let's say that the radius of an asteroid is about 100m. The density is $\frac{2.5g}{cm^3}$, According to $V=\frac{4}{3}\pi r^3$ calculate the size

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of the asteroid. So the mass of this asteroid is about $1.05 \times 10^{10}$ kg The average speed of each near-Earth asteroid is about 15.86 kilometers per second

According to $E = \frac{1}{2}mv^2$. So the kinetic energy of this asteroid is 1.32058 × 1018J, and it's not enough to destroy it with a tsar's h-bomb or some other explosive

As the name suggests, particle accelerators are used to accelerate particles, putting the particle accelerator together to make them collide, and that becomes a Collider. Its main principle is to use powerful electromagnetic fields to accelerate protons (or heavy ions) close to the speed of light and to collide them at precisely designed points of impact, creating extremely high energy conditions, to simulate the microenvironment after the Big Bang.

### 3.3 Energy Release From Particle Accelerators to Destroy Asteroids

The particles in the particle accelerator have to operate in a vacuum, so it's a good idea to imagine a pair of large hadron linear accelerators in a vacuum, where they can release two beams of hadrons, it can do this by changing the magnetic field and the electric field F=Qe. F=qvB to calculate their forces and then calculate their paths. To cause these two beams of hadrons to collide inside the asteroid it need to destroy, these two beams of hadrons collide and release 14 tev of energy (From the Large Hadron Collider LHC) which is $2.24016 \times 10^{20}$ J. The temperature could reach trillions of degrees Celsius at that instant, and the energy released by these two beams would be enough to destroy the asteroid, compared to the energy released by the Tsar's hydrogen bomb.

### 3.4 Interception Using Asteroid Orbit and Propulsion Technology

Then there's the other way, which is to capture small asteroids and control them, orbit them around the Earth, and put large thrusters on them, it can use both the Earth's gravity and the engine to accelerate the asteroid, and when it's fast enough, it can also intercept other asteroids in an emergency.

The advantages of building particle accelerator in space:

1. Reduce interference: Space is a vacuum environment, that can reduce the air or other matter to the movement of particles, thus improving the efficiency of acceleration.

2. Infinite Space: In Space, it can set up a larger accelerator structure, avoid space constraints on the ground, and be able to design longer acceleration channels to achieve higher energy.

3. Convenience of high-energy physics research: Experiments in space can reduce the Earth's gravity and environmental impact, making it easier to study some high-energy physics phenomena.

4. Cosmic Radiation Experiment: In Space, it can directly study the impact of cosmic radiation on the accelerator and its particles to provide data for the physics of the universe.

Building particle accelerator in space cons:

1. High cost: the cost of building and maintaining particle accelerator in space is very high, "Including launch, construction and operation costs

2. Technical Challenges: operating in space requires overcoming many technical challenges, including radiation protection, equipment reliability, energy supply and cooling systems. (the energy supply would be much smaller than on Earth, and the Linear particle accelerator would be built with electric fields in mind, not magnetic fields.)

3. Communication delays: there may be delays in communication with the ground control center, which may affect the real-time monitoring and adjustment of the experiment. Conducting operations on the space station

4. Manpower and maintenance: maintenance and repair in space is much more difficult than on the ground, posing a challenge to the handling of equipment failure. With modular equipment, only the broken parts need to be replaced

## 4. Conclusion

This article describes different kinds of asteroid interception methods, and studies have shown that particle accelerators can be constructed in a vacuum.

It is possible to achieve particle collisions in a vacuum, but very, very high precision is required. However, the approach presented in this article, advantages of this approach are greater than the traditional interception approach, where it can be implemented:

1. The launch can be started immediately within a short time. 2. High speed, high fault tolerance. 3. It is more powerful and easier to penetrate the asteroid and react inside it. This approach has some limitations and requires the ability to build particle accelerators in space. However, there are advantages to building particle accelerators in space. It can design a particle accelerator to be transported in segments, and then it can use two satellites to keep them in orbit and place a particle accelerator on each side of the Earth. For the energy supply, a large battery can be stored in the satellite, where solar panels are placed to recharge the battery. Overall, this study provides insights into new approaches to asteroid defense and provides basic ideas for future research and practice. Finally, it is hoped that this research will contribute to the development of related fields and lead to more meaningful discussions.

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