Apophis: Jurassic extinction vol.2, or an amusing stargaze?

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Abstract

65 million years ago, 77% of life on earth faced Armageddon in one of history's greatest mass extinctions due to a 15km asteroid strike. Dinosaurs never had space agencies, but humans do. Scientists were able to develop mechanisms for asteroid defense that can aid us when there is a fear of strikes in the shape of asteroids, which is what mankind will have to face by 2029 with Asteroid 99942 Apophis.

I. Introduction

Approximately 65 million years ago, an asteroid roughly 10 km in diameter hit the Earth with such a gigantic impact that it killed 77% of the species that were living on the planet then [1], including the beloved dinosaurs that fill fictional stories and tales. This was the most hazardous asteroid impact recorded in the history we know. Most recent asteroid impacts were the Tunguska impact that wiped out a forest in Siberia the size of Los Anglos in 1908, and the Chelyabinsk asteroid that caused significant damage to 7,200 buildings and injured over 1,500 residents in Russia 2013 due to its highly hazardous shockwaves caused by the explosions inside the asteroid due to its internal pressure. All of which takes us to our closest estimate of an asteroid impact, Apophis. Apophis, pronounced Uh-pu-fis, is an asteroid that caused loads of concerns since its discovery in December 2004 which will be discussed more in-depth in the rest of the article.

II. What is an Asteroid?

Before we unravel the threats caused by Apophis, some names have to be first clarified to avoid any confusion. Most people often mix up Asteroids, Meteors, Meteorites, Meteoroids, and Comets all together assuming they are just flying space rocks. But the fact is that they're different from each other in several ways and characteristics. [2]

Asteroids: An asteroid is a rocky or metallic object orbiting the sun with a diameter greater than 1 meter, most asteroids in the solar system lie between the orbit of Mars and Jupiter and are known as the asteroid belt, but a lot of asteroids tend to have different orbits that pass nearby our planet.

Meteoroids: A meteoroid is a rocky or metallic object in space smaller than 1 meter in diameter.

Meteorites: A meteorite is a meteoroid that makes it to the earth's surface.

Meteors: A meteor is the streak of light caused by a meteoroid burning due to its entry into the atmosphere.

Comets: A comet is an icy object orbiting the sun which usually spends most of its orbit outside the solar system making them far less hazardous than asteroids.

III. How often do NEOs hit the earth?

NEOs, otherwise known as Near Earth Objects, are meteoroids and asteroids orbiting in the solar system. And at some point, these objects tend to get uncomfortably close to our planet so they usually have to be tracked by scientists all around the world to keep taps on whatever may affect us. At a certain point when these objects are big enough to be considered as a potential threat, they are named PHA (Potentially hazardous object). But the question is, do all PHAs hit the earth? To answer this question, take a look at figure 1 and think to yourself, do they always hit the earth?

Smaller-sized NEOs typically hit the earth every day. At this particular moment, there is actual space

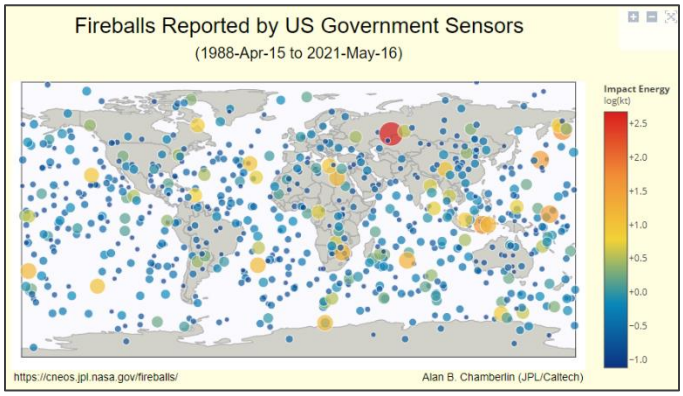

Figure 1: Fireballs reported and their impact energy

debris entering the earth varying in size from grains of dust to small rocky objects that may or may not burn in the atmosphere, which can be classified as PHAs. But how about the bigger-sized ones, maybe ones the size of the one that caused the Jurassic mass extinction? Due to the existence of the earth's best buddy, the moon, astronomers can study the history of meteor impacts and asteroids; that is due to the moon's surface which is filled with meteorite craters. And due to the absence of an atmosphere strong enough to cause weathering on the moon, these craters remain untouched from the moment the moon was formed. According to studies of craters around planet earth and on the moon, astronomers learned that Asteroids the size of the one that killed the dinosaurs usually tend to hit earth once every 100 million years on average. The ones the size of Tunguska impact tend to hit on average once every 200 years. And small asteroids like the one in the Russian impact of 2013 usually happen once every decade. But the question remains, what if an asteroid the size of Apophis -500 meters in diameter-approaches earth as a PHA, what can astronomers do in this situation?

IV. Asteroid Defense Mechanism and DART

A profound question: what if dinosaurs worked in space agencies that developed strategies to protect themselves from the asteroid mass extinction? Could they have saved themselves from ceasing to exist? As this is a profound question, it can't be answered. But what is known is that dinosaurs didn't even know they were going to meet their doom except when they saw a streak of light growing exponentially until it landed on earth and took out 77% of earth's species. So what if they had enough warning time, could they have used their natural instinct to run away from the asteroid?

Since humans aren't dinosaurs, humans do have a lot of working space agencies filled with brilliant minds that protect us from dangers similar to asteroid strikes, as well as tell us about the universe we live in. Scientists throughout the years have developed an Asteroid Defense Mechanism formed of five steps to protect mankind from such massive disasters.

i. Finding

Astronomers around the world tend to spend most time of their night gazing in the dark sky and studying it. You may think that every star you see in the sky is just different from the other stars in temperature, size, and distance from earth. But it's more complicated, from our dark sky we can see stars, asteroids, planets, nebulae, and a lot more. Asteroids tend to be moving a lot faster in our sky

relative to the rest of the celestials in the sky, which makes them appear to be moving while everything around them is still. Astronomers can find asteroids in our sky by looking out for an object moving while the rest of the stars around them are still in the frames they capture by telescopes. As shown in figure (2).

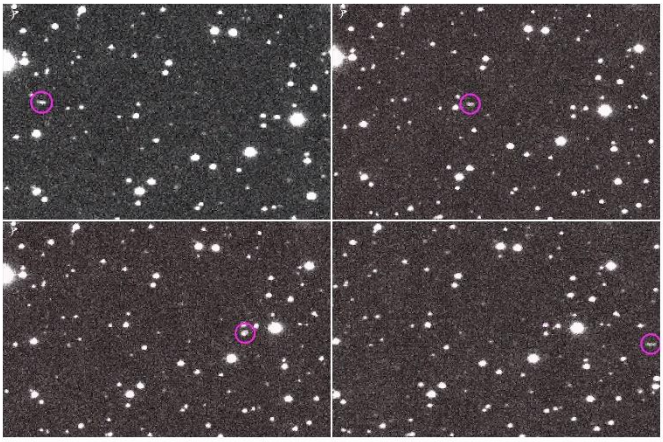

Figure 2: An asteroid in the sky

ii. Tracking:

After an observer has found a NEO in the sky, it is sent to the IAU (International Astronomy Union) to the minor planet center where the data is published for other observers around the world to keep track of the asteroid in the sky using radar to determine the distance between the earth and the asteroid, and taking multiple observations to calculate the asteroid's orbit using Kepler's laws.

iii. Characterizing:

Several methods are used to determine the characteristics of the asteroid -spin rate, chemical, and physical properties, and whether it is a single or a binary pair. –

From these methods are:

Brightness vs. time: it is a method to observe the brightness of the asteroid over time to determine the physical properties of the asteroid using its reflective ability as shown in figure (3).

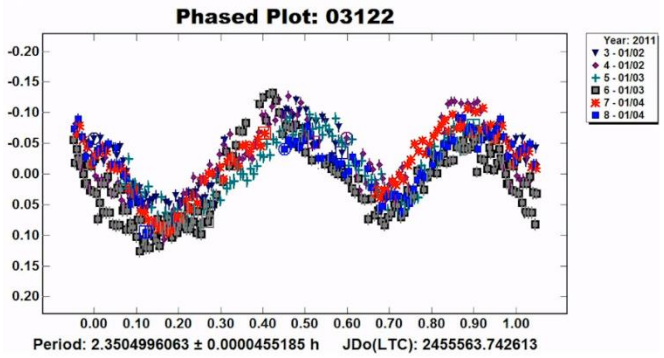

Figure 3: Brightness vs. time graph

Spectrographs: According to the chemistry of any element, each element absorbs certain bands of the light spectrum which can tell us about the elements inside the asteroid as shown in figure (4).

Radar: To determine the distance between the Earth and the asteroid.

Thermal infrared imaging: To determine the temperature of the asteroid.

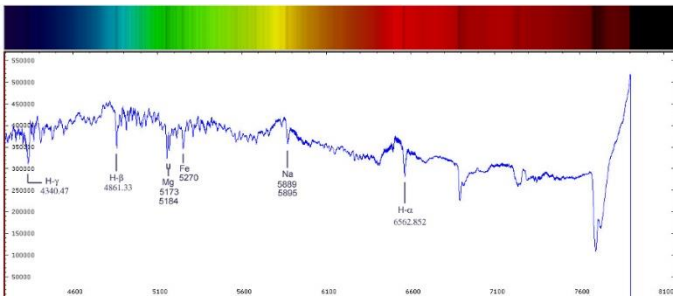

Figure 2: Spectrograph of an asteroid

iv. Deflecting:

After being able to find, track, and study the details of an asteroid, if it was assumed that a certain asteroid may resemble a threat to earth, how can this situation be dealt with?

Astronomers have developed several methods to deal with this type of situation if we have enough warning time before the asteroid strike:

Kinetic impactor: it is a system launched from the earth to strike the asteroid in just the right amount of kinetic energy to be able to change its orbit around the sun to push it away from the earth and prevent the Earth gravity to pull it down and strike the earth.

Gravity tractor: it is a system that works with only smaller-sized asteroids by revolving around the asteroid and affect its gravitational field according to Newton's universal gravitational force law and change its orbit around the sun to push it away from the Earth.

Let us assume we don't have enough warning time, what can be done at this particular instant?

Usage of nuclear weapons to destroy the asteroid is one of the most effective methods but it's politically challenging for space agencies to use such a dangerous method and avoid the concern of where the asteroid remains would go. The usage of powerful lasers to blow up the asteroid is also considered an effective method.

None of these methods have been tested before, but the first asteroid deflecting kinetic impactor experiment (DART Mission) will be launching in November 2021.

v. International Coordination:

Asteroid Deflection is a very serious step to establish, let's say that an asteroid is estimated to land somewhere in the state of New York in the United States, but the asteroid gets deflected by a kinetic impactor to change its landing site to Toronto in Canada; the Canadian government is not going to be happy. This is why International Coordination between space agencies worldwide is a must in these situations.

V. Where does Apophis stand here?

Apophis -otherwise known as 99942 Apophis- is an asteroid estimated to be 340 meters in diameter, since its discovery in 2004 it has raised a lot of concerns throughout the media due to its extremely close approach to earth in a couple of years. On 13 of April 2029, Apophis is going to be 30,000 Kilometers away from earth, about 10 times closer than the moon, closer than Earth's geostationary satellites, and will be seen by the naked eye in the sky. Apophis is a name from Egyptian Mythology where Apophis was the mortal enemy of Ra' the sun god. Apophis was thought to bring eternal darkness every night on Earth until Ra' defeats him at sunrise, thus bringing Earth back to light. Imagine how deadly this asteroid may have been if named after eternal darkness? Studies have shown that if Apophis were to hit Earth it would cause destruction extending for hundreds or thousands of kilometers with a strike the power of 1000 megatons of TNT. For a while, Apophis has been thought of as the Jurassic Impact vol.2 and the beginning of the end of the human era. Thanks to NASA's brilliant minds, a deep analysis has been formed on Apophis using the Asteroid Defense Mechanisms which is being updated monthly. [3] NASA was able to determine the precise orbit of Apophis approaching Earth as shown in figure (5).

Calculations done by JPL (Jet Propulsion Lab in Caltech) show that there would be a 2.7% possibility of an impact in 2068, but it was quickly ruled out after doing more calculations. [4] However, there are thousands of external sources that may affect the orbit of Apophis in the slightest move, causing an error in these calculations. What makes us sure that another massive object in the solar system won't affect Apophis with gravitational energy causing a change in orbit? Or a possible natural kinetic impactor such as a small-sized asteroid causing a

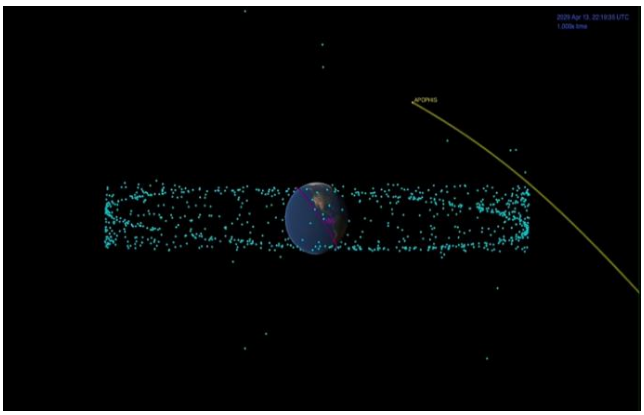

Figure 3: The orbit of Apophis (NASA)

slight change of orbit? There are endless possibilities for this particular situation. That's why the Asteroid Defense Mechanisms have been in continuous development in the past years, to protect mankind

from armageddon caused by asteroids. The planetary society organization has partnered up with the International Astronomy Union to give annual grants for Shoemaker NEO Trackers that track asteroids every night to aid the Minor Planetary Center in establishing the Asteroid Defense Mechanism system. Shoemaker NEO Trackers are amateur and professional Astronomers who designate their time at night tracking Near Earth Objects and Potentially Hazardous Objects such as Apophis, like the night guards of planet Earth, they provide a huge amount of data every night to the International Astronomy Union. Thus, protecting planet Earth from Apophis and other PHOs. Apophis isn't the only PHO in our solar system, estimates from the IAU show that there are about 3,400 PHOs in the solar system and thousands more that haven't been discovered yet.

VI. Conclusion

Awareness needs to be raised regarding Asteroid Defense Mechanisms and how scientists can contribute to providing a safe life for mankind. Also, more funds need to be given to space agencies to develop their strategies of Asteroid Defense, if fear strikes at any time, space agencies coming together will be our only hope.

VII. References

[1] D. P. B. Paul B. Wignall, The end-Triassic and Early Jurassic mass extinction records in the British Isles, Leeds: Science Direct, 2008.

[2] R. A. Freedman, Universe, San Diego: W.H. Freeman, 2009.

[3] I. J. O. a. J. Handal, NASA Analysis: Earth Is Safe From Asteroid Apophis for 100-Plus Years, California, 2021.

[4] D. J. T. a. F. B. a. K. P. R. A. Tucker, "Database of Apophis by JPL," California, 2005.