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A1 4 It's Blind of a Funny Story

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Abstract

In this paper we analysed the observational abilities of the astronomers in the film 'Armageddon', where they only identify the asteroid hurtling towards them 18 days before its impact. We found that based on existing infrastructure at the time, they should have had over 6.6 years of notice in order to formulate a response. Additionally, modern technology would spot the asteroid with up to $70,000$ years' notice.

Introduction

The Earth is under constant risk of colossal destruction in the form of an impact with an incoming object such as an asteroid. These objects are classified as PHAs (Potentially Hazardous Asteroids [1]) and the scenario of one of these being a threat to the Earth is the plot of 1998 film 'Armageddon' [2]. This paper is a continuation in a series of articles analysing the film and the scientific potential of its events [3]. In the film, the asteroid (previously established to have a diameter (D) of 1250 km [3]) was first observed eighteen days before it was projected to impact the Earth. The authors of this paper seek to determine realistically when this object would first have been observed and thus how much time they would have had to react.

NEAT Capabilities

Between 1995 and 2007, NASA had a project watching the skies for PHAs, called NEAT (Near Earth Asteroid Tracking) [4]. This project would have been active in 1998, when the film is set, and its arrays of observatories should have been able to view the asteroid. The smallest observable resolution is defined by the 'minimum visual angle' ($\theta = 2\tan^{-1}\left(\frac{D}{2s}\right)$) and can be derived geometrically (See Figure 1).

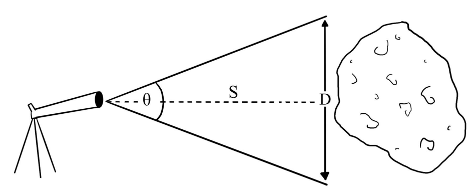

Figure 1: Diagram illustrating how the visual angle is calculated for a telescope and asteroid.

Rearranging this gives us:

$$s = \frac{D}{2\tan\left(\frac{\theta}{2}\right)} \quad (1)$$

Using D as the diameter of the asteroid (stated above), we can also use θ of our optics system to find the maximum distance (s) a target body (in our case, the asteroid) is visible at. The human eye has $\theta \approx 28$ arcseconds [5], giving $s \approx 9.2\times10^6$ km. The asteroid is stated to be travelling at a velocity (v) of 22,000 mph ($\approx$ 9.83 km/s) [2]. From $s = vt$, its distance (s) at a travel time of

18 days (t) is $\sim 1.5 \times 10^7$ km away at its first sighting. This means the human eye would be able to spot it when it was ~ 10.8 days away (using $t = s/v$). Using the Rayleigh Criterion: $\theta \approx 1.22\frac{\lambda}{d}$ [6], we can calculate the notice the NEAT telescopes would have given. For a wavelength of visible light (approximating $\lambda = 500$ nm), and a circular aperture of diameter (d) = 1 m, we get $\theta = 0.126$ arcsec. This translates to a distance of $\sim 2.0 \times 10^9$ km. At this distance, the asteroid would have been over 6.6 years away.

Contemporary Technologies

Extrapolating further, with the advancements in technology, a contemporary scientist would get an even greater notice. The Global mm-VLBI Array currently has the highest angular resolution. It has an effective aperture size around the same length as the distance between the Earth and the moon, and boasts an angular resolution of $\theta = 12 \times 10^{-6}$ arcsec [7]. This gives us a maximum distance of $s = 2.1 \times 10^{13}$ km, and a warning time of almost $70,000$ years; ample time to react.

It is also worth discussing at what point these observers would know that this asteroid was a threat. A PHA is defined as being over 140 m in diameter (ours is almost $10\times$ this), and having a Minimum Orbital Intersection Distance (MOID) - the point of closest approach - of within 0.05 AU of Earth. Our body fulfils this as a collision with earth means its MOID is 0 AU. It also needs an absolute magnitude (M) of 22 or brighter [1]. In order to confirm that we meet this third requirement, we take the following equation [8]:

$$D = 10^{3.1236 - 0.5log_{10}(a) - 0.2M} \tag{2}$$

Rearranged for M:

$$M = 5\left(3.1236 - 0.5log_{10}(a) - log_{10}(D)\right) \tag{3}$$

In previous papers [3], we determined the asteroid to be S-complex, a stony asteroid type which has an average albedo (a) of 0.26 [9]. Therefore, we can find the absolute magnitude of our asteroid to be: $M = 1.6$, much brighter than is required for classification as a PHA. It can thus be seen that the film is incredibly inaccurate in this regard. The 18 day notice period is scientifically unsound, and only getting more so with increasing technological advancements.

Conclusion

In conclusion, the astronomers in the film Armageddon should have identified the asteroid as a threat long before they did, as there was existing infrastructure (such as NEAT) and classifications for bodies which easily fit this asteroid's description. These establishments should have seen the body over 6.6 years before it impacted, giving much more time to react than the 18 days in the film. Should the scenario depicted in the film occur today, then the infrastructure will be capable of detecting the threat long before it posed any danger.

References

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