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P3 4 Tipler and Mosca Killed the Dinosaurs

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Abstract

We explored a hypothetical scenario to evaluate the number of copies of *Physics for Scientists and Engineers 6th (sixth) Edition* by Tipler, P. A. and Mosca, G. required to generate an impact equivalent to the asteroid event that caused the mass extinction of the dinosaurs. Our findings estimate that 17.41×10^{15} copies are required to match the asteroid's impact. Assuming an average cohort of 100 first-year Physics students, it would take the University of Leicester 174.1 trillion years to distribute this many books.

Introduction

It is well known that dinosaurs went extinct around 65 million years ago [1] as a result of a hyper-velocity asteroid impact in the Gulf of Mexico. We find how many joined hard-cover copies of *Physics for Scientists and Engineers 6th (sixth) Edition* by Tipler, P. A. and Mosca, G. would be required to cause an equal level impact and wipe out the dinosaurs.

This specific textbook was chosen not only for its recognition in the physics community but largely due to its reputation for being notably heavy.

Background

The Chicxulub crater is one of the largest impact structures on Earth. Scientists recognise this impact as the trigger for the Cretaceous-Tertiary (KT) mass extinction event, which abruptly wiped out the dinosaurs and much of Earth's life. It is documented as a hyper-velocity impact producing a crater with diameter of 180 km [1]. An illustration of the impact crater is given in Figure 1.

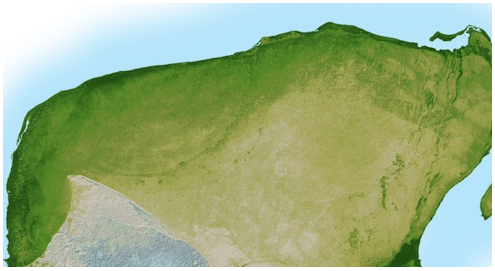

Figure 1: Illustration of Mexico's Yucatan Peninsula providing a glimpse of the Chicxulub impact crater in the upper left corner.[2]

Melosh Crater-Scaling Law

The Melosh crater-scaling law estimates the diameter of an impact crater by relating it to the impactor's size, density, velocity, impact angle, and the target surface's properties [3]:

$$D_{tc} = 1.161 \left(\frac{\rho_p}{\rho_t}\right)^{\frac{1}{3}} L^{0.78} v_i^{0.44} g^{-0.22} \sin^{\frac{1}{3}} \theta \quad (1)$$

Where D_{tc} is the diameter of the crater at the level of the original ground surface, ρ_p and ρ_t are densities of the projectile and target, respectively, g is the surface gravity, L is the projectile

diameter, v_i is the impact velocity, and θ is the impact angle from the horizontal.

Knowing only the crater diameter leaves several unknowns in the analysis; however, these variables are well-documented. The globally averaged impact angle, θ, on a planet will always be equal to 45° [4]. The projectile density, ρ_p is set at 2700 kg m^{-3} [5], reflecting the density of S-type (stony) asteroids, most common impactors for the inner planets.

The surface gravity, g, on Earth is 9.81 m s^{-2} and the target density, ρ_t, is the crustal density of Earth in the Gulf of Mexico, which corresponds to the typical oceanic crust density of 2840 kg m^{-3} [6]. Finally, the impact velocity, v_i, was around 25 km s^{-1} for the Chicxulub impact [7].

Calculations

Rearranging the Melosh scaling relation to calculate the projectile diameter:

$$L = \left(\frac{D_{tc} g^{0.22}}{1.161 \left(\frac{\rho_p}{\rho_t}\right)^{\frac{1}{3}} {v_i}^{0.44} sin^{\frac{1}{3}}(\theta)} \right)^{\frac{50}{39}} \quad (2)$$

Substituting the values, the projectile diameter, L, is calculated to be 33.6 km. Assuming that the asteroid was a perfect sphere with a diameter of 33.6 km, gives the volume as 19.86×10^{12} m^3. Using the asteroid density previously stated, $\rho_p = 2700$ kg m^{-3} and re-arranging the density equation to find mass:

$$m = \rho V \quad (3)$$

The mass of the asteroid is calculated to be 53.63×10^{15} kg. Therefore, to calculate the number of textbooks needed to wipe out the dinosaurs, simply divide this mass by the weight of a single copy. The weight of one single copy is 3.08 kg [8], giving a result of 17.41×10^{15} copies.

Conclusion

We demonstrated the scale of the impact event that led to the extinction of the dinosaurs by calculating an equivalent scenario using copies of *Physics for Scientists and Engineers 6th (sixth) Edition* by Tipler, P. A. and Mosca, G.

By applying the Melosh crater-scaling law and known parameters of the Chicxulub impact, it is found that a total of 17.41×10^{15} copies combined hitting the Gulf of Mexico at 25 km s^{-1} is required to produce an impact of equal magnitude. The number of copies is unfeasibly large; it would take the University of Leicester, distributing one copy per first-year Physics student (assuming an average cohort of 100 students), 174.1 trillion years to hand them all out.

References

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