Journal of Physics Special Topics
An undergraduate physics journal

P2 2 Cosmog's Nebulous Evolution

E. Rowlett, C. Corbett, I. Kaur

Department of Physics and Astronomy, University of Leicester, Leicester, LE1 7RH

October 29, 2024

Abstract

This paper explores the feasibility of the mass gained during Cosmog's evolution to Cosmoem evolution being converted directly from energy. We determined that this would cool a volume of air almost 300 m above Russia by 15K, a significantly large amount, suggesting that energy is not converted directly to mass.

Introduction

Cosmog, a creature from the Pokémon series, is incredibly lightweight and reminiscent of a galactic nebula [1]. Upon "evolution", which is a process resembling rapid metamorphosis into a new form, Cosmog becomes Cosmoem, based on a neutron star [2]. This form change involves a drastic increase in mass, and this paper investigates whether Cosmog could have gained this mass using the mass-energy equivalence, absorbing the energy from its surroundings.

Theory

We propose that Cosmog may gain mass upon evolution by converting energy directly into mass. It coudld achieve this using the mass-energy equivalence. Einstein's mass-energy equivalence equation [3] is as follows:

$$E = mc^2, \tag{1}$$

Knowing the mass of Cosmog ($M1$) and the mass of Cosmoem ($M2$), we can say that the required energy needed as an input is given by:

$$\Delta E = (M2 - M1)c^2 \tag{2}$$

Assuming that this energy is entirely thermal, we can use the specific heat equation [3] to find the temperature difference of a given environment after evolution:

$$\Delta Q = MC\Delta T \tag{3}$$

Where ΔQ is the difference in heat in the environment, M is the mass, C is the specific heat, and ΔT is the change in temperature. Rearranging this for the change in temperature:

$$\Delta T = \frac{\Delta Q}{MC} \tag{4}$$

It is assumed, for the sake of simplicity, that the heat is "absorbed" uniformly across the entire volume of the environment, disregarding thermodynamic processes.

Results

Cosmog's mass ($M1$) is 0.1 kg [1], and Cosmoem's mass ($M2$) is: 999.9 kg [2]. Calculating the mass difference, we find that ΔM is 999.8 kg. This is Cosmog's mass gain upon evolving into Cosmoem. Substituting into equation (2), we find that the total energy input required is 8.986×10^{19} J.

This is a vast amount of energy, equivalent to over 21,000 Megatons of TNT [4]. Despite this, we will still assume an evolution environment of an insulated room filled with room temperature air, with dimensions of 10 m / 10 m / 3 m. This gives us a volume of air of 300 m^3.

The density of air is 1.225 kg m^{-3} at sea level and has a temperature of 288 K [5]. Multiplying this by the volume, we have a mass of air of 367.5 kg. Additionally, the isobaric specific heat at room temperature is 1006 J kg^{-1} K^{-1} [6]. Substituting our found values into equation (4), we calculate a change in temperature of -2.431 $\times$ 10^{14} K. This is an impossible result, as temperature cannot be reduced below 0 K. Because of this, we instead calculate the volume of air that would have its temperature reduced from room temperature to freezing, 288 k to 273k.

To do this, we rearrange equation (3) to make mass the subject:

$$M = \frac{\Delta Q}{C \Delta T} \tag{5}$$

By substituting our values into equation (6), with an assumed temperature difference of 15 K, we find that the mass of air cooled down is 5.95 $\times$ 10^{15} kg, which is equal to a volume of 4.86 $\times$ 10^{15} m^3. To put this volume in context, treating this as a prism of air above the largest country on Earth, Russia, with a land area of over 16 million square kilometers [7], the calculated height is 296.7 m.

Discussion

The amount of energy absorbed is so large that we decided to simplify the process of absorbing energy into Cosmog. By assuming that the energy is conducted through the surface of Cosmog due to a temperature difference, we calculate a value for the thermal current required. In Pokemon Sun and Moon, Cosmog's introduction to the series, evolution takes roughly 15 seconds to occur [8]. Thermal current is given by:

$$I = \frac{\Delta Q}{\Delta t} \tag{6}$$

Where I is thermal current, ΔQ is change in energy and Δt is change in time. Therefore we find that the value of thermal current required for this to be 5.991 $\times$ 10^{18} J s^{-1}. The required thermal current is the equivalent of absorbing the energy of 1,400 megatons of TNT each second [4], which is an absurdly high amount.

This evolution requires enough energy to cool down the air from surface level to almost 300 m high above Russia from room temperature to the freezing point of water. This is a significant enough result that we do not believe the evolution could occur in this manner.

Conclusion

We find that it is extremely unlikely that Cosmog could gain sufficient mass to evolve solely through energy-to-mass conversion, as the amount of energy absorbed is too high, and the rate at which that energy is absorbed is also very high. It is far more likely that the mass is gathered in some way, rather than being created from the absorbed energy.

References

[1] `https://tinyurl.com/59nhyks8` [Accessed 15th October 2024]

[2] `https://tinyurl.com/4x37cdve` [Accessed 15th October 2024]

[3] P. Tipler, G. Mosca, PHYSICS for scientists and engineers, 2008

[4] `https://tinyurl.com/4s63cumm` [Accessed 15th October 2024]

[5] `https://tinyurl.com/jbkpcj57` [Accessed 15th October 2024]

[6] `https://tinyurl.com/yvdzascr` [Accessed 29th October 2024]

[7] `https://tinyurl.com/mum7fhfu` [Accessed 29th October 2024]

[8] `https://tinyurl.com/4fkw3r57` [Accessed 15th October 2024]