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Is Pokémon Evolution Dangerous?

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Abstract
This paper will look at the effect of Pokémon evolution using Einstein's equation for mass-energy equivalence, $E = mc^2$. The energy required to create the mass gained by a Pokémon in evolution will be calculated and compared to some real world energy values for perspective. The specific examples analysed in this paper are the evolution of Magikarp and the mega evolution of Rayquaza.

Introduction
The franchise "Pokémon" has been a staple of popular culture for many years, starting out as 2 video game titles in 1996 and later branching out into anime, spinoff games, a trading card game, books and toys. A major component of this universe is Pokémon "evolution" in which, under specific conditions, a Pokémon will change its morphology to a more mature form.

More often than not an evolution will involve a gain of mass which for the purposes of this article will be assumed to be instantaneous. Although in the video games the evolution animation takes varying amounts of time, this paper will assume that all energy absorbed at the instant that the Pokémon's form changes. The Youtube channel "The Game Theorists" made a video in 2016 discussing a theory of how this mass gained in evolution could be gathered [1]. A brief overview of the approach is that the ratios of elements that make up a Pokémon, in this case Magikarp, were calculated. The quantity of each of these elements needed to make up the mass form are then assumed to be pulled from the nearest available source [1]. This approach is flawed in that it equates the composition of Magikarp to that of a real world fish and then assumes Gyarados is composed of the same ratio of elements despite its vastly different morphology.

This paper aims to discuss an alternative and more true-to-the-universe approach to explain how this mass deficit is met. When a Pokémon evolves in the main series games it is accompanied by a large flash of light. This leads to the assumption that Pokémon use mass creation from photons to make up the mass deficit caused by evolution.

Two specific examples will be discussed; Magikarp and the mega evolution of Rayquaza. These Pokémon have been chosen as they both have very significant mass gains when they evolve.

Calculations
The energy needed to gain the mass to evolve can be quantified using the equation for mass-energy equivalence, equation 1 [2]:

$$E = mc^2. \quad (1)$$

In reality it would not actually be possible to simply create the required matter in the manner proposed, but for lack of a better approach this will be overlooked.

The next step is finding the masses of the target e 1. This gives a mass increase on evolution of 225 kg and 185.5 kg for Magikarp and Rayquaza respectively. Although Rayquaza has a smaller mass change, it evolves through mega evolution which reverses after the battle in which it is triggered. This means that the energy it takes in to evolved will then all be instantaneously released afterwards, adding an interesting dynamic to the discussion.

Name	Mass (kg)
Magikarp	10
Gyarados	235
Rayquaza	206.5
Mega Rayquaza	392

Table 1 – The masses of the 4 Pokémon being investigated in this paper. Masses were taken from the 7th generation pokedex entries as listed on [3]. The values are assumed to be averages for the species to account for natural variation.

Using equation 1 with $c = 3.000\times10^{8}\ ms^{-1}$ [2] this gives the total energy required as 2.025×10^{19} J, or 2.025×10^{10} GJ, for Magikarp and 1.670×10^{19} J, or 1.670×10^{10} GJ, for Rayquaza. Kashiwazaki-Kariwa Nuclear Power Plant, the largest nuclear power plant in the world now since closed, produced 8,212 MW, 8.212×10^{9} W, of power [4]. It would take this power station 2.466×10^{9} s which is equivalent to 78.2 years to produce the energy required for the Magikarp evolution.

Assuming this energy is from photons as discussed in the introduction a source of photons must be found. During daytime hours the Sun will be assumed to be the primary contributor of photons for evolution with other light sources being negligible. This also makes sense thematically as large portions of all Pokémon games are spent on unlit routes away from civilisation.

The solar constant is the power deposited by the Sun per unit area at a distance of 1 astronomical unit, the average distance between the Sun and the Earth. The value of this constant is 1368 Wm^{-2} [5]. This value can be multiplied by half of the total surface area of the Earth, assuming half of the Earth is receiving the Sun's light at any one time, to calculate that the Earth receives $3.4884\times10^{19}\ Js^{-1}$ from the Sun. This is approximately 58% of the total energy the Earth receives from the Sun in a single second based upon the calculations above. This includes all forms of radiation from the Sun, not just visible light.

The effect of such an event would not be anywhere near as damaging as one might expect. At most there would be a small amount of confusion as the Sun appears to flicker out briefly but nothing more would come of it [6]. This could become more of a problem potentially when the rest of the Pokémon population of the planet is accounted for but since there is no value for the rate at which Pokémon evolution occurs globally it would be impossible to calculate exactly. Given that the majority of Pokémon gain significantly less mass than this when they evolve the majority of evolutions would have a much lesser effect than that calculated for magikarp. It should also be considered that different species evolve under different conditions and appear in the wild with different frequencies. Some evolutions are even tied to locations within the games such as Mount Coronet, Charge Cave and the Icy and Mossy Rocks in various games [3]. This could lead to such locations becoming hotspots for natural evolution of Pokémon, making these regions spend much more time in the dark than the rest of the world.

Mega Evolution

Mega Evolutions add an interesting dynamic to the Pokémon evolution theory in that they undo after a battle ends causing all energy absorbed for the initial mass gain to be released again.

While Rayquaza's mega evolution would require less energy for the mass gain than the Magikarp evolution, the reversion after the battle would mean that the 1.6695×10^{19} J that went into the mass creation will all be released suddenly back into the environment. To put this in perspective the nuclear bomb used in Hiroshima generated 52×10^{12} J of energy through the nuclear fission within it [7]. Rayquaza reverting its form back would release over 321,000 times this energy, more than enough to erase a city.

Conclusion

The calculations carried out in this paper could be interpreted one of two ways. Firstly, they could be taken as proof that Pokémon evolution is physically impossible in the real world. Assuming that Pokémon existed it could be concluded that as long as many Pokémon do not evolve at once, the photons taken to make up the mass deficit would be more of an inconvenience causing semi regular, large area blackouts. On top of this mega stones should be considered to be weapons on par with nuclear bombs and prohibited from use.

References

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