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P4 1 Lightning in Inazuma, the Devastation of the Musou no Hitotachi

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Abstract

We examine Genshin Impact's Raiden Shogun's ability to split a mountain in half and simulate the resultant plasma that would have flooded the region of space left behind by the mountain. The paper calculates, the required energy to split the mountain in half, 1.7×10^{23} J, however, the goal of this paper is to simulate the behaviour of the column of gas between the two halves of the mountain. The explosion that would have arisen in such an event is beyond the scope of this study. We find there would be significant lingering damage as the column would have reached peak temperature of 2.1×10^{8} K and a pressure of 3.5×10^{7} Pa.

Introduction

Genshin Impact is set in Teyvat, a continent comprising many regions. We focus on Inazuma, a nation inspired by Japan, where the archon (god) Raiden Shogun rules. She defeats an opposing god using the 'Musou no Hitotachi' (an attack) which is able to split a mountain, Mt. Yougou (see Figure 1), in half. We modelled what would happen to the gas that flooded the area after the mountain was split.

Figure 1: Mt. Yougou after being split [1]

The Geography of Teyvat

In-game distances are not specified, however a character reveals that the distance between two locations, Liyue Harbour and the Guili Plains is 96 km [2]. Adjusting for the game's time progression, which is 10 times faster than the real world, we deduced in-game distances by using speed, distance and time to calculate a character, Yae Miko's travel speed (8.3 km/s). Yae Miko has been used to establish in game distances as different characters move at different speeds. We were able to use her speed to work out the dimensions of any land-based area by timing how long it took her to walk from one point to another.

The Musou no Hitotachi

To work out the minimum energy required to split Mt. Yougou in two we found that its volume, V, was 1320 km$^3\pm10$ by modelling the mountain as a cone with a height given by 3700 m by using Mt. Fuji as an analogue [3]. The 'Musou no Hitotachi' has a duration of 2 seconds [4], and the distance, d, between the two halves of Mt. Yougou is $\approx$18.3 km$\pm$2. Since Mt. Fuji is a basaltic stratovolcano [3] we used the average rock density, ρ, of basalts of 3000 kg/m^3 [5].

Modelling the system as if a constant force is being applied to push the halves apart over the duration of the strike, using Newton's first law, and using the fact that the initial velocity of the mountain would be zero, it can be found that the velocity, v, is,

$$v = at = \frac{Ft}{m} \tag{1}$$

Using SUVAT, the Force can be written in terms of distance, d,

$$F = \frac{2dm}{t^2} \tag{2}$$

Therefore Equations 1 and 2 can be substituted into the kinetic energy equation such that,

$$E = \frac{1}{2}mv^2 = \frac{1}{2m}F^2t^2 = \frac{2md^2}{t^2} = \frac{2\rho V d^2}{t^2} \tag{3}$$

Using Equation 3 we found the energy to separate one half was 8.3×10^{22} J (half the volume and distance is used).

$$E = \frac{3}{2}RT_{avg}N_{mol} = \frac{3}{2}RT_{avg}\frac{V}{\beta} \tag{4}$$

We assume Teyvat's atmosphere mirrors Earth's and model it monatomically. E is the energy to separate both halves (1.7×10^{23} J), N_{mol} is the number of moles, T is the temperature of the air, R is the gas constant, and β is the number of nitrogen moles per cubic m (0.02 mol/m^3 [6]). The average temperature (T_{avg}) of each mole of gas is $\approx 2.1\times10^8$ K.

$$E_{avg} = \frac{3}{2}k_BT_{avg} \tag{5}$$

Using Equation 5 (where k_B is the Boltzmann constant) we find the energy of the atoms is $\approx$27 keV. This is greater than nitrogen's ionisation energy which is 14.5 eV [7], and this implies the column becomes a plasma.

We simulated the system using a simplified 2D model that demonstrates how quickly the plasma dissipates and how its temperature and pressure changes over time in a slice of the cone. The simulation (Figure 2) accounts for diffusion, convection, turbulence and any pressure gradients. Diffusion is modelled by considering temperature differences between grid cells, the convection by considering temperature differences in the y-direction, turbulence by introducing a random component to velocities and temperatures based on the temperature's relative magnitude to the ambient air temperature, and the pressure by changing the temperature of surrounding cells based on any pressure gradients present (decrease in temperature under the presence of a positive pressure gradient).

Our model demonstrates a significant amount of lingering damage even 24 hours after the mountain was torn in two. The existence and dissipation of the plasma would devastate the surrounding flora and fauna, burning anything that lingers after the explosion. Using the model, we find that the peak plasma pressure is 3.5×10^7 Pa.

Conclusion

Raiden's Musou no Hitotachi was very effective against foes, but it posed risks to her own country. Our simulation does not examine the devastation wrought by the explosion which would be more significant than that of gas entering into the region where the mountain once stood. Nonetheless, our simulation demonstrates the extreme heat, pressure and damage left by the column, and we would ask Raiden to consider a level of restraint in future fights.

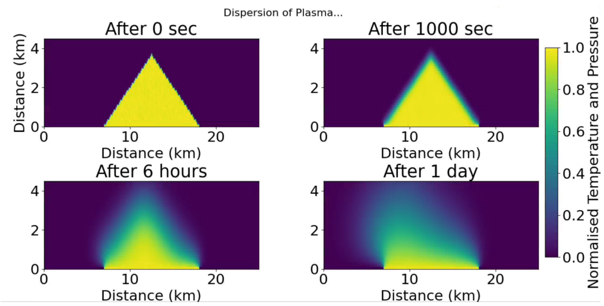

Figure 2: A simulation showing how plasma disperses over time where the surroundings are at 1 atm and 300 K.

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