Journal of Physics Special Topics
An undergraduate physics journal

P2_2 Understanding Goku's Spirit Bomb

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November 11, 2016

Abstract

Goku's iconic "Spirit Bomb" has aided the hero in difficult situations in the world of Dragon Ball. With the aid of a spherical photon gas model, we obtain a glimpse into the necessary requisites. By creating a hypothetical sun-sized SB, we find the model would require $1.5\text{x}10^{75}$ humans and would take about $1.4\text{x}10^{26}$ s to form.

Introduction

Dragon Ball (DB) is a popular Japanese animated series with a main protagonist named "Goku". In order for Goku to overcome the villains he encounters, he calls upon the power of Spirit Bomb (SB). The SB is fueled by "pure" energy referred to as "ki" which stems from any form of life. We model these Spirit Bombs as photon gas spheres in order to approximate their physical parameters as dictated by our universe. It is possible to obtain an approximation for the energy contribution required; assuming only human contributions.

Theory

We model the SBs as spherical distributions that are composed entirely of photons; the behaviour of which can be assumed to be similar to a photon gas. Furthermore, we assume the photon density for the distribution is sufficient enough to exhibit self-gravity. In order to maintain the simplicity of the structure, further relativistic and Newtonian effects, besides those relating to the aforementioned, are negated.

In order to calculate the total energy requirement for each SB, the number of collective photons, N, from **Equation 2**, is required. To approximate the temperature for a SB from **Equation 1** we assume that all SBs are of the same temperature. In the DB series [2], a SB is depicted to "vaporise" a target object; this is interpreted as the ability to break bonds. By assuming the target is composed primarily of carbon atoms, we are able to estimate the temperature based on the common bond dissociation energy of a carbon bond (approximately 415.5 kJ mol^{-1} - based on methane C-H bonds [3]):

$$T = \frac{2}{3}\frac{E_t}{R} \quad (1)$$

Where T is the Temperature of the SB, R is the ideal gas constant and E_t is the thermal energy. In this investigation, E_t is set to the mentioned bond dissociation energy for one mole of carbon bonds (Note: We assume gravitational compression produces additional heat). By keeping a constant T, we are able to find the number of photons:

$$N = \left(\frac{16\pi k^3 \zeta(3)}{c^3 h^3}\right) V T^3 \quad (2)$$

Spirit Bomb Type	Radius (m)	Photon Number	Total Energy (J)	Humans	Formation Time (s)
Large	8.99	7.98e+69	3.18e+51	5.51e+46	300
Universal	5.93	2.29e+69	9.09e+50	1.58e+46	85.9
Android 13	14.2	3.16e+70	1.26e+52	2.18e+47	119
Fusion	0.762	4.86e+66	1.93e+48	3.36e+43	0.183
Solar	6.98e+08	3.73e+93	1.48e+75	2.57e+70	1.4e+26

Table 1: Various different SBs that have been included in the investigation for this paper. Note: Exponents are denoted by "e+". Shaded cells indicate values for a hypothetical photon sphere. Note: The names correspond to different depicted SBs [1].

Here, ζ (3) is the Apéry's constant, V is the volume of the spherical distribution (granted by $4\pi R^3/3$) and the remaining terms are constants with their associated definitions [4] (Note: The radius is obtained by scaling the known heights of characters with a frame in which a SB is comparable). The product of N with the energy of each individual photon, with wavelength, λ, yields the total energy of the SB (E_{tot}), where:

$$E_{tot} = N(\frac{hc}{\lambda}) \tag{3}$$

We may also calculate the time required to gather sufficient energy (t_{sb}); assuming a linear timescale and a constant supply of energy.

$$\dot{E} = \frac{E_{tot}}{t_{sb}} \tag{4}$$

Discussion

We used a photon wavelength of 500 nm due to the blue tone of the SB [2]. From **Equation 2** and **3** we estimated the total energy of the SB with additional calculations uncovering the number of humans required to form various observed SBs. As average adults have a metabolic rate 80 W [5], over 30 minutes (active digestion) [6] this would produce $1.44\text{x}10^5$ J of energy. A SB only accepts 50% of the remaining "ki" per individual [2]. Hence the average human supplies $5.8\text{x}10^4$ J; assuming a one time donation and a 20% brain energy reserve. The ratio of SB energy over the energy per human yields the number of humans required to donate sufficient energy.

Furthermore, using the energy accumulation duration for the "Large" SB (which is quoted to be about 5 minutes [2]), the energy expansion rate is found to be $1\text{x}10^{42}$ W . Thus the corresponding formation times can be found by solving **Equation 4** for t_{sb} (refer to **Table 1**).

Conclusion

During our investigation we were able to approximate various parameters for four SBs that are depicted within the DB series. We were also able to consider the possible parameters for a sun-sized SB; see **Table 1**. It is apparent that Goku would require an astronomical number of humans to obtain the energy required to form the SBs depicted (more so than the Earth is capable of supplying).

References

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