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P3_5 Fire at Will!

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Abstract

We consider the force produced by Zarya's "Graviton Surge" in the video game Overwatch. The mass required to produce a gravitational field of the necessary strength is found and the consequences of utilising such a mass considered. It is shown that the surge must have a mass of 9.4×10^{12} kg, but limitations from special relativity make the existence of such a weapon impossible.

Introduction

Overwatch is a first person shooter game released by Blizzard Entertainment in 2016 in which you can play as a variety of different characters. One of these is Zarya, who makes use of a powerful particle cannon to dispatch her enemies.

This cannon also has the ability to produce something described as a "Graviton Surge", deploying a spherical object which draws all nearby enemies towards it. Such an object would require an extremely strong gravitational force to achieve this, which can lead to some interesting consequences.

Theory

As the ability is called "Graviton Surge" we can assume it only utilises gravity to achieve its strong attraction effect. The gravitational attraction between two massive bodies is given by

$$F = \frac{GM_a M_b}{r^2}, \tag{1}$$

where M_a and M_b are the masses of the two bodies, r is the separation of the bodies and G is the gravitational constant. For Zarya's Graviton Surge to be effective, this attraction would have to equal or exceed that of the Earth. We can then equate the gravitational force of the Earth with the force from the Graviton Surge as follows:

$$\frac{GM_E M_b}{{R_E}^2} = \frac{GM_{GS} M_b}{r^2}. \tag{2}$$

Here M_E and R_E are the mass and radius of the Earth respectively, M_b is the mass of the body being attracted, M_{GS} is the mass of the Graviton Surge sphere and r is the distance between the body and the sphere.

Eq. (2) can be re-arranged and simplified to obtain an expression for the minimum mass of the sphere

$$M_{GS} = \frac{M_E}{{R_E}^2} r^2. \tag{3}$$

Thus, if the mass of the Earth is 5.97×10^{24} kg and its radius is 6371 km [1] then we need only know the value of r, the maximum distance at which the graviton surge has an effect, in order to determine its mass. The graviton surge is said to pull in all enemies within 8 m [2]; substituting this value into Eq. (3) gives the mass of the graviton surge as roughly 9.4×10^{12} kg.

The surge itself is actually rather small in size as it is fired from a hand-held cannon.

With a large mass being compressed into a relatively small sphere, we should consider the Schwarzchild radius to determine if Zarya has by chance created a deadly black hole. If the sphere is smaller than this radius then the object must be a black hole. The Schwarzchild radius is given by

$$r_s = \frac{2GM_{GS}}{c^2}, \tag{4}$$

where c is the speed of light. Using the value for M_{GS} found in Eq. (3) we find that the Graviton Surge has a Schwarzchild radius of 1.4×10^{-14} m. This is extremely small and significantly smaller than the sphere appears in game, therefore we can conclude that it is not a black hole.

As the surge is fired from a hand-held cannon, we should also consider the recoil that might be produced upon firing. To do this we consider conservation of linear momentum. As Zarya can fire the cannon from rest, the momentum of the surge moving forward would have to equal the momentum of the recoiling Zarya (as the initial momentum of Zarya and her cannon is zero). The momentum of the surge is given by

$$p = M_{GS} \times v, \tag{5}$$

where v is the velocity of the graviton surge when fired. In the game, it is fired at a modest speed, we assume a value of 20 ms^{-1}, however the true value may differ. Using the value obtained for M_{GS}, we can then find that Zarya must recoil with a momentum of 1.9×10^{14} $kgms^{-1}$. Zarya has a height of 1.95 m [3]; if we assume based on this that she has a mass of 80 kg, a healthy weight for this height [4], then we find that she recoils with a speed of 2.4×10^{12} ms^{-1}.

Although we have assumed values for the velocity of the sphere and the mass of Zarya that may not be accurate, the mass of the sphere is so high that unless our estimates are out by many orders of magnitude, results will be comparable.

Discussion

From our calculations, it would appear unlikely that a Graviton Surge could be deployed in reality. The surge was shown to have a mass of 9.4×10^{12} kg, which is comparable to that of small asteroids [5]. However, unlike asteroids, the sphere producing the surge is rather small, perhaps only a metre in radius. Simple calculations shows that this would cause the sphere to have a density of 2.2×10^{12} kgm^{-3}. This density is extremely high, comparable to that of a white dwarf star [6].

However, a greater issue arises from considering conservation of momentum. Due to Zarya's extremely low mass in comparison with the surge, she recoils at an incredible speed, almost a million times the speed of light. As from special relativity no object can travel faster than the speed of light, it makes such a weapon theoretically impossible to use.

Conclusion

By considering the mass required to produce Zarya's Graviton Surge, we have determined it to be impossible to replicate in the real world as the weapon would result in a recoil at a speed faster than that of light. Unless technology could advance in some way to counter this, such a weapon must remain in the fictional world of Overwatch.

References

[1] `https://nssdc.gsfc.nasa.gov/planetary/factsheet/earthfact.html` [Accessed 25 October 2017]

[2] `http://overwatch.wikia.com/wiki/Zarya` [Accessed 25 October 2017]

[3] `https://d1u1mce87gyfbn.cloudfront.net/media/reference/zarya_reference.pdf` [Accessed 25 October 2017]

[4] `https://www.nhs.uk/livewell/loseweight/pages/height-weight-chart.aspx` [Accessed 25 October 2017]

[5] `https://en.wikipedia.org/wiki/List_of_Solar_System_objects_by_size` [Accessed 25 October 2017]

[6] Lerner, Rita and George Trigg. Encyclopedia of Physics. New York: VCH, 1990: 809.