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A4_2 Destructive Solutions: They Blew up WHAT?

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Abstract

In this article based on events in the Mass Effect universe, we investigate the effects of an 'Alpha Relay'-style explosion on Earth to see if the destruction seen in the game is possible. Using the Taylor-Sedov equation and inverse square law, we find that the intensity striking Earth from such an explosion is a mere 0.001% of solar intensity.

Introduction

In the Mass Effect videogame series, mass relays are structures used to transport ships around the galaxy. At one point in the Arrival downloadable content (DLC), we see the effect of the destruction of a mass relay on the inhabitants of a solar system. This particular mass relay will be referenced to as the 'Alpha Relay'.

One of the possible game endings sees every mass relay in the galaxy overload — an event triggered on purpose. Here we investigate the scenario in which their overload has the same effect as that of the Alpha Relay, with the aim of calculating the resultant damage dealt to Earth. To do so, we place an explosion identical to that of the Alpha Relay in the Solar System.

Theory

To begin with, we must model the explosion of the Alpha Relay. Using in-game footage of the event[1], we measured 18 s for the shockwave to reach the far side of its solar system from its starting position near the orbit of the outer planet. Due to limitations in reaction time and cinemagraphic clarity, a rough error of $\pm$ 1 s can be considered appropriate.

Using information about the orbits of the Alpha Relay system's planets[2], we find that the orbit of the outer planet, Bastzuda, is 8.9 AU. This allows us to draw the system below:

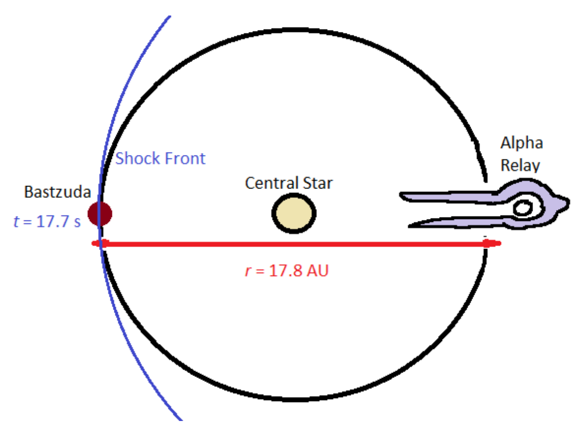

Figure 1: A simplified Alpha Relay system, showing the distance the shockwave must travel to reach the edge of the system (taken to be Bastzuda's orbit), r, as explained below. The planet, star and relay are not necessarily aligned.

From this diagram, we can tell that for the shockwave from the relay to reach the far edge of the system, it must travel its full diameter. So the explosion radius r is equal to the diameter of the system. In reality we should add the distance between the Alpha Relay and Bastzuda's orbit, however this distance is unknown, so the distance we use is a lower estimate of the true distance.

We can find the energy of the explosion using the Taylor-Sedov formula, originally used to calculate the yield of one of the first atomic explosions[3][4]:

$$E = \left(\frac{\rho_0}{t^2}\right)\left(\frac{r}{C}\right)^5, \quad (1)$$

where E is the energy released, ρ_0 is the density of space, t is time, r is the radius of the blast and C is the ratio $\frac{C_P}{C_V}$. C_P and C_V are the specific heat capacities at constant pressure and volume, respectively.

Assuming that the gas released during the explosion and the surrounding gases are ideal, monatomic gases, $C = \frac{5}{3}$. We make this assumption because the exact composition of the explosion is unknown and hydrogen, the most abundant element in the universe, can be successfully modelled as both monatomic and ideal[5].

Since the density of space is approximately one atom per cubic centimetre[6], $\rho_0 = 1.66 \times 10^{-33}$ kgm^{-3}. Substituting these values in, we find that $E = 5.34 \times 10^{25}$ J. The 1 s error became negligible when carried over.

Discussion

To find the resultant effect on Earth, we must use the observed time and the equation for power $P = \frac{E}{t}$ and consider our own Solar System. This gives us $P = 2.97 \times 10^{24}$ W, the power output of the explosion. We can find the intensity I of the shock front as it hits Earth using the inverse square law:

$$I = \frac{P}{4\pi x^2} \quad (2)$$

where x is the distance between Pluto (the location of Earth's mass relay in-game) and Earth, lying between 4.28×10^{12} m and 7.54×10^{12} m depending on Pluto's orbital position[7].

Substituting these values in, we get $I = 12.9 \times 10^{-3}$ Wm^{-2} and $I = 4.15 \times 10^{-3}$ Wm^{-2}. When compared to the solar intensity of 1.36×10^3 Wm^{-2}, these figures are at most only 9.49×10^{-4}% of its value.

With the comparative intensity in mind, it is likely that the only effect observed on Earth would be a distant light visible in the sky.

Conclusion

The final result of this investigation shows that the effect of our Solar System's mass relay exploding in the same manner as the Alpha Relay would not, in fact, cause any significant damage. It is certainly not the 'Earth ablaze' worst-case scenario made available by the game.

It would be interesting to find out if the damage caused by the Alpha Relay explosion on its own system is possible at all, now that the power output is known. A similar investigation could ignore the cinematic information of the Alpha Relay explosion and instead work backwards from the intensity needed to destroy a planet. This method might produce a result similar to the effects seen in the game.

References

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