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A5 6 The Power of the TARDIS

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Abstract

This paper calculates the energy required to move the Earth into its orbit around the Sun, as occurs in the 2008 *Doctor Who* episode "Journey's End". We find that 5.642×10^{34} J of energy is required to move the Earth into its orbit around the Sun, which, when considering the energy of the TARDIS, is more than enough energy to accomplish this.

Introduction

The British science fiction television series *Doctor Who* has provided inspiration for many Physics Special topics papers (e.g. [1] [2] [3] [4]). To celebrate the 60th anniversary of *Doctor Who*, and the return of David Tennant and Catherine Tate to the series, we examine a scene from the 2008 episode "Journey's End", where, after defeating the Daleks at the climax of the episode, the Tenth Doctor and his companions use the TARDIS to return the Earth to its orbit around the Sun (the Earth was removed from its orbit by the Daleks in the previous episode) [5]. In this paper, we calculate the energy required to achieve this and compare this to the energy of the TARDIS.

The energy of the Earth's orbit

The kinetic energy K of the Earth in its orbit around the Sun, assuming the Earth's orbit is circular, is given by the equation:

$$K = \frac{1}{2} M_E v^2 \tag{1}$$

where the mass of the Earth $M_E = 5.972 \times 10^{24}$ kg and the orbital velocity of Earth v is given by the equation:

$$v = \sqrt{\frac{GM_\odot}{R_\odot}} \tag{2}$$

where the gravitational constant $G = 6.674 \times 10^{-11}$ N m^2 kg^{-1}, the mass of the Sun $M_\odot = 1.989 \times 10^{30}$ kg, and the radius of the Sun $R_\odot = 6.960 \times 10^8$ m. Substituting Equation 2 into Equation 1, we obtain the following equation:

$$K = \frac{GM_\odot M_E}{2R_\odot} \tag{3}$$

In our scenario, the Earth is being moved from infinity, where the gravitational potential energy $U = 0$, to a distance $r = 1$ AU $= 1.496 \times 10^{11}$ m. The gravitational potential energy required to do this is given by the equation:

$$U = -\frac{GM_\odot M_E}{r} \tag{4}$$

The total energy of the Earth's orbit around the Sun is equal to the sum of the gravitational potential energy U and kinetic energy K [6]. Combining Equation 3 and Equation 4 we obtain an equation for the total energy E_{tot}:

$$E_{tot} = U + K = GM_\odot M_E \left(\frac{1}{2R_\odot} - \frac{1}{r} \right) \tag{5}$$

Substituting the values into Equation 5, we calculate that the energy required to move the Earth into its orbit around the Sun is equal to 5.642×10^{34} J.

The energy of the TARDIS

In the 2013 episode "Journey to the Centre of the TARDIS", the TARDIS is said to be powered by the Eye of Harmony, an "exploding star in the act of becoming a black hole" or, in other words, a supernova [7]. The total energy released by a supernova explosion is on the order of 10^{44} J [8], so the TARDIS should easily be able to move the Earth back into its orbit. In fact, since the energy required to move the Earth into its orbit around the Sun is on the order of 10^{34} J, the TARDIS has enough energy to do this over a billion times over.

Conclusion

We have calculated that the energy required to move the Earth into its orbit around the Sun is equal to 5.642×10^{34} J. The TARDIS is powered by a supernova, which has a typical energy of the order of 10^{44} J, meaning that the TARDIS has more than enough energy to accomplish this. We have somewhat simplified the calculations in this paper, ignoring factors such as the rotational velocity of the Earth as it spins about its axis, and the gravitational effects of other objects such as Jupiter which the TARDIS may pass close to during its journey. Additionally, in the scene from the episode, the TARDIS uses the power from the Torchwood Rift to move the Earth into its orbit, so the actual energy used by the TARDIS in moving the Earth would be less than what has been calculated.

References

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