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A4_2 Life is a Highway

Charlotte Paton, Kaia Thomas, Matthew Wing, Nat McCabe

Department of Physics and Astronomy, University of Leicester, Leicester, LE1 7RH

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Abstract

In this paper we examine the distance that an individual would travel around the Universe in their lifetime, based off of the popular song "Life is a Highway". To do this, the distance of an Earth orbit around the Sun was calculated. Further to this, the orbit of the Solar System around the centre of the Milky Way and the movement of the Galaxy through space were also considered. The average life expectancy of a person was set to 80.7 years and, from this, the total distance a person would travel is found to be $2.12 \times 10^{15} km$.

Introduction

The song "Life is a Highway", originally by Tom Cochrane, was once again popularised by the 2006 remake by Rascal Flatts for the animated film "Cars". This song lend itself to the question: if life was a highway, how long would that highway be? To analyse this, we calculate the distance a person would travel through the Universe throughout their lifetime.

Within this paper we assume that the person in question is stationary on Earth, so their movement around the planet will not affect the answer. Therefore, to get a final distance we consider the orbit of Earth around the Sun, the rotation of the Solar System around the Milk Way and the movement of the Galaxy through space.

Method

The average lifespan in 2020 for adults in the UK was found to be 78.7 years for males and 82.7 years for females [1]. In this paper we have chosen a midpoint of 80.7 years to be the average life expectancy.

To calculate the distance of one Earth orbit around the Sun the eccentricity of the orbit must first be calculated. This can be done using the following equation:

$$e = \frac{r_a - r_p}{r_a + r_p}, \tag{1}$$

Where r_a is the radius of apoapsis, and r_p is the radius of periapsis. From this the semi-major axis, a, and the semi-minor axis, b, can be calculated using the following equations:

$$a = \frac{r_a + r_p}{2}, \tag{2}$$

$$b = a \times \sqrt{1 - e^2}, \tag{3}$$

To find the exact perimeter of an ellipse would require an infinite series of calculations therefore, within this paper, we will use an approximation devised by the famous mathematician Ramanujan [2]. Firstly, a value of h (an arbitrary variable used to simplify Eq.(5)) is calculated from the values of the semi-major and semi-minor axis

$$h = \frac{(a-b)^2}{(a+b)^2}, \tag{4}$$

Using this the perimeter can be found through the following:

$$p \approx \pi(a+b)\left(1+\frac{3h}{10+\sqrt{4-3h}}\right), \quad (5)$$

By taking a given speed, the distance that the solar system orbits around the centre of the Milky Way as well as the distance in which the Milky Way travels through space can be found through the simple equation:

$$distance = speed \times time, \quad (6)$$

Results

The radius of apoapsis for the Earth around the Sun is taken to be $152,097,701 km$ and, similarly, the radius of periapsis is taken to be $147,098,074 km$ [3] . By substituting these values into Eq.(1) the eccentricity of Earth's orbit can be found to be 0.01671.

Using Eq.(2) and Eq.(3) respectively, the semi-major axis was found to be $149,597,877.5 km$ and the semi-minor axis was found to be $149,577,000.4 km$.

From Eq.(4), the value of h was found to be 4.87423×10^{-9} and hence, using Eq.(5), the distance of Earth's orbit was found to be $939,885,631.1 km$ or $6.28 AU$. Over the course of 80.7 years this equates to total distance of $506.80 AU$.

The speed in which the Solar System orbits the centre of the Milky Way is given to be 792,000 km/h [4]. Using Eq.(6), over the course of an average lifetime, a human would be expected to travel $5.599 \times 10^{11} km$ or $3742.58 AU$. Furthermore, the speed in which the Milky Way is moving through space is given to be 2.1×10^6 km/hr [4]. This equates to a distance of $9923.51 AU$ in an average life.

By considering all 3 distances together, the total distance travelled in one lifetime is found to be $14,173 AU$ or $2.12 \times 10^{15} km$.

Discussion and Conclusion

Within this paper, in order to calculate Earths orbit around the Sun, the precision of all calculations was kept to the greatest amount of significant figures possible. This is due to Earth's orbital eccentricity being very small.

It is difficult to visualise how big the distance calculated, 14173 AU, actually is. To provide some context, as of Friday 22nd October 2021, Voyager 1 has traveled 154AU. [5] In order to reach the total distance calculated within this paper, one would have to travel 90 times this distance

To further the results from this paper, more precise calculations can be done to asses the the distance that the solar system orbits the centre of the Milky Way, as well as the distance in which the Galaxy travels though space. Further, you may consider the average distance at which a human travels over the surface of the earth. However, whilst interesting, this would be likely have little to no effect on the final result due to scale of other components.

References

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[4] `https://nightsky.jpl.nasa.gov/docs/HowFast.pdf` [Accessed 11 October 2021]

[5] `https://voyager.jpl.nasa.gov/mission/status/` [Accessed 22 October 2021]