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A1_9 A Relativistic Chicken Nugget

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Abstract

This paper looks into using highly relativistic velocities to store food for longer than its used by date on Earth. Based on the calculations made using Einstein's special relativity, we found that storing a chicken nugget at higher and higher velocities increasingly raised the time before which it was considered inedible. However, this method of food storage is impractical in reality.

Introduction

The used-by-date of food is important in ensuring food is consumed before it could cause illness. There are many ways that humans have developed to make food remain edible for longer, an example being fridges [1]. In this paper we aim to calculate how effective it is to use highly relativistic velocities as a method of extending the shelf-life of a chicken nugget. To do this we will use Einstein's theory of special relativity [2] to calculate the time dilation related to a range of velocities. Time dilation is the name given to the phenomenon whereby objects at high velocities, near to the speed of light, experience time slower therefore extending the objects lifetime in the eyes of a stationary observer.

Theory

We start with the equation for time dilation (1) where Δt is the shelf-life time of a chicken nugget in the rest frame S, on Earth, γ is the relativistic parameter given in equation (2) and $\Delta t'$ is the shelf-life time of the chicken nugget in the relativistic frame S'.

$$\Delta t = \gamma \Delta t' \tag{1}$$

The relativistic parameter (2) is used to transform time between reference frames.

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}, \tag{2}$$

where v is the velocity of the chicken nugget in the relativistic frame and c is the speed of light. It is also assumed that half way through its journey, the chicken nugget experiences an instantaneous infinite acceleration to reverse its direction but keeping the magnitude of the velocity the same. This allows the chicken nugget to come back to Earth.

Method

We used the value for the speed of light, c, as $2.998\text{x}10^8$ m s^{-1} and assumed that a chicken nugget could last one week in a fridge on Earth (rest frame S). Although, the time used is not really important since this is just a comparison. We started by selecting an arbitrary high velocity of 0.75 c to send the chicken nugget off on a spacecraft, and used equation (2) to find the relativistic parameter, γ, which could then be plugged into equation (1), along with our value for Δt of 1 week, to obtain the shelf-life time of the chicken nugget at that speed. We chose to start arbitrarily with 0.75 c because we knew it would be large enough to make a noticeable difference to the lifetime of the chicken nugget.

Next, we repeated this process for a range of velocities and plotted the results for velocity against time in reference frame S' to give the graph (Figure 1) below. We also used the time dilation equation (1) to work backwards to find the velocity. We set $\Delta t = 1$ week and $\Delta t' = 0.5$ weeks, then using the relativistic parameter equation (2), we obtained a value for the velocity needed to double the life span of the chicken nugget. The 0.5 weeks represents how long has passed in frame S' compared to the original 1 week in frame S. This means that the chicken nugget lasts twice as long in frame S' in this instance. We also did this for 4x the shelf-life or roughly one month.

Results and Discussion

For the velocity of 0.75 c, we calculated a value of 1.51 for the relativistic parameter, γ, and 0.66 weeks for $\Delta t'$ which means a shelf-life of 1.51x the original one week. After repeating this process for a range of velocities, we plotted the results (Figure 1). This graph clearly shows the exaggerated relationship between velocity and time in reference frame S'. It shows that small velocities do not noticeably affect the shelf-life of a chicken nugget, but large velocities approaching the speed of light have increasingly large effects on the shelf-life.

We found that to double the life span of the chicken nugget, $\gamma = 2$, a velocity of 0.866 c was needed. To increase the shelf-life by 4x, $\gamma = 4$, requires a velocity of 0.968 c. Some of these results may seem promising for the future of food storage. However, currently these kinds of near light speed velocities are not achievable. The amount of energy this would require, compared to other food storage methods like fridges, is order of magnitudes larger. Therefore, using relativistic velocities for food storage is not feasible but definitely opens some interesting possibilities.

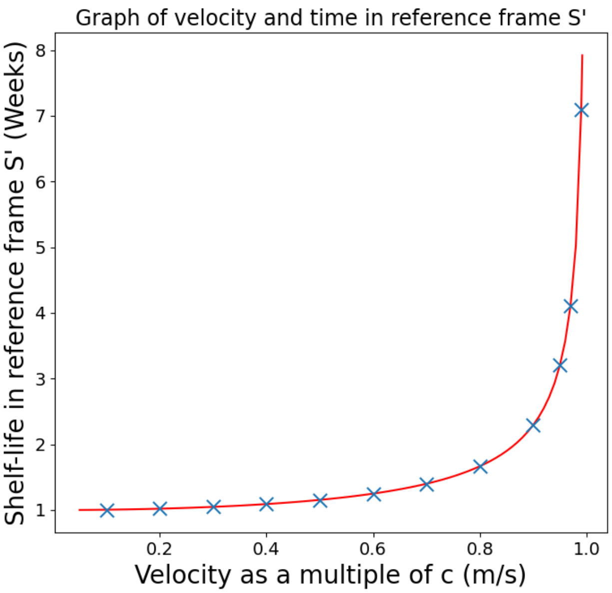

Figure 1: Showing the relationship between velocity and the time in the relativistic reference frame S'. Based on the 1 week shelf-life of a chicken nugget on Earth.

Conclusion

To summarise, the closer the velocity to the speed of light, the longer the shelf-life of a food item will be when returned to Earth. Figure 1 shows this relationship exactly as expected. Despite the promising results of this method of food storage, it remains unfeasible due to limitations on reaching relativistic speeds as well as the huge amount of energy that this process would require.

To develop this topic further, it would be interesting to look into the feasibility of sending perishable food supplies to other planets, at relativistic velocities, to determine whether or not we could support a colony on another world with fresh food as well as standard non-perishables.

References

[1] `https://en.wikipedia.org/wiki/Refrigerator` [Accessed November 30, 2022]

[2] `https://www.space.com/36273-theory-special-relativity.html` [Accessed November 30, 2022]