Special Relativity's spaceship is not recommended for humans: Weight and body dimension of a returning twin

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Abstract

In the present note, we consider the relativistic effects, according to SR, on the "travelling" twin's spatial body dimensions and weight**.**

Keywords: Twin Paradox, Special Relativity, Time dilation, Lorentz contraction.

Almost all applications of Einstein's Special Relativity (SR) theory [1] to the twin-paradox gedanken experiment, originally proposed by Langevin [2], have focused on the time dilation effect (e.g., [3-5]). This effect prescribes that the "traveling" twin will return to Earth younger that the "staying" twin. The ratio between the increase in age of the staying twin relative to the increase in age of the travelling twin is predicted to be equal to the Lorentz factor $\gamma = \frac{1}{\sqrt{1-(^{v}/_{c})^2}}$.

In the present note, we consider the relativistic effects, according to SR, on the "travelling" twin's spatial body dimensions and weight. Consider the case in which Alice leaves her identical twin Bobbie and travels with very high constant velocity, $\beta = {^{v}/_{c}}$= 0.99, to a distant star, and returns back to Earth. Upon leaving, both Alice and Bobbie are 180 cm. tall, 40 cm. hip-width, and 60 kg. weight. During the entire travel, Alice lies with her body stretched on a bed positioned parallel to the travel direction. Suppose the entire trip lasts one year according to Alice's time. According to SR, Alice should return to Earth about 7.1 years younger than Bobbie (and all other creatures on Earth). Moreover, due to distance contraction ($l = l_0/\gamma$) , she will become approximately 25.4 cm. height, much shorter than Bobbie (180 cm), while her hip width will stay the same (40 cm.). If, on the other hand, Alice's bed is positioned perpendicular to the travel direction, she will return as tall as Bobbie (180 cm.), but her hip width will shrink to about 5.6 cm. Positioning the bed at various angles between 0 to $\frac{\pi}{2}$ will produce the heights and hip widths depicted in equations 1 and 2 (see also Figure 1). For all angles $0 \leq \alpha \leq \frac{\pi}{2}$, Alice's mass is predicted to increase by a factor of γ, causing her weight to increase from 60 kg. to 60 γ ≈ 425.3 kg. For any angle in the aforementioned range, it is easy to show that the height and hip width of Alice is given by:

$$\text{Height: } l = l_0 \sqrt{\sin^2(\alpha) \ + \frac{1}{\gamma^2}\cos^2(x)} \approx 180 \sqrt{\sin^2(\alpha) + 0.0199\cos^2(\alpha)} \qquad \ldots\ldots (1)$$

$$\text{Hip-width: } w = 40 \sqrt{\cos^2(\alpha) \ + \sqrt{1-\beta^2}\,\sin^2(\alpha)} \approx 40 \sqrt{\cos^2(\alpha) + 0.0199\sin^2(\alpha)} \qquad \ldots\ldots (2)$$

The designation of Earth as the preferred frame of reference implies that the above transformations in age, body dimensions, and weight are real. Knowing this, no one should agree to his spouse taking the trip. Although she may return younger, she will also return shorter, almost square like a box, and very obese. On the other hand, in the framework of SR, the realization and measurement of the above predictions for small particles, atoms, and more complex microstructures should be attainable in linear or radial uniform motion.

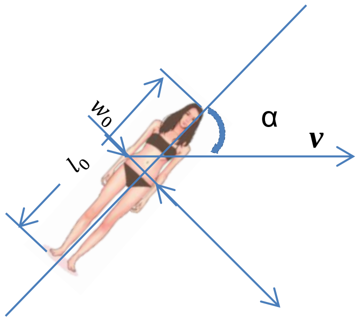

Figure 1: Alice's body rotated by an angle α, relative to the direction of motion

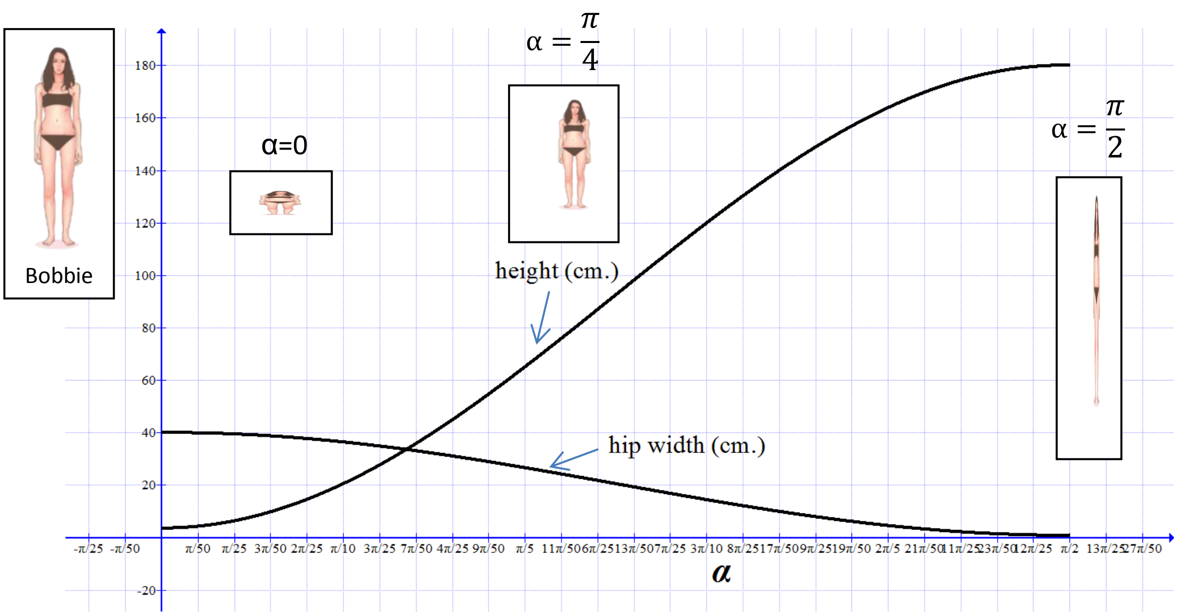

Figure 2: Allice's height and hip width as a function of the rotation angle α. The human figures depict Alice's final body dimensions at three selected angles.

References:

[1] Einstein, A. On the electrodynamics of moving bodies (1905). In J. Stachel (Ed.), *The collected papers of Albert Einstein,* vol. 2 (pp 304–95), Princeton, NJ: Princeton University Press (1989).

[2] Langevin, P. L'évolution de l'espace et du temps. *Scientia*, 10, 31 (1911).

[3] Marcio A. F. Rosa, Waldyr A. Rodrigues Jr. The meaning of time in the theory of relativity and Einstein's later view of the Twin Paradox. *Foundations of Physics*, **19** (6), 705-724 (1989).

[4] Pesic, P. Einstein and the twin paradox. *European Journal of Physics*. 24, 585-590 (2003).

[5] Iorio, L. An analytical treatment of the clock paradox in the framework of the special and general theories of relativity. *Foundations of Physics Letters*, 18 (1), 1-19 (2005).