Combining Speeds

This vignette is a simple excursion into physics.

Suppose you are sitting in an open convertible and the car is parked. You throw a baseball forward at 10 mph. Your friend Bill, standing in the road ahead of you, catches the baseball. As Bill sees it, the ball approaches him at 10 mph.

Now the car is being driven by another friend Sarah at 20 mph while you are on the passenger side. You throw the baseball at 10 mph just as before. Bill catches the ball and as he sees it the ball approaches him at 30 mph. The two speeds just add.

Now suppose the original situation, but instead of a baseball you are holding a flashlight. The light leaves you at 186,282 miles per second, which is so fast it is easier to denote it by the letter *c*. Bill's face is lit up and he measures the speed of the light approaching him to be the same speed *c*.

So far this is all obvious.

But now suppose Sarah is again driving at 20 mph and you turn on your flashlight. How fast does Bill measure the light approaching him? Common sense says *c* + 20 mph, again just adding the speeds.

But by *actual measurement* this is not how the universe works. Bill measures the light approaching him at speed *c*. It leaves you at speed *c* and even though you are moving it approaches Bill at speed *c*. How is this possible?

Since speed is a distance divided by a time, something strange must be happening with distance and time. You and Bill must measure distance, time or perhaps both differently. It turns out the answer is both. Of course, you each think the other is measuring wrong.

The differences between you and Bill in how you measure are such that no matter how fast Sarah drives, things conspire so you both measure light as moving at speed *c*.

The simple formula

$$v_{combined} \approx v_1 + v_2$$

turns out to be only an approximation although it applies superbly to balls and cars. But when at least one of the speeds is fast the exact formula of the universe must be used:

$$v_{combined} = \frac{v_1 + v_2}{1 + \frac{v_1 v_2}{c^2}}$$

When both speeds are small compared to *c*, the denominator is so close to 1 that it can be ignored, giving us the simple approximation above.

There is enough mystery here that adding more mystery by choosing strange words is silly, yet it is common. You and Bill measure distance and time differently, but instead of talking about distance and time writers talk about "space" and time, which sounds a bit mystical. Yet there isn't any "fabric of space" any more than there is a luminiferous aether, once believed to be the (now known to be non-existent) flexible medium through which light waves travel.

Welcome to the strange world of Albert Einstein's Special Relativity. Everything strange about it, which is everything about it, can be derived from the strange speed combining formula shown above, even including $E=mc^2$.

With no disrespect toward the Deity, this is a sloppy way to run a universe. It gets worse but that is not discussed in this vignette.