Brad Skow November 4, 2005

Philosophy 593S: Philosophy of Space and Time, Fall 2005
Supplement to Handout 7: Lowell's question

Handout 7 contains this speech:

"The photon took $t_1 + t_2$ seconds to get from me to q and back; since light travels the same speed in all directions, it reached q $\frac{1}{2}(t_1 + t_2) = t_1$ seconds after I emitted it; but that was just when I experienced point p on my worldline. So p and q are simultaneous."

Lowell was incredulous. "Suppose I'm running toward a wall with a superball, and I throw the ball at the wall, it bounces off, comes back, and I catch it. Suppose this takes t seconds. It's just not true that the ball hit the wall $\frac{1}{2}t$ seconds after I threw it. Here's the proof:

Suppose I'm moving at velocity $10\,m/s$ toward the wall (in the frame at reference in which the wall is at rest my velocity is $10\,m/s$), and I throw the ball at velocity $10\,m/s$ toward the wall, relative to my frame of reference, when I'm 20 meters from the wall. Then the ball is traveling at $20\,m/s$, so hits the wall 1 second later. It rebounds off the wall at $20\,m/s$ moving in the other direction[1]; at the moment of rebound I'm 10 meters from the wall, and I catch the ball $\frac{1}{3}$ seconds later when I'm $6\frac{2}{3}$ meters from the wall. So the ball took $1\frac{1}{3}$ seconds to get from me to the wall and back; but it reached the wall 1 second after I threw it, not $\frac{1}{2}(1\frac{1}{3}) = \frac{2}{3}$ seconds after I threw it."

Everything in that speech (which is really mine, not Lowell's) is correct, *if spacetime is galilean or aristotelian.* But we're in Minkowski spacetime now. One implicit premise in this speech is

> If x moves with velocity v relative to (inertial) frame of reference R_1, and R_1 moves with velocity v' relative to (inertial) frame of reference R_2, then x moves with velocity $v + v'$ relative to frame of reference R_2.

This premise is needed to conclude that the ball moves at $20\,m/s$ in the wall's frame of reference. But this premise is false in Minkowski spacetime. (Otherwise, not all inertial observers would agree on the velocity of light.)

The speech also contains the sentence "I throw the ball...when I'm 20 meters from the wall." But this does not make sense in Minkowski spacetime. Am I 20 meters from the wall, in the wall's frame of reference? Or in mine? The two frames disagree about my distance from the wall when I throw.

You might think this doesn't solve the problem: "Suppose I'm running toward a wall with a superball, as before. Let's do everything in my frame of reference. In my frame I am at rest. The wall is moving at $10\,m/s$ toward me. I throw the ball at $10\,m/s$ toward the wall. At the moment I throw the wall is 20 meters away (in my frame). As before the ball takes 1 second to hit the wall. But the ball doesn't bounce back at $10\,m/s$ in the opposite direction. It's

[1] Or near enough, so long as the wall's mass is much bigger than the superball's mass.

being hit by a (big, heavy) moving wall, so it bounces back faster than that, so gets back to me in less than 1 second."

Everything in this speech is correct, even in Minkowski spacetime. But it doesn't show there's anything wrong with the original argument. It is important that in the original argument we were using *photons*, not superballs. Unlike superballs, photons travel at $3 \times 10^8\, m/s$ whether they bounce of moving walls or stationary walls. So it will take the same amount of time to get back to me.