Why Shawyer's 'electromagnetic relativity drive' is a fraud

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5 October 2006

Abstract

It is well known that Roger Shawyer's 'electromagnetic relativity drive' violates the law of conservation of momentum, making it simply the latest in a long line of 'perpetuum mobiles' that have been proposed and disproved for centuries. However, to the best of my knowledge, no one has yet pierced the pseudo-scientific babble of Shawyer's 'Theory paper' to show why his analysis is rubbish and his 'drive' impossible. In this short note I show why his 'Theory' is wrong, in terms that even a high school physics student can understand.

Introduction

It takes a few weeks for each issue of *New Scientist* to filter through the distribution list and land in my in-tray at work, and so it wasn't until yesterday that I had the displeasure of reading the 8 September 2006 issue—specifically, Justin Mullins' glossy, gushing article about Roger Shawyer and his 'electromagnetic drive'. For anyone that has done even a semester of high school physics, Shawyer's 'drive' sounds completely preposterous: thrust in one direction, with nothing propelled in the other. What about conservation of momentum?

It was the end of a long work day, so I set myself a challenge: find the error in Shawyer's work before my train arrived at Frankston. I downloaded and printed his 'Theory paper' from the *New Scientist* website and set off for the evening.

Upon boarding at Southern Cross Station and opening the printout of his paper, my heart dropped. From the impressive credentials Shawyer was credited with in Mullins' article, I expected a scientific paper containing a subtle error that I would enjoy discovering. Instead, I was looking at a pseudo-scientific hodge-podge of equations drawn from just three solitary references: a first-year university general physics textbook; James Clerk Maxwell's original Treatise on electrodynamics (1873); and an obscure 1952 paper on microwaves published by the Institution of Electrical Engineers (UK). The first two references I own, and have read; the third I had never heard of, and didn't need to read. Shawyer's paper was complete rubbish.

I was disappointed because I knew that it was unlikely that I would find the error in Shawyer's paper—*ever*, let alone before the train reached its terminus. When a 'scientific' article is constructed out of random equations and physics jargon in the same way that my five-year-old son pastes together a montage of colourful scrap paper at kindergarten, it's impossible to know where to start. It is no longer a case of looking for 'the error', but rather a case of trying to find anything in there that *isn't* an error.

I suddenly realised why (to my knowledge) no professional physicist had yet dissected Shawyer's analysis. No one has so much spare time on their hands that they can dedicate hours upon hours of it to disprove every crackpot paper that they get sent in the mail; and even if they did, it would be impossible to communicate the errors to an author that doesn't even have a grasp of basic physics.

I put Shawyer's paper away as a lost cause, and started reading something else. But by the time I reached Richmond the anger was welling inside me. Mullins had reported that Shawyer had managed to extract an obscene amount of money from the UK government to fund his 'research'. We weren't talking about a well-meaning amateur with a pet theory of the universe, whose ego could be massaged into agreeing to disagree over a cappuccino in Lygon Street. We were talking about a charlatan who had defrauded a government agency to get his hands on taxpayers' hard-earned money (albeit taxpayers in a foreign country).

I pulled Shawyer's paper back out of my laptop bag, and started wading through the morass. I started having waking nightmares about what would be needed to disprove him: complicated mathematical solutions of horrendous equations; complex computer simulations of conical waveguides; … I shuddered at what I had, mentally, committed myself to. But just as the computerised woman in the train's roof told me that we were approaching Seaford Station, the penny dropped. It was something that I could have explained to my Year 11 students when I was a still a teacher.

Arriving home, I jumped onto the net to try to see if someone had already published the solution: it was so simple. The only reason I got bogged down in Shawyer's paper was because I was trying to look for *complicated* answers; surely, I reasoned, there must be plenty of people, having done enough physics to disprove Shawyer, but not having had the pleasure of working in relativistic electrodynamics, that would have seen the flaw more rapidly?

My net crawling had mixed results. As expected, a handful of individuals had already come forward to not just pronounce the obvious (that it was impossible because it violated conservation of momentum), but moreover to show explicitly where Shawyer's analysis was flawed. But it didn't seem like anyone had written it up in detail; nor did they seem to be arguing it too forcefully. The whole scandal seemed to be in a stalemate, with Shawyer and his proponents claiming that his analysis was correct, and that no one had proved otherwise. Why was this so?

I looked back at Shawyer's paper, and realised how he had managed to perpetuate the scam for so long. His paper *looks* like advanced physics. Anyone who couldn't solve a few quick problems in relativistic electrodynamics before breakfast would blanch at the prospect of tackling it; and anyone who could, would know immediately that it is a pile of crap, and wouldn't bother going past the first two pages. Only I was stupid enough to get riled up about a con artist defrauding a government in a country I have never even visited.

What's right in Shawyer's paper

The key to understanding the flaw in Shawyer's paper is to first understand the bit that is (despite himself) *right* in the paper—and to extricate this nugget of truth from the montage of irrelevant material that he has pasted all over it.

Shawyer's paper basically describes particles bouncing elastically off walls; that is the way that he derives the force that gives the 'thrust' for his 'drive'. But the stuff he injects into his truncated conical device is *microwaves*. Most people would ask: how does that work?

Microwaves, like everything in the Universe, can be described in terms of 'waves', or in terms of 'particles'. If asked to explain how they reheated my spaghetti bolognese this evening, I would use the 'wave' description as the easiest one. But Shawyer is absolutely justified in switching between a 'wave' description and a 'particle' description, whenever he felt like it (in fact, practically every other sentence of his paper). The only problem is that, unless you intimately know the equations that he throws around like confetti at a wedding, his unclear and badly explained twists and turns are likely to leave you wondering whether he really *must* be a genius of Einsteinian proportions. (This is an unfortunate misconception that many people have: that a genius is someone who says things that no one else can understand. The truth is that a genius is someone who can make *everyone* understand.)

The net result is the following. Forget all of the stuff in Shawyer's paper that talks about 'group velocities' and 'wavelengths' and 'Q factors'. Just concentrate on his diagrams of little photons (microwave particles) bouncing around inside his contraption, and the physics equations he writes down to go with those bouncing particles. Take it from me that he's right about that, and strip out all the really scary looking equations that have Greek letters in them.

Now remember your high school physics, and look at what's left.

Start with Shawyer's Figure 2.4. He shows his truncated conical contraption, with a particle bouncing around inside it. It must have a constant energy, because it's being reflected elastically at every wall. That means that the magnitude of its momentum, p, is constant.

As Shawyer correctly shows, the particle reflects off each wall in the way that you learnt at school (angle of incidence equals angle of reflection). But because the walls are *inclined* to the 'axial' direction (the axis going down the middle of the cone), this means that the angle that their momentum makes with the axial direction becomes 'steeper' at the narrow end of the cone, and 'shallower' at the bigger end of the cone. If you draw a few diagrams, and use some high school geometry, you can work out how much 'steeper' and 'shallower' the particle's momentum angle gets, each time it bounces off a wall. Shawyer's Figure 2.4 correctly shows this phenomenon.

Now look at the arrows below the diagram in Shawyer's Figure 2.4. If you remember your high school physics, these are *force vector* arrows. They show the direction and strength of the force that the particle imparts on each wall as it hits it.

Shawyer's F1 is the force on the 'large' end of the cone, and F2 is the force on the 'small' end of the cone. As he correctly shows, F1 is bigger than F2, because the particle's momentum is much closer to 'head on' to the large end. (Remember, the size of the particle's momentum does not change, only the direction it is heading in.)

After going through a few more trips into wave-land, Shawyer computes the difference between F1 and F2. That's where his 'drive' comes from. All the complicated equations he throws in are just fluff around this basic result.

What's wrong in Shawyer's paper

Now we get to the point that a number of people have already made, but perhaps not confidently enough. Look at the arrows that Shawyer labels 'Fs1' and 'Fs2' on his Figure 2.4. These are supposed to be the forces that the particle imparts to the wall of the conical part of his contraption.

But hang on a minute! When a particle bounces elastically off a wall, doesn't the wall feel a force that is *perpendicular* to the wall? Of course it does: if you remember your high school physics, you subtract the initial momentum vector from the final momentum vector, and the resultant force points into the wall. (OK, it's actually called the 'impulse', not the force, but it's effectively the same thing for what we're talking about here).

Now look back at Shawyer's Figure 2.4. *He has Fs1 and Fs2 pointing perpendicular to the axial direction, not perpendicular to the cone's walls.*

His arrows are wrong.

This is the fundamental blunder that renders Shawyer's paper meaningless. If you remember your high school physics, it is simple enough to draw a diagram to prove to yourself that, when a particle bounces off the wall of the cone, *the increase in the particle's momentum in the axial direction is exactly balanced by the impulse imparted to the cone in the opposite direction.*

This is what has already been argued by those who have bothered to wade through Shawyer's paper. It is not affected by all the 'wave-land' equations that Shawyer throws in. It is the fundamental error in his analysis.

So what do we *really* find out from this analysis, when we do it correctly? Simply this: when a particle bounces around elastically inside a closed container, neither of them go anywhere. If you start in the right reference frame, then when the particle is moving left, the container is moving right; when the particle is moving up, the container is moving down; and so on. When the particle and the container collide, the directions of motion change, but their momenta still add up to zero. Nothing accelerates.

There is no 'drive'.

How does Einstein's theory of relativity change things?

That heading should be enough to have scared most people off reading this sentence. Relativity is really complicated, right? Must be—Einstein invented it.

Shawyer throws relativity into his paper, if only because he really can't avoid it for a particle that moves at the speed of light (well, *is* light, or its cousin, anyway). Maybe some weird spooky relativistic effect makes Shawyer's scam drive work?

Fortunately (for us, not Shawyer), relativity doesn't change a thing. I purposefully described everything above in terms of *momentum*. It turns out that one thing that relativity does *not* change is that momenta can still be added together, just like they can in Newtonian mechanics.

So the answer to the question in the previous heading is: Not at all.

Shawyer's 'electromagnetic relativity drive' is a fraud.