Radar Guns and Einstein's Theories

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***Abstract**: Radar guns provide an excellent and inexpensive means of explaining and demonstrating some of Einstein's theories in a very simple and undeniable way. Specifically, radar guns demonstrate how the speed of the emitter cannot add to the speed of the light being emitted, but the speed of light can be combined with the speed of the receiver. In practice, this appears to conflict with a basic tenet of mathematicians who believe that motion is reciprocal, and therefore radar guns must show that motion is reciprocal. A step by step analysis of how radar guns work shatters that basic tenet.*

Key words: Radar; Relativity; motion; light; particle; wave.

I. Basic Radar Gun Physics.

Almost everyone should be familiar with the basics of how a radar gun works. Figure 1 below shows a radar gun being pointed at an oncoming car that is traveling toward the radar gun at 55 miles per hour.

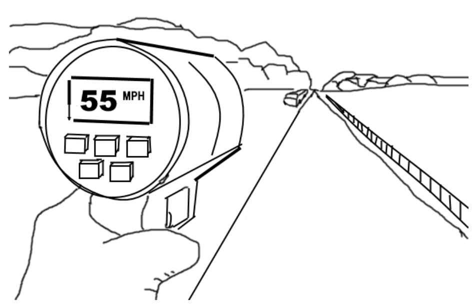

Figure 1

The operator of the radar gun simply points it at a target and squeezes the trigger, which causes radio wavelength photons to be emitted toward the oncoming car. Some of the photons get reflected off the car and return back to the gun with a different oscillating wavelength. A computer chip within the gun then compares the different wavelengths, computes the difference in velocity the different oscillating wavelengths represent, and the operator reads the mileage calculation on the small view-screen on the back of the gun.

The first question that is addressed in this paper is: What speed does the radar gun display if the gun is operated from a moving vehicle and the gun is pointed at a stationary object (i.e., a highway sign, a tree or parked car) at the side of the road?

In numerous discussions with mathematician-physicists, they seemed to be in unanimous agreement that motion is reciprocal, and they all agreed with this statement from the individual who had the most impressive credentials:

> A radar gun in a car traveling down the highway at 60 MPH will measure a tree to have a speed of 60 MPH.

But, that answer is in disagreement with fundamental physics. It disagrees with what Dutch physicist Willem de Sitter observed in 1913[1] and wrote in 1916 in "*Einstein's Theory of Gravitation, and its Astronomical Consequences*."[2] And it disagrees with Albert Einstein who used de Sitter's observations in his book "*Relativity: The Special and General Theory*."[3]

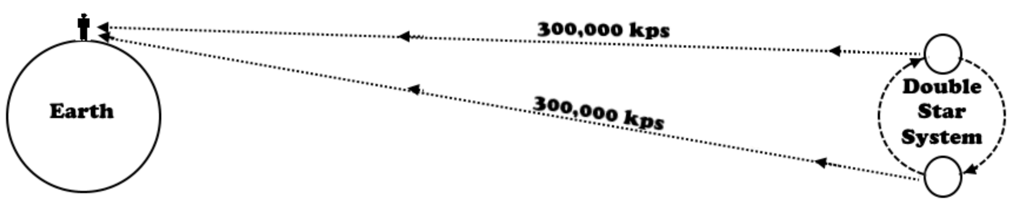

Figure 2

Figure 2 illustrates de Sitter's observation. The two stars in the double star system orbit each other, which means that when one star is moving toward the earth, the other is moving away from the earth. According to Isaac Newton and Swiss theoretical physicist Walther Ritz, the light from the star moving toward the earth should travel at $c+v$, where v is the speed of the star toward earth, and the light from the star moving away from the earth should travel at $c-v$. That has become known as "Emission Theory." De Sitter's observations showed that "Emission Theory" was *not true*. The light arrived at 300,000 kilometers per second (kps) from *both* stars. Furthermore, if "Emission Theory" were true, that would mean that, while the light is traveling to the earth, the faster moving light would pass by the slower moving light, and an observer on earth would see the same star in different locations. That doesn't happen.

Einstein agreed. He decided there must be a *maximum speed limit* in our universe that prevents light from traveling faster than 300,000 kps. And all light *must* be emitted at 300,000 kps *in all directions*. The binary star moving away from the earth showed that the light it emitted still traveled at 300,000 kps even though it would not be in conflict with the maximum speed. So, no matter how fast the emitter is traveling, *or in what direction,* the light that is emitted will travel at 300,000 kps.

And that means that a radar gun will always send out photons at 300,000 kps (actually 299,792,458 meters per *local* second, but this paper will use 300,000 kps as *c* to keep things simple) regardless of how fast the gun is moving.

So, if a police car is parked at the side of the road and the officer points his radar gun at a highway sign 20 feet way, the gun will give "no reading," which is equivalent to a reading of zero. The photons of light going from the gun to the sign traveled at the same speed and with the same oscillation wavelength as the light returning from the highway sign to the gun. The target was moving at 0 mph and the radar gun could compute no difference in oscillation wavelengths.

If the officer points his radar gun at a car coming toward him at 55 mph, the light photons from the gun will travel at *c* to the target, the target car will encounter the photons as arriving at $c+v$, and the photons returning from the target will travel at *c*, but the oscillation wavelength of the returned light photons will be shorter. The radar gun will show 55 mph as seen in Figure 1. If the police car starts moving and travels toward the oncoming car at 60 mph as the officer takes another reading, the radar gun will *still* show the speed of the oncoming car as 55 mph. The speed of the patrol car did not alter the speed of the light photons traveling to the oncoming car. The light photons still traveled at *c* to the car.

And, if the officer is curious while still traveling at 60 mph, he could point the radar gun at a highway sign next to the road, and he would again get "no reading," just as he did when he was parked. The light photons from the radar gun traveled to the highway sign at the same speed and oscillation wavelength as the light photons returned from the sign.

That is in full accord with de Sitter and Einstein.

II. Photons and Wavelengths

A photon is typically illustrated as shown on the left in Figure 3 below. In this paper I will use the versions on the right. The photon is a tiny particle that oscillates up and down (and/or side to side) as it moves. One complete oscillation is the photon's wavelength.

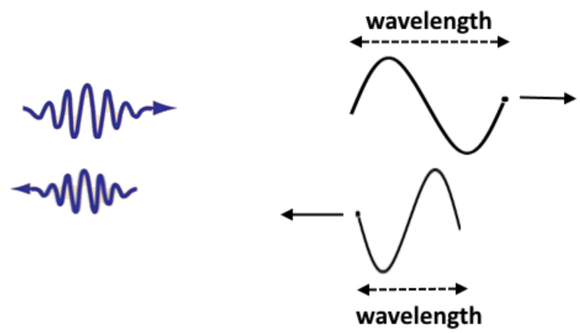

Figure 3

If a radar gun is pointed at an oncoming speeder from a parked patrol car, the outbound photon will have a longer wavelength than the returned photon. How does that happen?

First, the radar gun's transmitter sends out a burst of billions of individual photons like shotgun pellets from a shotgun, as shown in Figure 4 below.

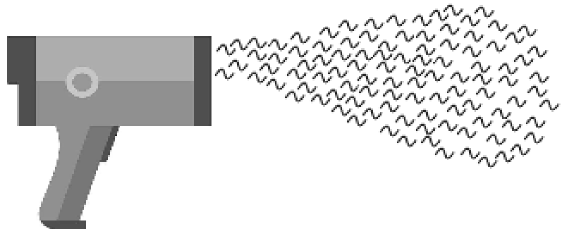

Figure 4

The billions of photons travel at the speed of light *c* in the direction of the target – but spreading out in a cone pattern (as shown above) along the way. As a result of the spreading, only a small fraction of the photons actually hit the target. And because the target is coming toward the emitter radar gun, the photons hit atoms in the target at the speed of light plus the speed of the target or $c+v$. When a photon hits an electron within an atom, the electron gains energy and jumps to a higher energy level. That creates an unstable atom, so the electron immediately drops back down to its normal level and a *new* photon is released in a random direction. Because the incoming photon was received at $c+v$, the new photon has a shorter oscillating wavelength and higher energy than the original. (The kinetic energy of the atom moving toward the photon also added to the energy of the new photon.)

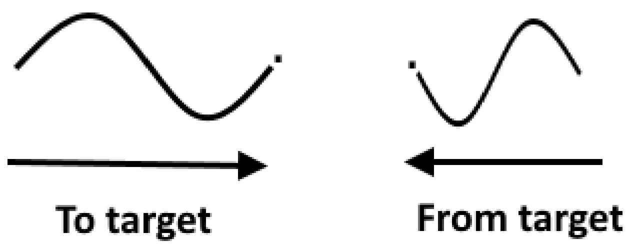

Figure 5

Figure 5 above provides an illustration of the outgoing, longer wavelength photon compared to the returned, shorter wavelength photon. One oscillation is one wavelength.

Since the atoms in the target car send the new photons off in all directions, only a tiny fraction of the photons in the original burst actually make it back to the radar gun. Meanwhile, the radar gun's transmitter has switched to receiver mode and receives back those photons. The receiving equipment within the gun ignores the countless photons of different photon frequencies such as those emitted by radios, light bulbs, the sun, and virtually every object, and only accepts those photons oscillating close to the frequency of the original photons (i.e., only the returning photons). Comparisons of oscillation frequencies are made, and a computer chip within the gun then compares the wavelength of the original photons it sent out to wavelength of the returned photons. The original photons were sent at *c* and with their original wavelength. The returned photons were emitted at the *c+v* wavelength. The computer chip within the gun subtracts the *c* wavelength from *c+v* wavelength and gets *v*, which is the speed of the oncoming car.

III. A Mathematics Problem

It seems that virtually every mathematician-physicist will argue that motion is reciprocal, which to them means that if the radar gun is in a stationary police car and the target vehicle is approaching at 60 mph, the view screen will show the same thing as when a the police car is moving at 60 mph and the gun is pointed at a *parked* car next to the road. Either way, the gun will display 60 mph. That's the way mathematical equations work.

But, as explained above, when it comes to radar guns and the speed of light, reciprocal mathematical equations do not relate to our real universe. There is a big difference between moving bodies when discussing and comparing how light is emitted versus how light is received. Because the speed of an emitter cannot be added to the speed of the light being emitted, the radar gun will theoretically be sending out photons of the same wavelength whether they are emitted from a parked patrol car or a moving patrol car traveling a 30, or 50, or 80 miles per hour. That means the emitted photons will *never* travel at *c+v*, they will travel at *c* in all those situations.

The speed of the *receiver*, however, greatly affects how light is received and measured. If the receiver (sometimes referred to as the "observer") is moving toward the emitter (which may be moving or not), the light photons will arrive at *c+v*, where *v* is the speed of the receiver. If the receiver is moving away from the emitter, the light photons will arrive at *c-v*. The arrival speed of the photons determines the wavelength of the new photons the atoms in the receiving body create and send back to the radar gun. If the receiver is moving toward the emitter at 90 mph, the photons the receiver emits will have a shorter wavelength than the wavelength of the photons it received. If the receiver is moving away from the emitter at 90 mph, the wavelength of the photons the receiver emits will longer than the wavelength of the photons it received.

IV. More Mathematics Problems.

Einstein's Theory of Special Relativity says that the faster an object is moving, the slower *time* will pass for that object. If the radar gun measures *miles per hour,* an hour will be *longer* while the radar gun is moving. That means that a second will also be longer. And that means when you assume the speed of light to be 300,000 kilometers *per second*, that second while moving will be longer than a second is measured while stationary. A car measured to be traveling at 100 miles per hour by a stationary radar gun will be measured to be traveling slightly less than 100 miles per hour by a moving ordinary radar gun.

Another problem with moving radar is that *light* is always emitted at 300,000 kilometers *per second*. So, if your second is longer because you are moving, the light you emit will travel slower than light emitted by a stationary emitter (or by an emitter traveling slower than you). It still travels at 300,000 kilometers per second, but it is a longer second.

Engineers have developed a two-emitter radar gun called simply "moving radar" which sends out two different radio frequency photon pulses at the same time, one toward the ground and the other toward the oncoming vehicle. When the moving radar emits photons toward the ground at a slower *c*, new photons will be returned by relatively stationary atoms in the earth at local *c* as local *c* is measured by that stationary body. Knowing the local speed of light emitted by stationary objects and the slower speed of light as emitted from the moving radar allows the moving radar to compute the correct speed of the oncoming car.

V. A Proposed Experiment

The above examination of the workings of radar guns suggests an interesting experiment. So far, the experiment described below is only a "gedanken" or "thought experiment," but it should be very easy and inexpensive to verify or disprove by real experiments.

Einstein's First Postulate to this Special Theory of Relativity states as follows:

> The same laws of electrodynamics and optics will be valid for all frames of reference for which the equations of mechanics hold good.

This postulate has generally been interpreted to mean that a person within one frame of reference will get the same results to an experiment as a person in another frame of reference performing an identical experiment, even if one frame of reference is stationary and the other is moving at a high inertial speed. It is only when the details of the two experiments are compared that it is discovered that a second is longer in the frame of reference that was moving. Therefore, even though both frames measured the speed of light to be 300,000 kilometers *per second*, the length of a second was different, which means the measured speed of light was also different.

The physics of radar guns seem to show another way that test results within a stationary frame are actually different from test results in a moving frame, even if though the same laws of electrodynamics and optics are used, and even though the same equations of mechanics are used.

In the book Einstein wrote with Leopold Infeld[5], Einstein and Infeld describe what happens when a light bulb is turned on in the center of a moving laboratory.

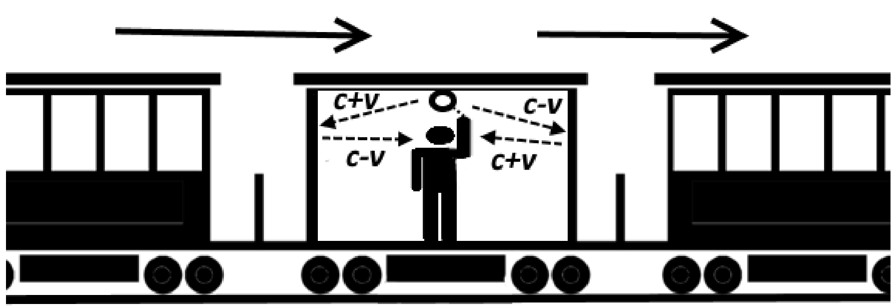

Figure 6

In Figure 6, the moving laboratory is on a train that is traveling at high speed (*v*) from left to right. When the light above the observer is turned on, the rear wall of the laboratory is moving toward the oncoming light at *v*, so the light encounters the photons at *c+v* and that wall is illuminated first. However, the newly created photons emitted at *c* from the illuminated rear wall have to catch up with the observer as he moves away (at velocity *v*) from the point in space where those new photons were created. Meanwhile, the opposite happens with the front wall. Light takes longer to reach that wall because it is moving away from the oncoming light photons (*c-v*), but the new photons that are created take less time to reach the observer who observes those photon as arriving at c+v. The result is that the observer sees both walls illuminated at the same time. But, what would happen in that same moving laboratory if a *radar gun* was pointed at the rear and front walls?

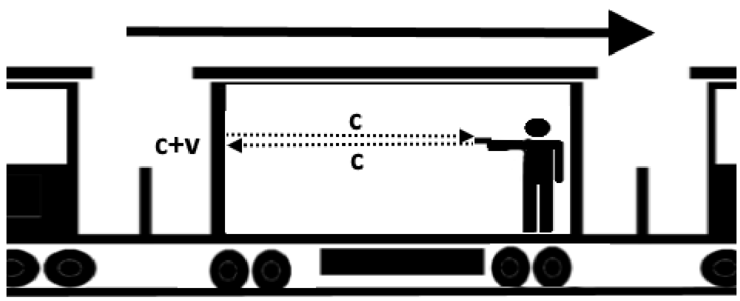

Figure 7

Figure 7 shows an observer with a radar gun firing the gun at the rear wall on a train that is moving from left to right at velocity *v*, which we can assume to be 60 mph. Since the movement of the emitter does not add to the speed of the photons emitted, the photons travel to the wall at *c*. However, the rear wall is moving toward the oncoming photons at velocity *v* (i.e., 60 mph), thus the photons hit the atoms in the rear wall at *c+v*. New photons with higher energy and a shorter oscillating wavelength are then emitted by atoms in the wall back to the radar gun at velocity *c*. The radar gun compares the oscillating wavelength of the photons it emitted to the wavelength of the returned photons and calculates the speed of the laboratory to be 60 mph.

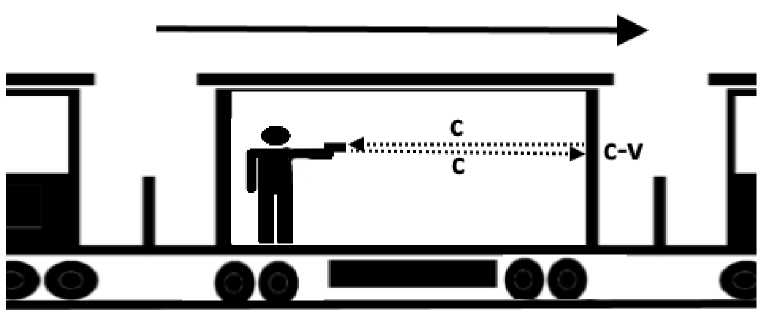

Figure 8

When the observer moves to the opposite end of the laboratory on the train, and when he shoots the radar gun at the front wall, the front wall encounters the photons traveling at *c-v* and the atoms return photons with less energy and a longer wavelength. The radar gun compares the wavelength of the photons it emitted to the wavelength of the photons it received back and calculates the speed of the train to be *negative* 60 mph.

This experiment says that an observer within an inertial frame of reference *can* determine if he is moving or not relative to the ground outside by using a radar gun, and he or she can even tell in which direction the reference frame is moving. This is *not* movement relative to any imaginary ether (or aether), it is movement relative to the earth under the train. While such movement is relative, it is in no way *reciprocal*. Nor is the movement of the earth relative to the sun reciprocal. Nor the movement of the sun to the movement of the Milky Way Galaxy. Nor the movement of the Milky Way Galaxy to the nearby Andromeda Galaxy. If some stationary point is needed to measure movement of other galaxies, the point where the Big Bang occurred should serve that purpose. So, it can be stated that all movement in our observable universe is relative to that point. The moving car is moving relative to the stationary radar gun, and they may both be moving relative to the sun, but radar guns only measure the speed of the target car relative to the point on the surface of the earth where the gun was located when fired.

VI. Conclusion

The explanations above clearly conflict what is written in most college physics textbooks. Such textbooks typically describe light as waves, and they describe the Doppler effect as working the same way whether the emitter is moving toward an observer or the observer is moving toward the emitter.[6] Very few (if any) textbooks contain this anything like this quote from Richard Feynman's book "*QED*":

> "I want to emphasize that light comes in this form — particles. It is very important to know that light behaves like particles, especially for those of you who have gone to school, where you were probably told something about light behaving like waves. I'm telling you the way it does behave — like particles.[7]

Einstein said somewhat the same thing, but it was in his typical, much more convoluted and less easily deciphered way:

> Indeed, it seems to me that the observations of "blackbody radiation," photoluminescence, production of cathode rays by ultraviolet light, and other related phenomena associated with the emission or transformation of light appear more readily understood if one assumes that the energy of light is discontinuously distributed in space. According to the assumption considered here, in the propagation of a light ray emitted from a point source, the energy is not distributed continuously over ever-increasing volumes of space, but consists of a finite number of energy quanta localized at points of space that move without dividing, and can be absorbed or generated only as complete units.[8]

There can be no doubt that light consists of photons, not waves, and when radar gun photons are emitted toward a target or are returned from a target they are actually a scattering of oscillating particles that are totally unlike a wave.

Furthermore, a moving light source emits photons at the same speed (the local speed of light) whether the photons are emitted behind the moving source, ahead of the moving source, or at right angles to the direction the source is moving. Every photon travels at local *c* and has the exact same wavelength (assuming it was created by the same type of atom). The only difference is that, because the emitter is moving, the photons emitted behind the emitter will be more widely scattered than the photons emitted in the direction the emitter is moving, as illustrated in Figure 9 below.

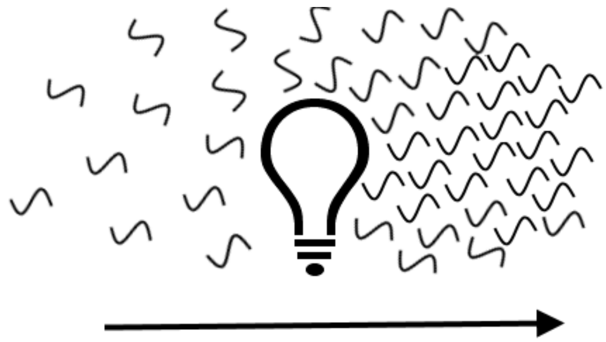

Figure 9

A radar gun will receive back more photons from an oncoming target than an identical target moving away from the gun. However, a radar gun will also receive back more photons from a polished car than a rusty car, and it will receive back more photons from a large truck than from a small car. So, the number of photons received back is not important – as long as there are enough to compute the target's speed.

Most importantly, a moving emitter does *not* emit higher frequency waves in the direction of movement as indicated in the quote below from a popular physics textbook:

> A police radar unit employs the Doppler effect with microwaves to measure the speed *v* of a car. A source in the radar unit emits a microwave beam at a certain (proper) frequency f_0 along the road. A car that is moving toward the unit intercepts that beam but at a frequency that is shifted upward by the Doppler effect due to the car's motion toward the radar unit. The car reflects the beam back toward the radar unit. Because the car is moving toward the radar unit, the detector in the unit intercepts a reflected beam that is further shifted up in frequency. The unit compares that detected frequency with f_0 and computes the speed *v* of the car.[9]

Except for using waves instead of particles, the first part of that quote is generally correct. The Doppler effect does apply when the *target* car encounters the oncoming light. However, the second-to-last sentence in that quote says that because the target car is moving toward the radar gun, the waves the target sends back will be "*further* shifted up in frequency" due to *the target's* Doppler effect. That is untrue. The few photons that return to the radar gun will not be in any kind of wave pattern, much less one that is *further* Doppler shifted.

Many college text books also incorrectly proclaim that the speed of light is the same for the emitter as for the observer, meaning that the observer (or target) never encounters light arriving at *c+v* or *c-v*. It is a demonstrably *incorrect* interpretation of Einstein's Second Postulate, a subject which I wrote about at length in another paper.[10]

The motion of objects in our universe may most easily be described as being relative to other objects, but normal motion is *not* reciprocal. In his paper introducing Special Relativity[11], Einstein claimed he made the ether (or aether) "superfluous" for physicists measuring motion, but unfortunately he failed to give mathematicians a replacement. Today it seems that the point where the Big Bang occurred could be considered as a replacement.[12]

VII. **References**

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