Quantum-Refraction Thruster

W. Scott Smith
scott712@hotmail.com

No conceivable rocket could possibly take anyone to the second-nearest star in a single human lifetime. This is because rockets require too much reaction-mass, energy and expense. This paper addresses the Mission of providing an inexpensive Propellantless Space Drive by using the energy and momentum of the EM Quantum Flux to drive a novel Quantum Thruster. The Refractive Quantum Thruster will also provide a straightforward method of harvesting clean, useful mechanical energy from the Quantum Vacuum. This will replace all other energy sources, including fossil fuels and nuclear energy.

- Existing experiments support the concept.
- Existing Physics can be interpreted to reconcile the conflicts with our usual expectations.
- This can be built and implemented using existing techniques.

The Minkowski-Abraham so-called "debate" has been discussed for more than a century. Minkowski held that the momentum of light increases when light enters a refractive material. He held that it increased by a factor that is directly equal to the refractive index. Abraham held that the momentum of light decreases when light enters a refractive material, by a factor that is equal to the inverse of the refractive index. There are many experiments that exemplify one theory or the other theory. For the present purposes, it is sufficient to simply acknowledge that one can produce either result, depending on what kind of experiment one chooses to do. This discussion will focus on Minkowski Momentum.

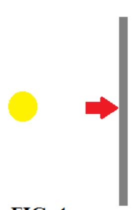
FIG. 1

Fig. 1 shows a light shining on a mirror. The red arrow indicates how hard the light is hitting the mirror. Fig. 2 shows the same light shining on the same mirror, but this time the mirror is inside a refractive medium. The red arrow is larger because the same light has greater momentum inside the refractive medium than it has outside of the refractive medium. This has been experimentally confirmed for many years.

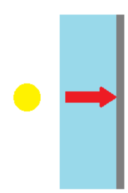
FIG. 2

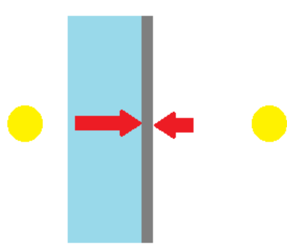
FIG. 3

Obviously, by combining Figs. 1 and 2, it is seen that the two-sided mirror in Fig. 3 will experience a net-force to the right since the right-pointing arrow is longer than the left-pointing arrow. This experiment has never been done with both parts simultaneously, probably because this conclusion is so obvious.

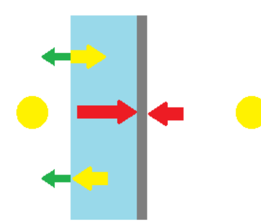
FIG. 4

Minkowski postulated that the extra momentum in the direction of the mirror was compensated-for by the forces of the light as it entered and exited the refractive medium. The yellow arrows in Fig. 4 indicate whether the light is entering or exiting the refractive material. Green arrows represent this imaginary compensatory refraction-force. In other words, if Minkowski were correct, the overall system would be in balance and there would be no overall net force. This is because the left-pointing red and green arrows are equal and opposite to the one right-pointing red arrow.

Fig. 5 shows what really happens. The refractive forces, shown by the green arrows, always act toward the refractive medium both when light enters and when it exits the refractive material. In other words, these refractive forces supplement the net force that is acting on the mirror; and there will be a net force acting on the entire mirror/refractive-medium system.

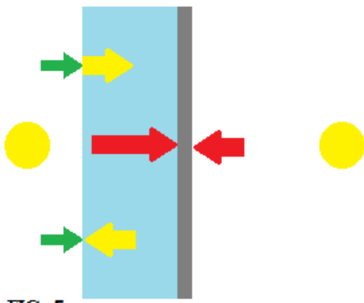

FIG. 5

How can this be? The directions of the refraction forces are like those forces of a car that is entering a slow-speed zone. As the car decelerates, it exerts forward directed forces on the road. These forces are directed into the slow-speed zone. When the car accelerates as it leaves the slow-speed zone, again, it exerts forces on the road that are directed back into the slow-speed zone, just as in Fig. 5. .

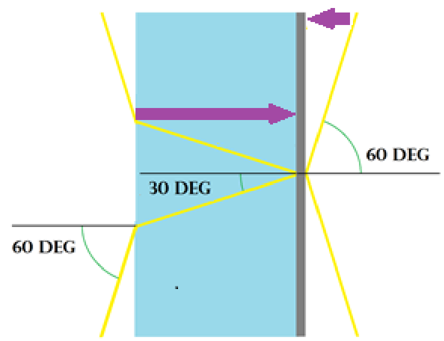

FIG. 6

Fig. 6 illustrates what happens to a typical pair of equal and opposite light beams. Both beams approach the system at 60 degree angles; however, the ray on the left is refracted so that it strikes its side of the double mirror at a more-normal 30 degree angle. The refracted ray strikes its side of the mirror harder than the ray that strikes the bare side of the mirror; this is because its normal momentum component, shown by the longer purple arrow, is longer than the momentum component of the non-refracted ray, which is shown by the shorter purple arrow.

Below, F is the force of a ray of light striking a mirror at a zero-degree angle. The momentum of F is equal to the momentum of the other light rays that are shown in Fig. 6. The forces of the other rays acting on the mirror are

F cos 30 degrees = 0.8660 F   and   F cos 60 degrees = 0.5000 F.

This leaves a net force of: F cos 30 degrees - F cos 60 degrees = 0.3660 F.

The light beam that enters the refractive material is like a car with linear momentum, coasting into a curve from a straight length of road. While it is in the curve, it has angular momentum; after it leaves the curve and enters a second straight length of road, it has linear momentum, again. The light exerts forces on the refractive material and the refractive material exerts forces on the light, just as the wheels of the car and the road exert forces on each other. Each wave-front of the light pivots around the refraction force of the material as it slows down one side of the wave-front then slows down the opposite side of the wave front, a short time later.

It is generally thought to be impossible to obtain a net thrust from an EM field that is equally energetic in all directions; therefore, the Phase I priority is to perform the experiment in Fig. 6; it has the potential to demonstrate a net force from a proxy of an EM field that is equally energetic in all directions by using refraction. Equal and opposite laser beams will be directed at two sides of a two-sided mirror, as in Fig. 6. One side of the double-mirror will be covered with a refractive material. The mirror will be mounted on a torsion balance setup. This arrangement will simulate the equal and opposite forces that act directly on most objects that are in an EM field that is equally energetic in all directions such as the EM Quantum Flux. Many people would argue that this experiment is unnecessary because it "obviously" violates the Laws of Motion and/or the Laws of Thermodynamics or violates Momentum Conservation; however:

- This does not violate the Action and Reaction Principle because it, instead, obeys the First Law of Motion that requires an object to move if it is acted upon by an outside force, which in this case is the radiation pressure of the EM Quantum Flux. It obeys the second law of motion; the Thruster accelerates in response to a net force. It does not violate Momentum Conservation because the radiation pressure of the EM Quantum Vacuum is imparting outside momentum.

- The Thruster is not a closed system; outside energy and momentum are continuously provided to it; in other words, we are not getting something out of truly-nothing. It is entirely possible that the Thruster and similar natural processes are depleting the total energy of the Quantum-Flux; but in-principle, this is no different than a coal plant depleting the World's supply of coal; therefore, conservation laws are not violated.

- Entropy is not violated because order can arise out of disorder as long as there is an outside energy source that pays the price; a growing plant is an example of this.

- The Refractive Thruster is a proper Thermodynamic System because high energy-density, low entropy VUV wavelengths of the EM Quantum Flux serve as a high-potential reservoir; they will be converted into mechanical energy and high-entropy, low energy-density heat which is discharged into a low-potential reservoir, the thermal sink of the surrounding environment.

The proposed Quantum Refraction Thruster can be built using Sputtering technology to lay down successive layers of refractive materials and metals. Layers of Thrusters will be separated by a low refractive-index material that will permit the Quantum Flux to form inside of it. Adding up the radiation pressure of the Quantum Flux from 40 nm on up, yields 3.2 k Pa per layer. At this rate, 32 layers would give about one atmosphere of pressure. Of course actual performance would be some part of this theoretical maximum pressure. Nonetheless, practical thrust from a compact metamaterial is probably within reach of a modest research effort using the equipment materials and photonics of today. It will probably be comparable in cost to microprocessors since it can probably be made with the same equipment.

Many layers of Thrusters will cover two panels that are mounted so that they can be independently pointed in any direction. Whenever the panels face the same direction, this is maximum throttle. Whenever the panels face in opposite directions they are at zero throttle. They can of course adopt any intermediate position to attain any intermediate throttle setting in any direction. They can also be positioned to cause any desired rotation.

Someday, vehicles will accelerate constantly at a rate of one-g and so they will experience a constant Earth-like onboard gravity. People will travel to Mars in ten days or less. Near-light speeds may be reached within a year using a continuous, one-g acceleration.