Radiation Friction: Shedding Light on Dark Energy

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In 1909, while working on the quantum nature of light, Einstein developed the notion of "radiation friction." Radiation friction becomes significant when the temperature of the radiation and the velocities of the galaxies moving through it are great. Here I suggest that the decrease in the velocity-dependent radiation friction occurring as a result of the expansion of the universe may be the cause of the observed acceleration of the expansion of the universe. Interestingly, the decrease in the density of light energy and the apparent domination of dark energy, become one and the same.

1. Introduction

Over the past two decades, observations of the relationship between the luminosity (m) of type Ia supernovae and the redshift (z) of their host galaxies have provided strong evidence that the expansion of the universe is accelerating [1, 2]. The cause of the acceleration however remains a mystery [3]. Naming one of the possible causes of acceleration "dark energy" may be a first step in describing the acceleration [4], but is a panchreston that gives no deeper understanding to the problem since there is no independent evidence of the properties or even the existence of dark energy [5]. Indeed the press release for the 2011 Nobel Prize in Physics [6] awarded to Saul Perlmutter, Brian Schmidt and Adam Riess for discovering the acceleration of the expansion said, "*The acceleration is thought to be driven by dark energy, but what that dark energy is remains an enigma - perhaps the greatest in physics today. What is known is that dark energy constitutes about three quarters of the Universe. Therefore the findings of the 2011 Nobel Laureates in Physics have helped to unveil a Universe that to a large extent is unknown to science. And everything is possible again*." Here I present a heuristic point of view based on a mechanical picture of the universe which suggests dark energy may be equivalent to a decrease in the density of light energy.

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2. Results and Discussion

I have recently reinterpreted the three crucial tests of the General Theory of Relativity [7]: the precession of the perihelion of Mercury [8], the deflection of starlight [9], and the gravitational redshift [9] in terms of Euclidean space and Newtonian time. I have also reinterpreted the relativity of simultaneity [10], the optics of moving bodies [11,12], the inertia of energy [13] and the reason charged particles cannot exceed the speed of light [14] in terms of the second order relativistic Doppler effect occurring in Euclidean space and Newtonian time. Consequently, here I view the redshift of the galaxies, which is the observational evidence for the expansion of the universe, to be a relativistic Doppler shift that takes place in Euclidean space and Newtonian time. I further assume that the recession of the galaxies is a result of a repulsive force that was initiated at the big bang ($F_{repulsive}$). The enormous repulsive force that initiated the recession of the galaxies is counteracted in part by the universal force of gravity ($F_{gravity}$) that tends to draw the galaxies together. If the density of matter that currently comprises the receding galaxies was greater in the past, the kinetic energy per unit mass ($\frac{1}{2}v^2$) of the universe must be greater than the gravitational potential energy per unit mass ($G\frac{M}{r}$) of the universe and the total energy per unit mass (E) of the matter in the universe must be positive:

$$E = \frac{1}{2}v^2 - G\frac{M}{r} > 0 \quad (1)$$

Where, G is the gravitational constant, M is the mass of matter in the universe, r is the radius of the universe and v is the velocity of the receding galaxy at distance r.

The observation that the galaxies are not only moving apart but that the movement is accelerating indicates that the net force per unit mass ($\frac{F_{net}}{m}$) involved in the large scale structure of the universe is positive:

$$a = \frac{d^2s}{dt^2} = \frac{F_{net}}{m} > 0 \quad (2)$$

Where, a is acceleration through Euclidean space (s) and Newtonian time (t).

An increase in the net force per unit mass can result from an increase in the repulsive force initiated at the big bang and/or a decrease in a force that counteracts the repulsive force. The force of gravity counteracts the repulsive force, slowing the expansion, but any inequality of the two forces will result in an acceleration or a deceleration, depending on which is greater. If the two forces are and were always equal, no acceleration or deceleration of the receding galaxies would be observed. Under these conditions, an acceleration of the recession of the galaxies could result from a decrease in a postulated frictional force ($F_{friction}$).

$$\left[F_{repulsive} - F_{gravity}\right] - F_{friction} = m\frac{dv}{dt} \quad (3)$$

The frictional force would resist both the repulsive force and the force of gravity in a velocity-dependent manner.

In Book II of the *Principia*, Newton [15] wrote about the ubiquity of friction. Since Newton's time, the existence of non-Newtonian viscous solutions whose viscosity either increases with velocity (e.g. a solution of starch, which is dilatant) or decreases with velocity (e.g. ketchup, which is thixotropic) have been discovered and studied [16]. I have shown that at any temperature greater than absolute zero, as a result of a Doppler shift expanded to second order [10], photons inevitably and ubiquitously act as a dilatant solution and produce a velocity-dependent counterforce [14]:

$$F_{friction} = D\ T^2\ \frac{v^2}{\sqrt{1-\frac{v^2}{c^2}}} \quad (4)$$

Where, D is a drag coefficient, T is the absolute temperature of the radiation, v is the velocity of the moving body and c is the vacuum speed of light.

The velocity-dependent friction caused by this counterforce can be seen to increase the apparent mass of a body [17], demand irreversibility [18], and prevent the velocity of charged bodies from exceeding the speed of light [14]. A time-dependent decrease in this "radiation friction" may be responsible for accelerating the expansion of the universe.

The inevitable existence of the counterforce produced by light on a body moving though radiation has been well studied over the last century [14,16-41] although a complete equation necessary to quantify the counterforce produced by radiation against any kind of optical body is still wanting [34,38]. Nevertheless, an optomechanical counterforce exists at any temperature above absolute zero and thus radiation friction is inevitable and ubiquitous [18]. Einstein [41] wrote, "*radiation will exert pressure on both sides of the plate. The forces of pressure exerted on the two sides are equal if the plate is at rest. However, if it is in motion, more radiation will be reflected on the surface that is ahead during the motion (front surface) than on the back surface. The backward-acting force of pressure exerted on the front surface is thus larger than the force of pressure acting on the back. Hence, as the resultant of the two forces, there remains a force that counteracts the motion of the plate and that increases with the velocity of the plate. We will call this resultant "radiation friction" in brief.*" Since the radiation energy density of the universe has decreased with the fourth power of the radius [42], it is possible to divide the history of the universe into epochs ranging from when the radiation friction was substantial towards ones when the radiation friction becomes negligible. Henry et al. [43] and West [44] realized that the radiation friction caused by the cosmic radiation background would decrease as the universe expanded.

When stars and galaxies began to form, the universe had a temperature in the thousands of Kelvin degrees range and the cosmic background radiation could be described as cosmic visible wave background radiation. As the universe expanded, this would have given way to a cosmic infrared wave background radiation, and thence to the currently observable cosmic microwave background radiation; which, in the future, can be expected to give way to a cosmic radio wave background radiation. With each decrease in radiation density and increase in wavelength, the optomechanical counterforce decreases [14]. As a consequence of the relationship between force and acceleration given by Newton's second law, the observed acceleration of galaxies could formally be a consequence of a decrease in the force due to radiation friction.

Moreover, since the radiation friction depends on the square of the velocity of the moving body [14], faster moving galaxies formed in the early universe would have experienced more friction in a standard radiation field than would slower moving galaxies formed in the later stages of the evolution of the universe. Since an optomechanical counterforce that resists the recession of the galaxies depends on both the velocity of the galaxies and the temperature of the radiation through which the galaxies recede, the radiation friction decreases even more rapidly than would be expected from the expansion alone.

While the model for acceleration presented here is speculative, it does not require the "*bizarre stuff*" [45] that a model based on dark energy requires. The time-dependent decrease in the force of radiation friction is an alternative mechanism to the time-dependent dominance of the mysterious dark energy. Indeed, an increase in darkness is equivalent to a decrease in light. Since the accelerating expansion of the universe is the best evidence for the existence of dark energy, it may be productive to see whether known entities such as photons with their friction-inducing properties [46] can replace the mysterious, enigmatic and puzzling entity known as dark energy. The relationship between the cosmological constant and the accelerating expansion of the universe is also being discussed [47-50]. Einstein [51] introduced the cosmological constant (λ) to account for a kinematic force that would prevent the expansion of the universe. In the scenario presented here, such a constant can be interpreted as the drag coefficient that relates the frictional force of light to the relative velocity of the galaxies and the temperature of the radiation.

While this year, many journals commemorate the 100th anniversary of the General Theory of Relativity, for me this year also commemorates Einstein the original thinker, Einstein the skeptic, and Einstein the man. In a celebration of the 50th anniversary of the Special Theory of Relativity, Max Born [52], a friend and scientific adversary of Einstein's, wrote, "*But for me—and many others—the exciting feature of this paper was not so much its simplicity and completeness, but the audacity to challenge ISAAC NEWTON'S established philosophy, the traditional concepts of space and time.*" Let's challenge today's established philosophy of physics based on the "*assumption of no friction*" by revisiting Albert Einstein's concept of radiation friction.

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