Cosmic Redshift Elegantly Explained by Minkowski Space-Time and General Relativity

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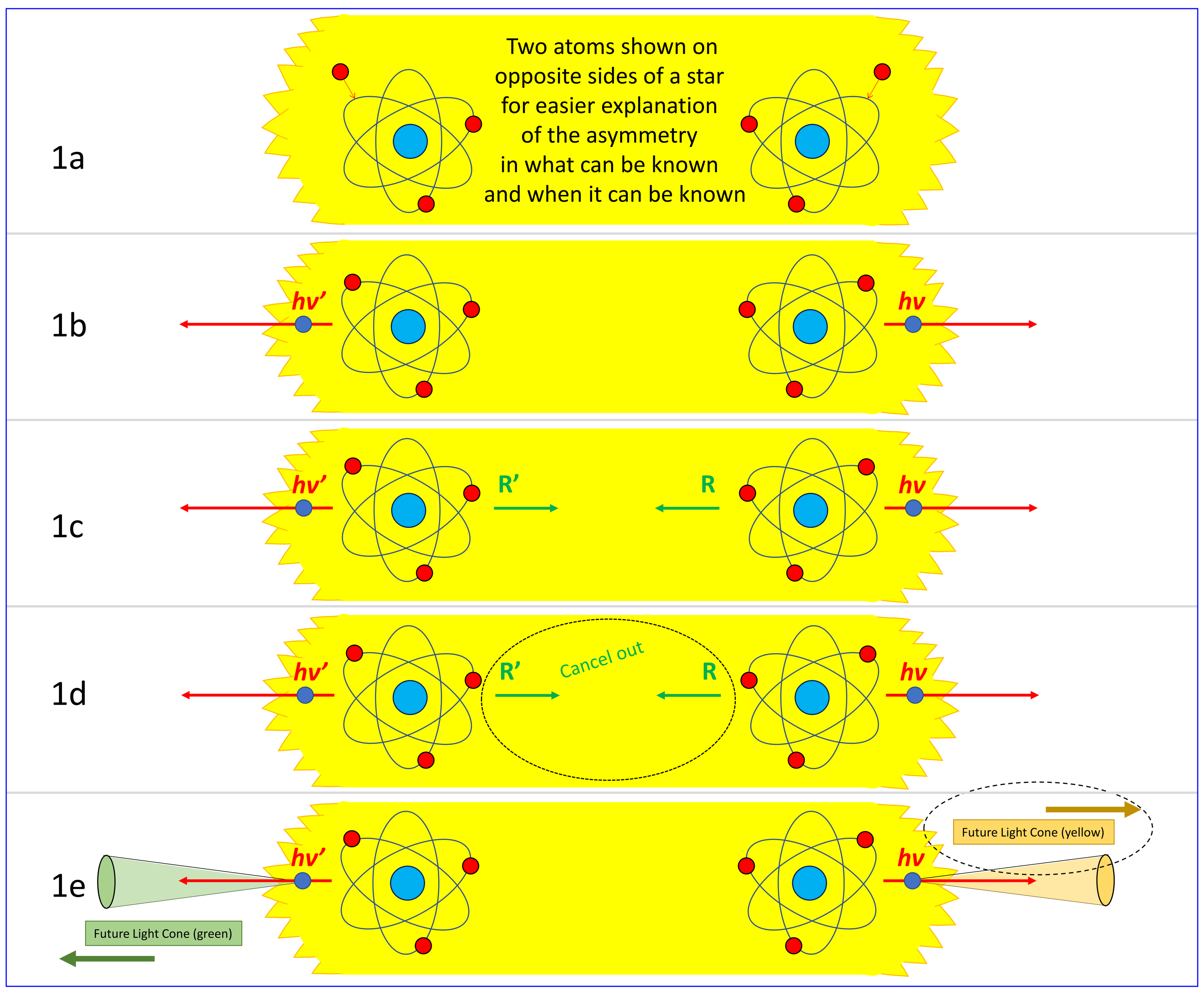
Abstract

An elegant explanation for the phenomenon of cosmic redshift is presented that relies only on the conservation of energy and basic physics. Central to this explanation are answers to two questions: 1) *when and where* can information about an event be known; and 2) do asymmetries arise in space-time that can affect our observations?

General Relativity demands conservation of energy in all its myriad forms. The stress-energy tensor defines an equivalence between mass, temperature, pressure and motion which is illustrated by Einstein's equation, $E=mc^2$. The interchangeability of energy and mass implies that the gravitational attraction between masses can be viewed, equivalently, as a gravitational attraction between their energies.

By extension, gravitational attraction exists between photons. This is because each has energy (e.g., energy of hν). Gravitational attraction of photons to a huge mass is the central concept underlying the theory of why black holes are "black" and gravitational lensing. Cosmic redshift is exactly the same concept, except that it occurs over vast distance and the equivalent of mass that the photon finds "in its rear-view mirror" accumulates one passing photon at a time. No new physics is needed.

Effectively, cosmic redshift is hypothesized to arise as a consequence of photons finding energy in their past that could not be knowable in advance. *When and where* a photon's energy becomes known thus creates an asymmetry.

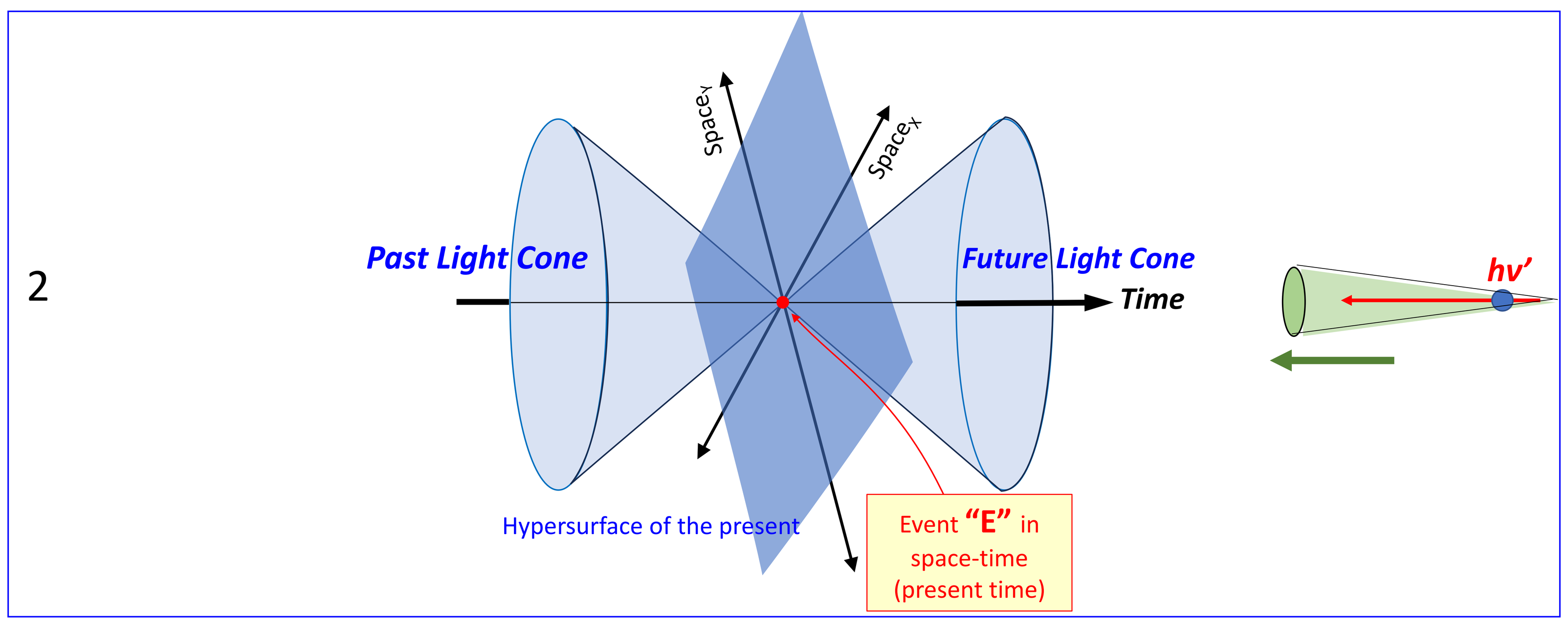


A Dual Persona of Gravity is Energy

The fluid translations between energy and mass from Einstein's equation implies that gravity can be viewed not only as an attraction of mass to mass, but also as a manifestation of the attraction of energy to energy – where planets and stars are just highly concentrated 'point' sources of energy. The energy in photons can be gravitationally attracted to other photons – at least those photons that they become aware of.

Cosmic Redshift: A Consequence of the Conservation of Energy

Figures 1a through 1e show two photons emitted in opposite directions (shown emitted from opposite sides of a star). The photons are emitted with an energy *hv* and *hv'*. According to the conservation of energy, these emissions create equivalent recoil energies, R and R' (e.g., Mössbauer effect) which cancels out. The two photons (*hv* and *hv'*), travelling in mirror-opposite directions will create an asymmetry in how much energy can be known to be traveling in each direction. This asymmetry underlies the observation known as cosmic redshift.



Minkowski Space-Time

Figure 2 shows the key concept of Minkowski space-time where an event, "E," – which is a point in space at a particular instant of time – can eventually affect things in its future and which has been affected by events in its past. These effects are constrained in spatial dimensions by the speed of light. The event, E, can only have been affected by events that occurred in its past (constrained by the speed of light). The future events that can be impacted by the event, E, and the past events which have impacted the event, are within the future light cone and past light cone, respectively.

Events occurring outside of these light cones, regardless of how powerful, cannot affect events within either the past or future light cones. This is because the speed of light limits the ability to communicate via electromagnetic radiation and gravitational waves. [Quantum entanglement, which suggests faster than light information flow, seems energy neutral.]

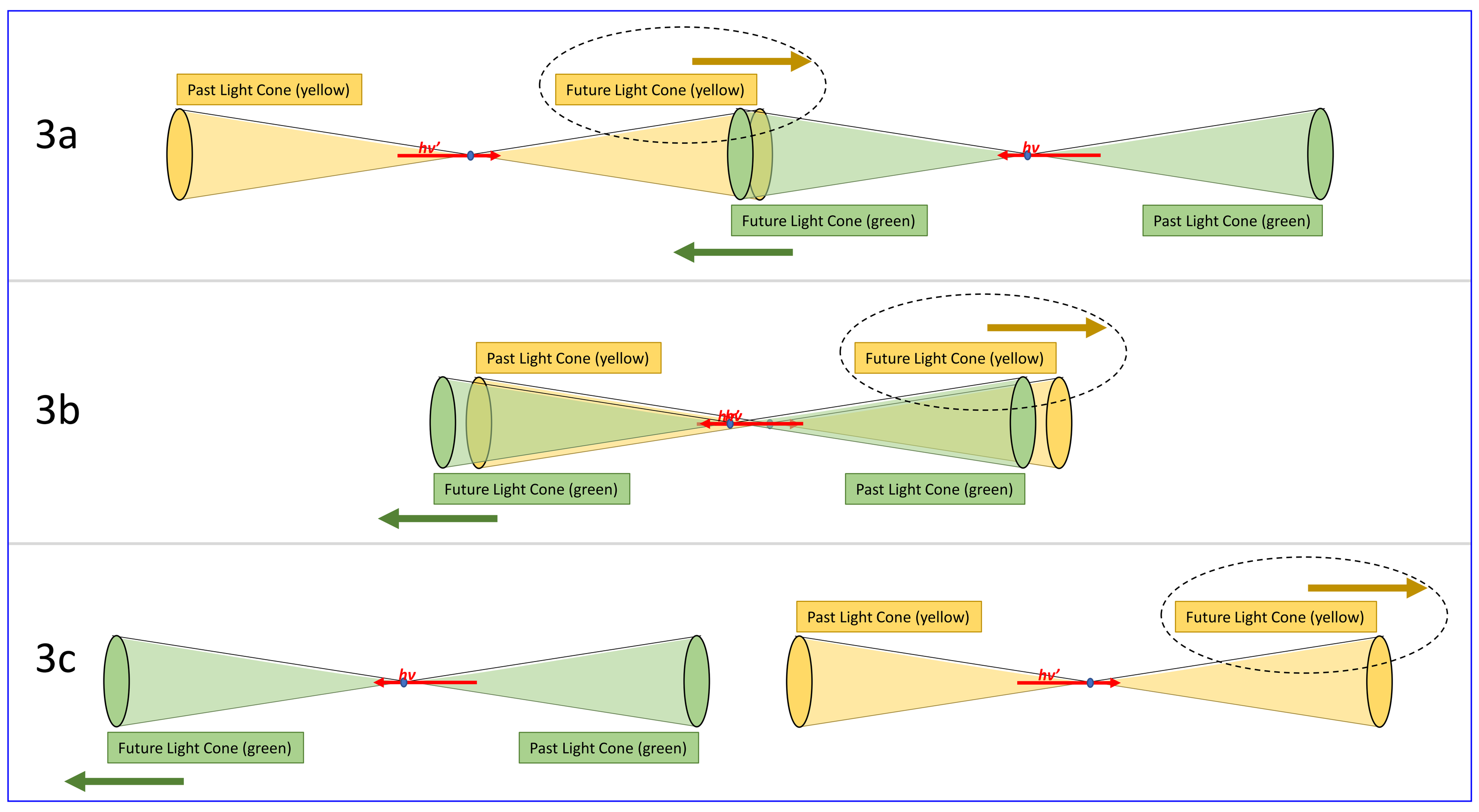
For example, the photon with energy *hv'* in Figure 2 (green cone) cannot have an effect on the event E because the photon is in the future light cone of event E. Only when they pass each other – and each other's past light cones overlap – can they affect each other. This creates an asymmetry regarding *when and where* energy can be known.

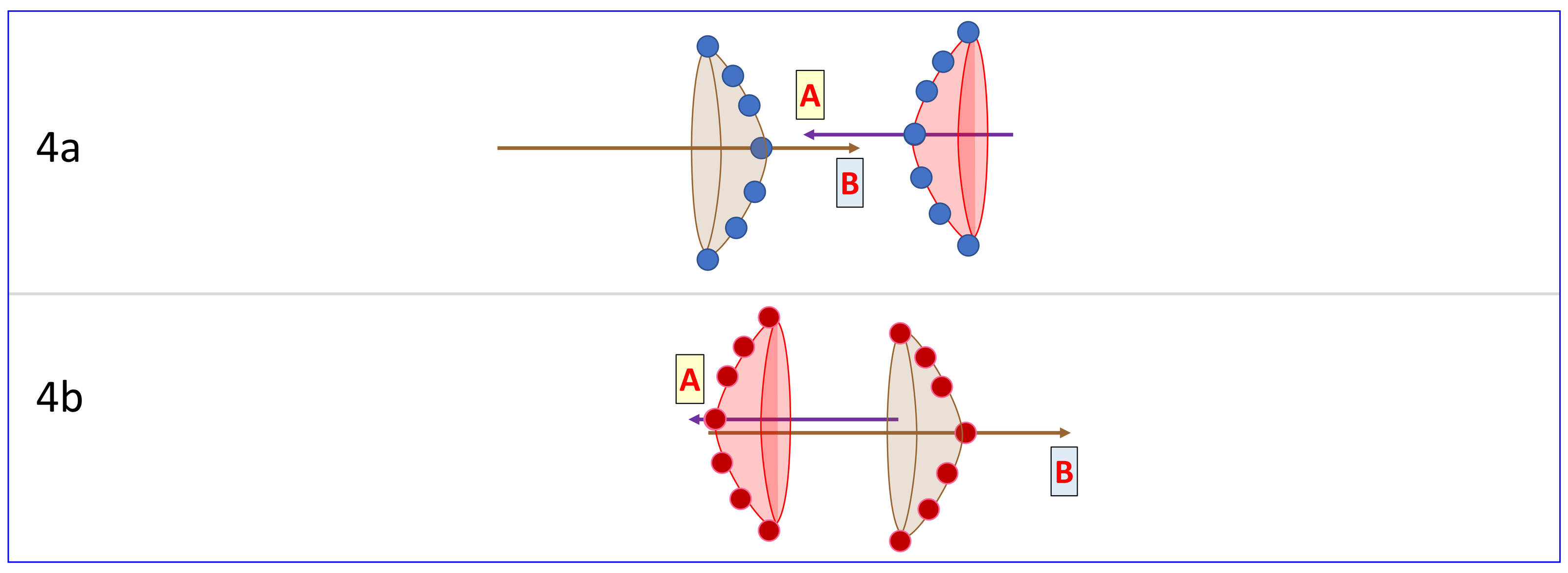
Passing Photons Exchange Kinetic Energy for Gravitational Potential Energy

As shown in Figures 3a through 3c, when the photons, originally traveling into their respective future light cones, pass into each other's past light cone they will overlap and only then they will then become "aware" of each other. Once these photons enter each other's past light cone, these countervailing photons will elastically exchange a portion of their kinetic energy for an equal amount of gravitational potential energy. This exchange of energy (e.g., loss of kinetic energy) appears as a redshift of the wavelength of the photon. Conceptually, this is identical to the redshift of a photon emitted from a black hole toward the event horizon. Because every photon has its own unique history, every photon will have its own unique sense of space-time curvature. In other words, its unique sense of space-time will be relative.

Every photon that enters another photon's past light cone – will appear as energy in that past light cone. The sudden appearance of this additional energy (e.g., energy not knowable when it was in its 'future light cone') acts as a source of gravity and increases the drag from the gravity-well behind it – that the photon needs to climb out of. This asymmetry creates minute gravitational redshifts that accumulate over vast distances – and innumerable photon encounters – thus creating a linear redshift vs. distance. "Lyman Alpha Forests" in the spectrum of very remote objects are attributable to this gradual loss of spectral energy as intergalactic hydrogen absorbs specific photon energies in a shifting spectrum.

Photons are aware of pre-existing mass and energy which can result in a net blueshift or redshift as a photon approaches the gravity well of a large galaxy cluster or departs from one, respectively (e.g., the Integrated Sachs-Wolfe effect). While the photon may respond to the pre-existing distribution of mass and energy, it cannot be aware of the energy in an emitted photon traveling toward it – which is in its future light cone. This was shown in Figure 2.





Gravitational Attraction Creates Redshift Without Chromatic Distortion

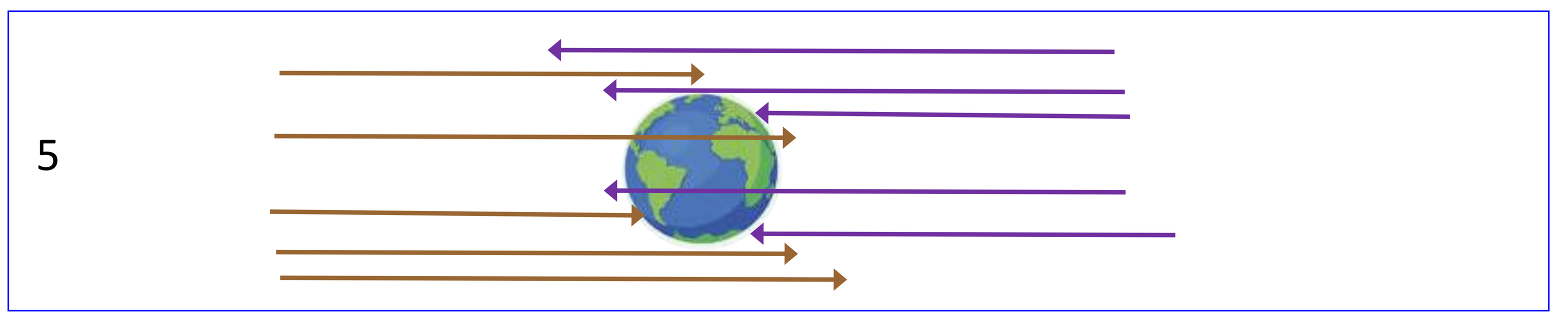
Gravitational attraction between photons has been discussed in the literature since the 1930s. Currently, the effect of the gravitational attraction of photons is of interest in the field of lasers because this effect may become a disruptive source of distortion in high-speed laser communications at earth-scale distances.

Figures 4a and 4b show two passing photon fronts where the gravitational attraction creates an exchange of gravitational energy for kinetic energy exchange without chromatic distortion. Other explanations such as those proposed by Fritz Zwicky were based upon serial absorptions and reemissions (e.g., "tired light"). This process was criticized because it would create blurring and chromatic distortion over the course of billions of years of travel and innumerable cycles.

The hypothesis presented here uses the concept of the sudden presence of additional gravity (energy) behind the object as the source of redshift – which would be frequency-independent and would not create a chromatic distortion.

Redshift as Seen From Earth in All Directions

Figure 5 shows two groups of light rays approaching the earth from opposite directions. The approaching photons from the right may, or may not, be aware of all matter and energy in the universe, but they cannot be aware of the energy in the photons approaching from the opposite side until their past light cones overlap. Those photons will only learn about the energy in the approaching photons once they pass by each other. Once they become aware of the energy that has passed by, they will become gravitationally attracted to each other and they will exchange gravitational potential energy for kinetic energy. Assuming recoil energies R and R' in Figure 1 cancel out, <u>a photon can never "catch-up-to" the mirror-opposite photon emitted in Figure 1e</u>. The loss of kinetic energy would lower the frequency, or redshift, both photons.



Photon-Photon Interactions Differ from the Mechanics of Slow Speed Interactions

Two approaching photons that are both moving at the speed of light are undetectable to each other because they are both in each other's future light cone. The photons may be aware of the energy that was the source of the approaching photon's energy, but it cannot be aware of the event that imparted energy to the photon as *hv* and the corresponding recoil energy R (Figure 1). A photon will never "catch-up" to the mirror-opposite photon of the photon it just passed (Figure 1e).

Objects interacting at speeds much less than the speed of light will respond to the effects of the mass / energy / gravity of the interacting objects. These mutual interactions make the mechanics elastic and symmetric. In the case of the baseball ejected from earth, as shown in Figures 6a through 6c, the baseball will have, from the baseball's perspective, a component of acceleration toward the approaching asteroid that will partially counteract the effect of the earth's gravity (6a and 6b). Once the baseball passes the asteroid (6c), the acceleration of the baseball will be toward the combined earth and asteroid system. In this example, all of the energy within the system will have been known in advance and the energy will be conserved. Asymmetries caused by past and future light cones play no role in this "slow-speed" interaction.

***"Seek elegant solutions"* - Mahmoud A. Melehy**