Discrete Motion at Quantized Velocities

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ABSTRACT
Motion is perhaps the most consequential phenomenon in physics. Therefore, a poor understanding of the nature of motion must ultimately lead to intractable problems in physics. In this paper, we set out to illuminate the nature of motion: we argue that a moving body propagates by discrete motion based on a binary set of velocities $S = \{c, 0\}$, where c is the velocity of light. Basing on this model of discrete motion, I argue that matter must be capable of existence in two states: a state capable of attaining velocity c and a state capable of nil velocity. This duality of state is therefore a necessary condition for motion. I further propose that the smallest interval for discrete motion is equal to the de Broglie wavelength and that the velocity of a particle over this interval is equal to zero at the edges of the interval and equal to c within the interval, both velocities being attained in a quantum leap. Equations are proposed for time spent in motion and time spent while stationary in this interval. I argue that it is the time spent while stationary that accounts for all subluminal velocities and it is this very duration of time that was first formally noted in Zeno's paradox of the arrow. In the discussion section, we explore the implications of this position. The paper ends with a conclusion and a recommendation for further inquiry.
Key words: Discrete motion, quantized velocity, state duality, Zeno's arrow paradox

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1 Introduction

A particle moving between two points A and B does not cover the distance in one smooth movement but in a series of alternate bursts and freezes of motion. In the burst-of-motion phase the particle travels at the velocity of light while in the freeze-of-motion phase it is stationary. So the velocity of light is not only the maximum possible velocity in the universe as deduced in *The Special Theory of Relativity*, but it is also the least possible non-zero velocity that a particle can assume. The vast spectrum of subluminal velocities that we observe in nature arise from the interplay between the respective durations of the burst-of-motion phase and the freeze-of-motion phase. Since matter cannot propagate at the speed of light, discrete motion initially requires matter to assume a state that can propagate at c. I shall call it the x-state because I am not certain about its nature. Suppose that the interval AB is the smallest moveable distance in the particle state. At point A, the particle is converted into the x-state; from A to B it moves in the x-state at velocity c; and at point B it changes from the x-state back into a particle. The time taken for the state transition from ordinary matter to x-state and back to ordinary matter is what accounts for all subluminal velocities. For ease of reference, we shall call the transition from ordinary matter to the x-state sublimation and from the x-state back to ordinary matter condensation.

2 Methods

This paper is based on the hypothesis of discrete motion at quantized velocities followed by the mathematical and logical exploration of the consequences of this model of motion.

3 Results: Mathematical descriptions of discrete motion

3.1 Smallest moveable distance

Suppose that a particle of mass m moves from point A to point B at velocity v and that the length AB is the smallest moveable distance. Since the particle exists as matter only at points A and B, the time taken to move the distance AB is the period of the particle. It follows that the smallest moveable distance *in particle state* is equal to $(\frac{h}{mv})$, the de Broglie wavelength of the particle.
i.e. least moveable distance *in particle state* $\Delta x = (\frac{h}{mv})$ .... *(i)*

3.2 Duration of burst and freeze phases of motion

Suppose t_t= overall time a particle of mass m takes to move from A to B at average velocity v
t_c= time spent to move from A to B at the speed of light in x-state of matter
t_s= time taken by particle of matter to sublimate at point A and to condense at point B
Then $t_t = t_s + t_c$
Therefore, $t_s = \frac{h}{mv}(\frac{1}{v} - \frac{1}{c})$
Or $t_s = \frac{h}{mv^2}(1 - \frac{v}{c})$ .... *(ii)*

This is the duration of the freeze phase of motion (the ephemeral pause). It is the duration that Zeno
referred to in his paradox of the arrow.
The duration of the burst phase or the ephemeral flight $t_c = \frac{h}{mvc}$

3.3 Probability of burst and freeze phases during motion

The probability that the particle is in motion (i.e. in burst phase) = $\frac{t_c}{t_c+t_s} = \frac{v}{c}$ ……………………… *(iii)*
The probability that the particle is stationary (i.e. in freeze phase) = $\frac{t_s}{t_c+t_s}$ = (1 - $\frac{v}{c}$) ………… *(iv)*

3.4 Relative velocity

Suppose that two particles A and B are in motion along parallel trajectories at velocities v_A and v_B respectively. What would be the velocity of B relative to A (designated v_{BA}) during a time interval Δt?
According to our model of motion, B moves relative to A in three circumstances:

- *when A is stationary and B is in motion*

  The duration of this phase = $\Delta t \left(\frac{v_B}{c}\right)$.

  The factor $\left(\frac{v_B}{c}\right)$ is the probability that B is in motion at velocity c *(see equation (iii))*.

- *when A is in motion and B is stationary*

  The duration of this phase = $\Delta t(\frac{v_A}{c})$.

  The factor $(\frac{v_A}{c})$ is the probability that A is in motion at velocity c *(see equation (iii))*.

- *when both A and B are in motion*

  The duration of this phase = $\Delta t(\frac{v_A v_B}{c^2})$.

  The factor $(\frac{v_A v_B}{c^2})$ is the probability that both A and B are in motion and are moving independently of each other at relative velocity v_{BA}.

Therefore, the total distance moved by B relative to A,
$v_{BA}\Delta t = \text{c}\Delta t \left(\frac{v_B}{c}\right) \pm \text{c}\Delta t(\frac{v_A}{c}) \pm v_{BA}\Delta t(\frac{v_A v_B}{c^2})$
i.e. $v_{BA} = v_B \pm v_A \pm v_{BA}(\frac{v_A v_B}{c^2})$
Or $v_{BA} = \frac{v_B \pm v_A}{1 \pm \frac{v_A v_B}{c^2}}$ ……………………… *(v)*
This is the Einstein equation for relative velocity.

4 Discussion

4.1 Implication of discrete quantized velocities for calculus

The calculation of a particle's velocity at a point is based on the concept of the infinitesimal interval (whose length in this paper is given by equation (i)). The idea is that the average velocity over such an interval approximates to the velocity at a point. The model of motion that I have described here stipulates that the velocity of a particle within the infinitesimal interval is c but is nil at the boundaries of the interval and that both velocities are attained not gradually but in a quantum leap. Clearly, the average subluminal velocity v does not approximate to c or zero.

4.2 Implication of discrete motion and Newton's First Law of Motion

A statement of Newton's First Law of Motion reads: "Every body continues in its state of rest or of uniform motion in a straight line unless compelled by an external force to act otherwise". Given this law and given the factuality of the freeze phase of motion, would we be right to say that the transition of a moving body from nil velocity in the freeze phase to luminal velocity in the burst phase of motion is effected by a force?

According to our model of discrete motion at quantized velocities, the said changes in velocity do not happen gradually but in a single quantum leap and are effected at a point. Therefore, if a force was required to cause this velocity change, that force would have to be infinite in magnitude. However, infinite forces do not exist in nature, and so we must conclude that the quantum leap in velocity from nil velocity in the freeze phase to luminal velocity in the burst phase of motion is not caused by a force but by the fact of a particle's change in physical state from matter to the x-state. Likewise, we must further conclude that the reverse drop in velocity from luminal velocity in the burst phase to nil velocity in the freeze phase of motion is also not caused by a force but by the fact of a particle's change in physical state from the x-state to matter.

Proceeding in the direction pointed by these conclusions, we are led to surmise that just as energy in its physical state cannot come to a state of rest, matter in its physical state cannot leave a state of rest — that is, the fabric of space is such that it only admits of the motion of energy or a similar state of matter. Therefore, the motion of matter would be impossible in a universe where state fluctuations were not possible. In other words, the capability of matter for wave-particle duality is what makes its motion possible. If this be the case, then the role of force in the motion of matter is merely to initiate state fluctuations, which fluctuations then sustain motion.

4.3 Implication of discrete motion on uncertainty of measurement

This model of discrete motion suggests that there should be no measurement problem in physics. Firstly, all motion of matter is based on a binary set of velocities $S = \{c,\ 0\}$, where c is the velocity of light and discrete motion occurs over the interval $\Delta x = \left(\frac{h}{mv}\right) (see equation\,(i))$. Where would uncertainty in position or momentum arise? Secondly, at velocity c the particle of matter exists in the hypothesized x-state that propagates as a wave while at nil velocity it exists in the ordinary state of matter with no wave properties. Where would uncertainty in its wave or particle nature arise?

5 Conclusion

This paper has proposed a model of discrete motion at quantized velocities for all particles of matter. The model is based on a binary set of velocities $S = \{c,\ 0\}$, where c is the velocity of light. Specifically, it proposes that given an infinitesimal interval equal to the de Broglie wavelength, a particle of matter in motion attains velocity c within the interval and nil velocity at the edges of the interval, both velocities being attained in a quantum leap. To propagate at velocity c, a particle of matter must first transition to a hypothesized x-state; conversely, to stand still, matter must revert to its ordinary state from its hypothesized x-state. Therefore, the capacity of matter for duality of state is a necessary condition for its motion. The time taken to accomplish state transitions accounts for all non-zero subluminal velocities since these transitions occur when motion is at nil velocity. Basing on this model of motion, we were able to propose an equation for the duration of state transitions in an interval equal to the de Broglie wavelength and to derive the Einstein equation for relative velocity.

As a recommendation for research, I suggest further inquiry into the nature of the hypothesized x-state of matter to determine whether it is simply a form of energy or a new state of matter.

6 Declarations

The author certifies that he has no affiliation with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.