International Journal of Theoretical Physics, Vol. 36, No. 6, 1997

Photon Wavelength, Information Transport Speed, and Mass. An Information Mechanics Perspective

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Received October 3, 1996

In Newton's mechanics, Maxwell's electromagnetism, Einstein's relativistic mechanics, quantum mechanics, and Kantor's information mechanics (IM), the speed of light in vacuum c has been treated as independent of wavelength. However, in IM, the transport of information by means of an electromagnetic signal appears to offer a perspective for reconsidering photon information transport speed, extending the concept of (rest) mass to treat the photon as having a mass of 1 bit.

In Kantor's information mechanics (IM) (Kantor, 1977; hereinafter cited as *IM*), for finite universe **U** in which longest possible length is λ_1 (*IM*, p. 188) and total accessibility of information is I_U (*IM*, p. 155), consider a photon γ_{λ_1} in **U** with wavelength λ_1. Such a photon would not be able to distinguish a position smaller than **U**. For this reason, it would appear consistent with the accessibility of information to an observer to treat γ_{λ_1} as at rest in **U**.

In IM, the amount I, in bits, of information represented by a photon with wavelength λ is λ_1/λ. Thus, in IM, γ_{λ_1} represents 1 bit of information.

Next, consider a photon γ_{λ_2} with wavelength $\lambda_1/2$. γ_{λ_2} is able to designate a position smaller than **U**. For this reason, it would not be consistent with the accessibility of information to an observer to treat γ_{λ_2} as at rest in **U**. How fast can γ_{λ_2} move, transporting information in **U**?

Consider an observer **O**, in a hypothetical laboratory much smaller than $\lambda_1/2$, whose laboratory is moving along in substantially the same direction as γ_{λ_2} at such velocity that λ_1 would appear to **O** as shrunk along the direction

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of motion to length $\lambda_1/2$. In IM, for such a laboratory at such a velocity, internal and external information would be adequately describable as separable (from which would flow the applicability of relativity) (*IM*, pp. 179, 188–211, 217–226).

The case of γ_{λ_2}, as seen in **O**'s moving frame of reference, would thus be reduced to the previous case of γ_{λ_1}, as representing 1 bit of information. The relativistic transformation of length λ_1 to **O**'s moving frame of reference is just the inverse of the transform of amount of mass-energy from that frame of reference to a rest frame in **U**. If one treats that 1 bit in **O**'s moving frame of reference as the photon's (rest) mass, transforming back to a frame of reference substantially at rest in **U** yields the total amount of information represented by γ_{λ_2} in **U** as 2 bits.

More generally, consider a photon γ_{λ_I} representing I bits in **U**, $I << I_U$. Its wavelength λ as seen from a frame of reference substantially at rest in **U** would be λ_1/I. Imagine a frame of reference moving with γ_{λ_I} such that λ_1 would appear to an observer in that frame of reference as shrunk down to length λ_1/I. Were a photon to move faster in **U** than the speed required to transform λ_1 down to match the photon's wavelength, then that photon would have to represent more than λ_1/λ bits of information in **U**. Similarly, if a photon were emitted into that lowest level apparent rest state as seen from a frame of reference moving with such velocity that λ_1 looked shrunk along that direction to length λ, it would be seen in a frame substantially at rest in **U** as representing λ_1/λ bits of information.

From the above, and from conservation of information (IM Postulate 3; *IM*, p. 179), it would seem that the speed of a photon transporting information in **U** (including also purely timelike transportation in the case where the photon is at rest in **U**) would be such that a hypothetical observer in a hypothetical frame of reference moving along with the photon would see λ_1 as having a size such that the photon's wavelength would fit in once. In the domain of applicability of special relativity in IM (*IM*, pp. 90–96, 220–225), for a photon with wavelength λ as seen in a frame of reference substantially at rest in **U**, the photon's speed of information transport would be

$$v \sim c\sqrt{1 - (\lambda/\lambda_1)^2} \tag{1}$$

In this way, it appears consistent to extend the concept of mass to apply to a photon, treating each photon's (rest) mass as 1 bit. (In mass units, this would correspond to $h/\lambda_1 c$, where h is Planck's constant.)

In IM, to exist, an object must represent at least 1 bit of information. From the above, it would seem consistent to treat the photon's polarization bit (Kantor, 1991) as its existence bit, and to also interpret that 1 bit as an amount of (rest) mass.[2]

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[2] With respect to the subject matter hereof, this paper supercedes *IM*, especially p. 181 (discussion), pp. 235–236 (Section 3.5.1), and p. 268 (in Table 3, row 1, replace the 0 entries in columns 7 and 8, respectively, with 1 and 6.397E-40).

Moreover, from the above, it would seem inconsistent with information conservation to treat a photon as being able to transport information at c independent of wavelength (as possibly distinguishable from calculating allowed-state photon frequency in **U**).

Note that the "range" of a "virtual particle" with a mass of 1 bit would appear to be of order R_U, the "radius" of **U** (*IM*, pp. 186–187, 211–213).

REFERENCES

Kantor, F. W. (1977). *Information Mechanics*, Wiley, New York.
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