WHAT IS SPACE?

G.H.KESWANI

At the foundations of physics lie two fundamental entities, space and time. Even life, is played out in the framework of space and time. Although we cannot experience space and time with our senses there is an inner awareness of both. In the case of time the humans have an approximate physiological clock and eyes which have some rough measure of space.

One may sample the classical understanding. Leibnitz, one of the greatest of thinkers of all times and Hobbs, one of the sharpest philosophers, denied that space is a real entity. It is rather something we construct in our imagination in order to represent the position of bodies. Newton's is mathematical space, something we construct mathematically in order to describe continuous motion and successfully.[1]

Let us see how far the physics can carry our understanding of space. My introspection have led me to believe that space has definite <u>physical properties</u> which really go to the core and construction of the special theory of relativity, viz., the constancy of velocity of light in vacuum or free-space, which is commonly supposed to be empty.

This constancy was noticed by Poincaré[2], in 1898 in his paper entitled "la mesure du temps".

He observed that astronomers have assumed that the velocity of light received from the celestial bodies had the same velocity, and this assumption led to consistent results. He, therefore, postulated that "light has a constant velocity". Poincaré likened this postulate, which he also called a 'Rule', to the Principle of Sufficient Reason, with respect to reliability and importance.

The questions <u>why</u> it is constant and impassable have not been addressed. But it is also true that there are other constants of physics such as the Planck's constant, h, for which we do not know why it is exactly, what it is.

We shall examine the proposition that space is not free and that light interacts with it; that space has the properties which are <u>connected</u> physically with the speed of light.

I am putting together the facts which are already known.

To this purpose we go to Maxwell's Treatise on Electricity and Magnetism written well before Poincaré's essay.

What he found, was that the ratio of the induced electric field (his displacement current) to the applied electric field, and the ratio of the induced magnetic field to the applied field, in both the cases, have specific constant values for different media. The two ratios are named permittivity (electrical constant) and permeability (magnetic constant). When the medium is "vacuum" or "empty" space, the ratios are called absolute permittivity and absolute permeability, with symbols ε_0 and μ_0, respectively and both have <u>specific and constant</u> non-zero values.

Strangely enough, the product of these ratios (μ_0 x ε_0) turns out to be, perhaps the most important constant of Physics as Maxwell anticipated it. And more strangely this product was always the same, and exactly equal to $1/c^2$, i.e. $c = \sqrt{(1/\mu_0\varepsilon_0)}$, where c is the velocity of light!

The dimensions and values of μ_0 and ε_0 for "empty" space[3] are given below.

Permittivity of free space, or electric constant, ε_0 $L^{-3} M^{-1} T^4 I^2$ ⎫ The fourth dimension is
Permeability of free space, or magnetic constant, μ_0 $L M T^{-2} I^{-2}$ ⎬ the current I.

$$\text{Product} \quad \varepsilon_0 \text{ x } \mu_0 = \text{has dimensions } L^{-2} \text{ x } T^{+2}$$
$$= T^2/L^2, \text{ i.e. } 1/\text{velocity}^2$$

$$\mu_0 = 12.566{,}370{,}6144 \times 10^{-7} \text{ H/m}$$

$$\varepsilon_0 = 8.854{,}187{,}818 \times 10^{-12} \text{ F/m}$$

$$1/\mu_0 \varepsilon_0 = c^2 = (2.997{,}924{,}58)^2 \text{ m/s.}$$

It is hardly to be believed that the velocity of light was therefore measured from 1856-1878 on the basis of the ratio of the electric and magnetic units, as it was called, based on experiments in the laboratory. It was only in 1878 that the velocity of light was first measured in air by time-of-flight techniques. Maxwell himself was the second person who measured the velocity of the light on the basis of the ratios of the units. See the attached excerpts from Maxwell's Treatise.

Now comes the wonder. Doesn't then, this so-called free space, have physical properties, (permeability and permittivity), which are measurable, and also permits electromagnetic waves to go through itself (space) with velocity determined by these two properties of space, constant, finite though small, and specific? The cosmic space permits this, and only this velocity for the propagation of electromagnetic waves, which has a simple mathematical relationship with its properties, as a physical fact. The constants μ_0 and ε_0 are a kind of resistance limiting the passage of electromagnetic waves searing through space in all directions, and from all distances, and on all times.

Therefore, SPACE is, in full sense of the word, a real physical entity, and is linked inexorably with the velocity of light.

Question: Why does space not interact with other fields and matter?
Answer: In fact, space does contract, as time also does, when motion is given to a body, on which the measurements of space or time are made. Cosmology assumes that space expands, but time remains the same, flowing evenly.

However, at present the product ε_0 and μ_0 remains invariant, in the whole universe judging by the astronomical data, and the velocity of light as well remains constant even for light coming from great distances billions of light years away. But it is possible that

there could be conditions of matter and radiation in the extreme in which the product ε_0 x μ_0 changes, locally.

But my main idea here was to show that the constancy of the velocity of light arises from the fact that space has discrete and measurable properties, fixed ε_0 and μ_0, which determine the velocity of electromagnetic waves through space and these discrete values prevail throughout the Cosmos, the largest laboratory, as confirmed by astronomical observations. The mystery of the constancy of the velocity of light, that no matter how it is ejected into "free" space (including such space within matter), is solved. There is an omnipresent medium, as Maxwell thought some times. It is a new type of medium and it has interaction, with the emitted light travelling through it, even in scattering. Although there may be interchange of energy on the way, light has the same velocity in the selfsame "free" space, everywhere so long as ε_0 and μ_0 of space remain constant. There could be pockets in the universe where ε_0 and μ_0 are different due to abnormal gravitational and electromagnetic conditions, but that is a different matter.

I have discussed the "matter" of space at the terrestrial and cosmological level, but not at the quantum level of, say, "Dirac's Sea", spontaneous decay of vacuum, virtual particles, and violation of conservation of mass/ energy to the extent $\pm \Delta E$ and for time Δt, if ΔE x Δt is less than $h/4\pi$, in which, much could be conjured up, and mathematics found to fit, hand in glove, with the new experimental results. The mathematics is bounteous.

REFERENCES

1. Ref: Richard Arther, *Brit.J.Phil.Sci.,* "Space and Relativity" in Newton and Leibnitz, 45, 219-240, (1994).
2. *Rev.Met.Mor.*6, 371-384, Eng.trans. in *The Value of Science,* Dover, pp.26-36.
3. A Modern Handbook of Physics, B. M. Yavorsky and A. A. Detlaf, trans. N. Weistein, Mir Publishers, Moscow, 1982.