

# Newton's laws of Motion applied to Light

by Retd. Prof. Suresh R. Norman

- 1) Newton's First law of motion states that a body at rest continues to be at rest and a body in motion continues with the same motion in a straight line, until acted upon by an external force.

*In the case of light, its dual nature is perceived as that of Electromagnetic waves (not a physical body with mass, but massless entities carrying energy) or photons (particles or wave packets having quantized energy and a finite but infinitesimal mass) travelling through space and matter.*

Also light by its nature, is never at rest, so it has no rest mass, and it travels in a straight line in a vacuum at a constant speed, the speed considered to be the ceiling or limiting speed for the physical Universe by Einstein, in his Special theory of Relativity. This constant and limiting speed of light is  $c = 300,000\text{Km/s}$  and  $c$  is constant in all inertial and accelerated frames of reference. (unless everything in the Universe freezes when it chills to a uniform 0 degree Kelvin, and light too freezes its gallant motion !)

But when the local characteristics of the medium in which light travels changes, its local speed also shifts gears – eg an atmosphere medium having a value of permeability  $\mu$  and permittivity  $\epsilon$  dictates the local speed of light equal to  $1/\sqrt{\mu\epsilon}$  and not the limiting speed of light in a vacuum  $c = 1/\sqrt{\mu_0\epsilon_0}$ .

The external force here is a change in the medium and its characteristics through which light is travelling.

The external force could also be a changing gravitational field and gravitational force the light is traversing against or a changing space-time curvature field it is negotiating, as per Einstein's General theory of Relativity or an externally impinging Electric or Magnetic field, or bumping into a plasma field or a collision with an atom or a particle.

If there is no change in medium or its characteristics in the path of the light waves/photons, then there is no external force being applied to the light, and there is no rate of change of momentum of its photons and the energy of its waves is conserved, and light travels at a constant speed unimpeded.

- 2) Newton's Second law of motion states that the rate of change of motion of a body is directly proportional to the applied force and takes place in the direction of the force.

For light, the rate of change of the motion of its waves or the rate of change of photons momenta depends on the external impediments – eg. laser fields or E-fields or H-fields or Plasma fields or space-time curvature fields (former Gravitational fields) etc. – ie. light does not travel at a steady speed but is accelerated or decelerated as per the changing environs and the change in the

speed or momentum of light is proportional to the externally applied force, which is any or a combination of the external fields I mentioned , encountered by light in its journey.

Also, if space is considered to be smooth and isotropic with constant unchanging characteristics , and this space is expanding at a certain rate , there is a rate of change of energy of the light waves which is proportional to the force of the expanding space and its rate of expansion.

Further , as the expanding space stretches the light waves , it also adduces infinitesimal amounts of energy from the light waves (  $E= h \Delta v$  ) , so that the light continues to travel at the same speed since the medium is assumed constant , but having its energy curtailed somewhat, resulting in a proportional drop in its energy , manifested in its decreased frequency.

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