THE SPEEDS OF WAVES
IN THE FIRMAMENT[1]

We report here on recent work on the properties of the firmament. This work has to do with the characteristic speeds in the firmament. The speed of "sound," that is, any disturbance through the firmament, can be considered analogous to that of normal matter. Here we implicitly assume that such analogy is valid, and we assume that, as absolute space, the firmament behaves as a perfect fluid.
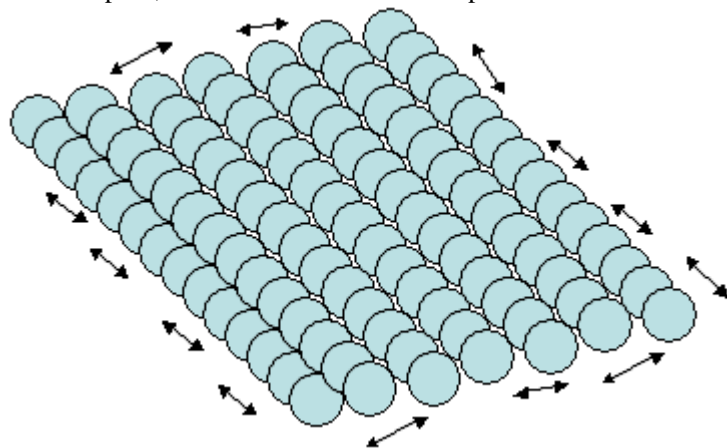

Figure 1: Two layers of Planck particles making up the firmament showing the kinds of motions that can exist for the particles. The motions make up the various waves that can exist and propagate through the firmament.

Transverse Wave Speed

In a transverse wave, the particle displacement is perpendicular to the direction of propagation. Light is an example of a transverse wave, so are the waves we can make with a rope tied to a doorknob. We generally picture transverse waves as bouncing up and down. Figure 2 shows a transverse wave propagated left to right through a stack of layers in the firmament. Imagine taking the sheet in Figure 1 and shaking it up and down like a blanket.

The formula for the speed of the transverse wave, v_t is:

$$v_t = \ (T/\mu)$$

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 [1] This article is an updated version of an appendix first published in the *B.A.* by Gerardus D. Bouw, 2002. "Earthquakes, Snowfalls, and Geocentricity," **12**(99):5.

where μ is the mass per unit length. For a rope waved up and down with the end tied to a doorknob, the mass per unit length may be one ounce per foot of rope. For the firmament, the Planck particle mass is 2.2 10^{-5} gram and its diameter is 1.6 10^{-33} cm. Stringing the particles side-by-side for a centimeter gives μ = 1.347 10^{28} gm/cm (about $1/250^{th}$ the mass of the moon). Taking the tension to be the gravitational attraction between neighboring Planck particles, the gravitational tension becomes:

$$T = G\mu^2 = 1.211 \ 10^{49}$$

which means that

$$v_t = \ (G\mu).$$

Substituting in the Planck values for T and μ gives

$$v_t = 2.998 \ 10^{10} \text{ cm/sec}$$

which is the speed of light. We conclude that the transverse-wave speed of a disturbance in the firmament is the observed speed of light *viz.* 2.99792458 10^{10} cm/sec.
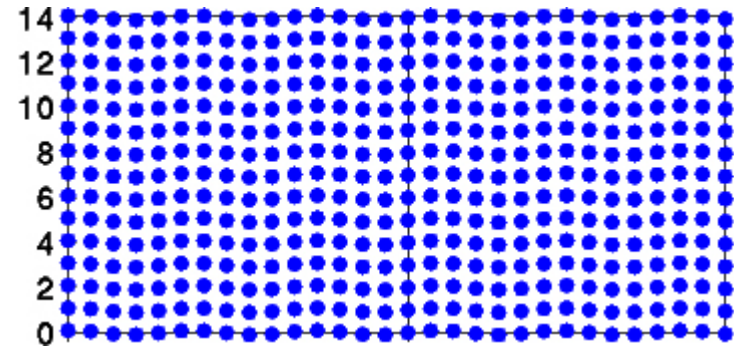

Figure 2: Transverse Wave in the Firmament

Thermal Speed

A second transmission speed can be derived from the temperature of a medium. This speed is also sometimes called "quantum speed." It is the average speed of a particle in the firmament caused by the heat of the firmament, which has a temperature of $T = 1.42 \ 10^{32}$ kelvins.[2] The formula that gives the quantum speed v_q is related to Boltzmann's constant k, and the Planck particle mass m, and is derived by equating the kinetic energy of a particle to its thermal energy as:

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[2] At these immense values, one can just as well read Fahrenheit for Kelvin.

$$v_q = \sqrt{(3kTm^{-1})}.$$

Crunching the numbers gives a value for v_q of 5.21 $\times$ 10^{10} cm/sec. This is 78% higher than the speed of light. However, the coefficient 3 under the radical assumes that each particle has three degrees of freedom, which is to say that the particle can freely move in any of the three directions: up-down, left-right, and forward-backwards. If there is only one degree of freedom, then the quantum speed becomes 3.008 $\times$ 10^{10} cm/sec which is roughly the speed of light. Since light follows the path of least resistance, one-degree of freedom tentatively seems to be the appropriate model.

So far we have defined two speeds in the firmament, both with a speed equal to the speed of light. The question arises, Are they related? The answer is, No. For a transverse wave, the particles are moving coherently, as a group. In the thermal case, the particles are bouncing all over the place, in all directions for the greater-than-light speed value and oscillating back and forth against each other in the one-degree of freedom case.

Longitudinal (Pressure) Wave Speed

The third speed is the most interesting because it measures the speed of a pressure wave (a compression wave, also known as a longitudinal wave) through the firmament. To derive it we need to measure the compressibility of the firmament. What is needed is a property called the "bulk modulus" (B_m) of the firmament. The speed (v_b) can then be derived by relating it to the density ρ by the relationship:

$$v_b = \sqrt{(B_m/\rho)}. \qquad (1)$$

The bulk modulus relates pressure and volume via the expression:

$$B_m = \frac{(P - P_0)\ V_0}{V_0 - V}.$$

Here P and V are the compressed pressure and volume while P_0 and V_0 are the original pressure and volume respectively.

(r)   (c)   (r)   (c)   (r)   (c)   (r)   (c)   (r)
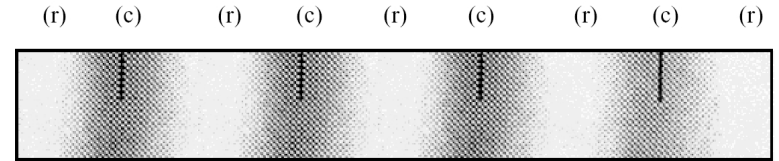

Figure 3: a longitudinal wave moving from left to right. The particles do not ride with the wave; they move back and forth, compressing at the regions marked (c) and rarifying in regions (r). Regions (c) and (r) also move to the right, but individual particles move to the right for half a wavelength and then move to the left for the other half. This is the case for any pressure wave, whether the spoken word or the shock wave of an explosion.

Normally, we picture the firmament as non-compressible, but we assume that a difference exists between the uncompressed volume we call space and the compressed firmament. Essentially, we look at the problem of compressing the universe to the density of the firmament. In that case, P_0 is zero, there being very little pressure in the vacuum of space, and P is of the order of at least 10^{49} dynes, the pressure between two adjacent grains of the firmament. The initial volume, V_0, is the volume of the universe which is roughly 10^{85} cm^3. The final volume is the volume of the starting ball of firmament constituting the Big Bang, that is, of the order of 10^{-39} cm^3. The starting density we assume to be the critical density of the universe which is of the order of 10^{-29} gm/cm^3. We are now able to arrive at a crude estimate of the rate at which a compression wave can travel through the heaven we call outer space.

When the numbers are used in equation (1), we find that the speed of longitudinal wave is roughly 3×10^{39} cm/sec (10^{29} times the speed of light). At that speed, the signal crosses the universe in roughly 10^{-11} second or one-hundred billionth of a second. The actual speed is likely much higher since the pressure inside the compressed ball is likely to be greater then the pressure between two Planck particles in contact with one another. After all, we did ignore the contributions of the two neighboring particles beyond the ones touching. We can come up with an upper limit by assuming that the maximum pressure is 10^{49} times the number of particles in the primordial fireball, that is, 10^{59}. This gives a speed of roughly 10^{68} cm/sec, crossing the universe in about 10^{-40} second. It may well be that it will take a Planck time (10^{-44} sec) if all the numbers were better known, but that is just a conjecture for now. In an earlier analysis based on stellar structure theory, a speed of sound through the firmament was estimated to be 10^{107} cm/sec.

Conclusion

We examined three types of disturbances in the firmament and examined the characteristic speed associated with each. Two of the disturbances involved waves (transverse and longitudinal) and the third is the counterpart of thermal motion that can be manifest Brownian motion, though we do no examine that particular property in this paper.

The first waveform we looked at was that of transverse waves. We discovered that these waves traveled through the firmament at exactly the speed of light. From this we can conclude that electromagnetic energy is transmitted through the firmament at the speed of light and that the firmament is, itself, the medium transmitting the wave energy through space.

We next looked at thermal motion. The surface temperature of the firmament is extremely hot, but we do not feel its heat because it is immediately absorbed by a neighboring Planck particle. That is the case whether one particle hits another or whether the energy of the particle is transmitted as a wave. We found the thermal speed of the Planck particles to be of the order of the speed of light, possibly somewhat higher, depending on the degrees of freedom in the firmament.

Lastly, we looked at longitudinal wave transmission, the phenomenon we commonly use to explain sound waves. We discovered that the transmission speed for such a wave is 10^{29} times the speed of light. At that speed a disturbance at the geometrical center of the universe will reach the edge in a hundred-billionth of a second. We suggest that this may be the speed of gravity.

Finally, what makes us able to find these properties without invoking the General Theory of Relativity is that the firmament is indistinguishable from a plenum (an infinitely dense medium) to the created universe. As such, the firmament is the absolute space for which Sir Isaac Newton sought. As absolute, relativity does not apply to it. The firmament is the standard to which all motion in the universe is to be referenced.