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Tachyon Masses

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The present model of the universe postulates that a parallel universe, in which particles can only move faster than light, exists. In article **10-Broken Symmetry** antiparticles are defined as moving faster than light. But, in order to be more specific, the region where all particles are moving in accordance to $v > c$ will be called the Tachyon universe. Anti-particles are therefore the Tachyons that tunnel into our universe. In order to exist in our universe their speed must be less than the speed of light. But they are still forbidden to interact with ordinary matter. Any interaction results in a mutual annihilation.

In order to deal with Tachyons we have to start with the relativistic mass of Einstein's **Special Theory of Relativity** $m = m_0 / (1-v^2/c^2)^{1/2}$

Let us define a ***generalized complex mass*** M as:

$$\mathbf{M = (m_0 + im_t) / (1-v^2/c^2)^{1/2}} \qquad (1)$$

$$M = m + im_t / (1- v_t^2/c^2)^{1/2}$$

The speed v is discontinuous at the boundary c and splits into v and v_t . This discontinuity corresponds to a ***spontaneous symmetry breaking***. The Generalized complex mass M has a real and an imaginary part. The imaginary component of M is proportional to m_t which is the **Tachyon** mass by definition.

Equation 1 defines two universes: our universe where particles move slower than light (speed = $v < c$) and a parallel universe where particles are moving faster than light (speed = $v_t > c$). Although we cannot measure the mass of the Tachyons their energy should be real and positive in both regions.

The Tachyons will cross the potential barrier (where $v = c$) and tunnel into our universe when their speed equals c. The T momentum will be: $p_t = h / \lambda_t = ((E_t - V)^2 - (m_t c^2)^2)^{1/2} / c$

At the boundary $E_t = V$ and $p_t = h / \lambda_t = i\, m_t\, c$, or $\lambda_t = -ih / m_t c$

Both the momentum and the wavelength of the Tachyons are imaginary. Since at the boundary the speed of the Tachyon equals the speed of light c:

$v_t = f_t \lambda_t = -if_t h / m_t c$ the frequency of tunneling becomes imaginary for any v_t .

$$\mathbf{f_t = im_t\, v_t^2 / h} \qquad (2)$$

With $\beta = (1\text{-}v^2/c^2)^{1/2}$ the generalized energy $\bar{\mathbf{E}}$ can be defined as:

$$\mathbf{\bar{E} = Mc^2 = (m_0 + im_t)c^2 / \beta = mc^2 + im_tc^2 / \beta = mc^2 + i\hat{w}c^2} \qquad (3)$$

with $\mathbf{\hat{w} = m_t/\beta}$ becoming the relativistic Tachyon mass. For $\mathbf{v_t > c}$

$\beta = i(v^2 - c^2)^{1/2}/c$, $i\hat{w}c^2 = m_tc^3/(v_t^2 - c^2)^{1/2}$, $\mathbf{\bar{E} = mc^2 + m_tc^3/(\ v_t^2 - c^2)^{1/2}}$

The generalized energy $\mathbf{\bar{E} = mc^2 + E_t}$ becomes real and positive. Since Tachyons are moving faster than light their rest mass is zero and the first term of $\bar{E}$ drops giving a real and positive Tachyon energy E_t as:

$$\mathbf{E_t = m_tc^3/(v_t^2 - c^2)^{1/2}} \qquad (4)$$

Eq. (4) tells us that in the region where all particles are moving faster than light the energy is real and positive. For very large Tachyon speeds $\bar{\mathbf{E}} = E = mc^2$ but for intermediate energies the Tachyon masses increases linearly with v_t .

For $\mathbf{E_t = b}$ (constant) we get $b = m_tc^3/(v_t^2 - c^2)^{1/2}$ or

$$\mathbf{m_t = b\ (v_t^2 - c^2)^{1/2}/c^3} \qquad (5)$$

Since c = 1 at the boundary $m_t = b\ (v_t^2 - 1)^{1/2}$ (v>1)

The Binomial expansion of $m_t = (b/c^3)\ v_t\ (1 - c^2/\ v_t^2\ )^{1/2}$ with $v_t > c$ (5) becomes:

$$m_t = (b/c^3)\ v_t\ (\ 1 - c^2/(2\ v_t^2) - c^8/(8\ v_t^8) - c^{16}/(16\ v_t^{16}) - \ldots\ldots.)$$

Accepting that only the first two terms are the main contributors to the mass, we get:

$$\mathbf{m_t \approx (b/c^3)\ v_t\ \{(\ 1 - c^2/(2\ v_t^2)\}} \qquad (6)$$

which may lead to discrete Tachyon masses if the speeds $\mathbf{v_t}$ are quantized. This is needed since the Tachyons have no rest mass.

At the boundary of our universe $v_t = c$ thus $\mathbf{m_t^* = \ (b/c^2)\ \{(\ 1 - c^2/(2\ c^2)\}}$

with c = 1 we get $m_t^* = b/2$ and the quantized Tachyon mass is:

$$\mathbf{m_t(n) = (b/c^3)\ v_t(n)\{(\ 1 - c^2/(2\ v_t^2(n)\}} \quad \mathbf{,\ n = 1, 2, 3,\ldots} \qquad (7)$$

Inserting Eq. 7 into Eq. 1 for large enough Tachyon speed ($v_t \gg c$) the generalized complex mass M becomes:

$$\mathbf{M = m + ibv_t\ (1 - c^2/(2\ v_t^2)\ /\ c^3\ \beta} \qquad (7)$$

where $b = m_tc^3/(v_t^2 - c^2)^{1/2}$

The Generalized mass M is consistent with QM and Special Theory of Relativity. It can also be extended to Fractal spaces and fractal dimensions when self-referential discontinues iterations are adopted.