The Kinetic Energy of Relativistic Particles

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Abstract: This article explores the kinetic energy of a particle with mass m accelerated from rest to a final velocity within an Absolute Reference Frame (ARF). Using a Minkowski-based approach and focusing on the integral form for energy calculations, we derive an alternative formulation for kinetic energy that differs from traditional relativity by recovering the classical form, $KE=mv^2/2$, within the ARF context. This formulation implies a mass-dependent energy cap as velocity approaches the universal maximum, c, aligning with classical mechanics in the limit while diverging from relativistic predictions at high speeds[1]. A proposed experiment using particle accelerators and precise calorimetry could reveal observable discrepancies in energy deposition, potentially challenging the conventional kinetic energy model.

1. **Introduction**

In conventional relativity, the kinetic energy KE_{rel} of a particle with mass m moving at velocity v is given by:

$$KE_{\mathrm{rel}} = (\gamma - 1)\, mc^2 \tag{1}$$

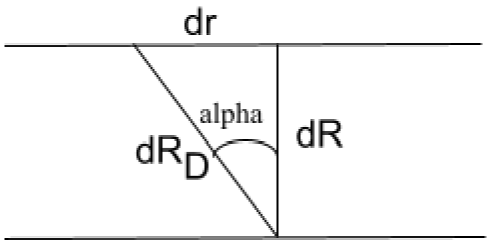
where the Lorentz factor γ is:

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{2}$$

This relativistic formulation has been experimentally confirmed across various high-energy physics applications, as discussed in foundational texts like Jackson's *Classical Electrodynamics* [1]. However, the ARF hypothesis proposes that kinetic energy may reach a mass-dependent limiting cap at Absolute Velocity c, suggesting a fundamental deviation in energy deposition at high velocities. This implies that kinetic energy might have a different formulation within the Absolute Reference Frame (ARF), where interactions are moderated by an intrinsic absolute velocity cap [1, 2].

2. Derivation of Kinetic Energy in an Absolute Reference Frame (ARF)

Notice that ARF is only introduced because I successfully defended the assumption that there is an extra spatial dimension and that our universe is a Lightspeed Expanding Hyperspherical Hypersurface.



Minkowski Diagram

Figure 1. The derivation of the Kinetic Energy is based on this diagram, and thus, it is relativistic despite using an absolute reference frame (ARF). The ARF comprises the perpendicular axis R and any perpendicular vector within the 3D hyperplane, represented by a horizontal line. The diagram embodies Minkowski's interpretation of Lorentz transformations as rotations of the 4D metric [5]. You can see the angle of rotation as alpha. I am using hyperbolic functions in this derivation. That said, that is irrelevant, and using trigonometric functions would produce the same final conclusion.

Minkowski Spacetime reflects what is happening in the actual 4D Spatial Manifold. Minkowski's spatial coordinates describe a hyperplane traveling at the speed of light in some undefined direction. HU shows that this is the local linearization of the hyperspherical hypersurface (for short distances, the hyperspherical hypersurface can be approximated to a hyperplane). The vector perpendicular to the hyperplane is the same as the radial direction on the hyperspherical hypersurface. In other words, there is no sense in speaking about a direction of propagation in time. Once you add one extra spatial dimension, it makes all sense to talk of a perpendicular direction in a 4D Spatial Manifold.

That is why I mentioned ARF. If one just stays in the 4D Spacetime, my argument survives. The only difference is that the perpendicular vector in spacetime becomes an arbitrary inertial framework. The argument remains the same since this reference frame maps to the lab frame.

To derive the kinetic energy, we calculate the work dW done to accelerate the particle from rest ($v = 0$) to a final velocity of v_0 in the ARF. We'll use hyperbolic transformations that align with the ARF approach and represent a 4D Minkowski space framework.

2.1 Definition of Force and Displacement

1. **Force**: We define force F as acting in the direction of motion. In the ARF, the force remains aligned with the changes in the particle's velocity, and we express it as:

Using time as an imaginary quantity

$$F = m\,\frac{dv}{dt} = mc^2\,\frac{d\left(-\frac{v}{ic}\right)}{icdt} = mc^2\frac{d\tanh(\alpha)}{dR} = mc^2\frac{d\tanh(\alpha)}{d\alpha}\frac{d\alpha}{dR} \tag{3}$$

$$with\ \tanh(\alpha) = -\frac{v}{ic} \tag{4}$$

$$\frac{d\tanh(\alpha)}{d\alpha} = 1 + \tanh(\alpha)^2 = 1 - \left(\frac{v}{c}\right)^2 = \gamma^{-2} \tag{5}$$

Using time as a real quantity

$$F = m\,\frac{dv}{dt} = mc^2\,\frac{d\left(\frac{v}{c}\right)}{cdt} = mc^2\frac{d\tan(\alpha)}{dR} = mc^2\frac{d\tan(\alpha)}{d\alpha}\frac{d\alpha}{dR} \tag{6}$$

$$with\ \tan(\alpha) = -\frac{v}{c} \tag{7}$$

$$\frac{d\tan(\alpha)}{d\alpha} = 1 - \tan(\alpha)^2 = 1 - \left(\frac{v}{c}\right)^2 = \gamma^{-2} \tag{8}$$

This means that it is irrelevant if we have time as an imaginary quantity or not. The Physics it describes is in the absolute-velocity dependent force shown below:

$$F = m\,\frac{d^2x}{dt^2} = mc^2\left(1 - \frac{v^2}{c^2}\right)\frac{d\alpha}{dR} \tag{9}$$

This means that it is irrelevant if we have time as an imaginary quantity or not. The Physics it describes is in the absolute-velocity dependent force shown below:

From there you can go to:

$$m\,\frac{d^2x}{dt'^2} = mc^2\frac{d\alpha}{dR} \tag{10}$$

$$dt\,\sqrt{1 - \frac{v^2}{c^2}} = dt'\ or \tag{11}$$

$$dt = \frac{dt'}{\sqrt{1 - \frac{v^2}{c^2}}}\ (a.k.a.\ Time\ Dilation) \tag{12}$$

$$\frac{m}{\sqrt{1 - \frac{v^2}{c^2}}}\,\frac{dv}{dt'} = mc^2\frac{d\alpha}{dR}\ \ (time\ dilation\ and\ relativistic\ mass\ increase) \tag{13}$$

2. Displacement dr :

Displacement dr is defined along a vector within the hyperplane in Minkowski space.

$$dr = dR_D \cdot \sin(\alpha) \tag{14}$$

2.2 Energy Integral

To find the kinetic energy, we calculate the work done from $v = 0$ to $v = v_0$ by integrating the expression for $dW = F.dr$:

$$dW = mc^2 \frac{d\tan(\alpha)}{dR_D} \frac{dR_D}{dR} dR_D \sin(\alpha) = mc^2 \frac{d\tan(\alpha)}{d\alpha} \frac{dR_D}{dR} \sin(\alpha)\, d\alpha \tag{15}$$

3. **Change of Variable and Integral Setup**: To integrate, we change the variable to α using the following relationship:

$$\frac{d\tan(\alpha)}{dR_D} dR_D = \frac{d\tan(\alpha)}{d\alpha} \frac{d\alpha}{dR_D} dR_D = \frac{d\tan(\alpha)}{d\alpha} d\alpha \tag{16}$$

Resulting:

$$dW = mc^2 \frac{\sin(\alpha)}{\cos(\alpha)^3} d\alpha \tag{17}$$

Since [4]:

$$\frac{dR}{dR_D} = \cos(\alpha) \tag{18}$$

4. Integral in Terms of α: Using the expressions for dR_D and substituting into the work integral, we obtain:

$$KE_{\text{ARF}} = \int_0^{\alpha_0} mc^2 \frac{\sin(\alpha)}{\cos^3(\alpha)} d\alpha = mc^2 \left[\frac{\tan^2(\alpha)}{2} \right]_0^{\alpha_0} = mc^2 \frac{\tan^2(\alpha_0)}{2} \tag{19}$$

Here, α_0 is the hyperbolic angle corresponding to the final velocity v_0 , where:

$$\alpha_0 = \tan^{-1}\left(\frac{v_0}{c}\right) \tag{20}$$

5. **Solving the Integral**: Integration gives us:

$$KE_{\mathrm{ARF}} = mc^2 \frac{\tan^2(\alpha_0)}{2} = \frac{mc^2}{2} \frac{v_0^2}{c^2} = \frac{mv_0^2}{2} \tag{21}$$

This result resembles the classical form for kinetic energy and highlights a cap on kinetic energy when using the ARF, which differs from the prediction of relativity[1].

3. Proposed Experimental Test in Calorimetry

To test the ARF model, we propose measuring the energy deposition of high-velocity protons, like those accelerated in the Large Hadron Collider (LHC). Conventional relativity predicts that a proton with 6.5 TeV energy should deposit all of this energy in a calorimeter. However, according to the ARF model, the energy deposition is capped at approximately 470 MeV:

$$KE_{\mathrm{ARF}} = \frac{m_p c^2}{2} \approx 470 \text{ MeV} \tag{22}$$

3.1 Discrepancy in Calorimetric Measurements

In high-energy physics, calorimeters are often calibrated based on penetration depth, an indicator of how deeply particles penetrate the detector material before depositing their energy. Typically, calibration begins with velocity calculations derived from synchronization parameters, which then translate into energy estimates using relativistic formulas. This energy is then correlated with penetration depth, assuming that deeper penetration indicates higher energy deposition.

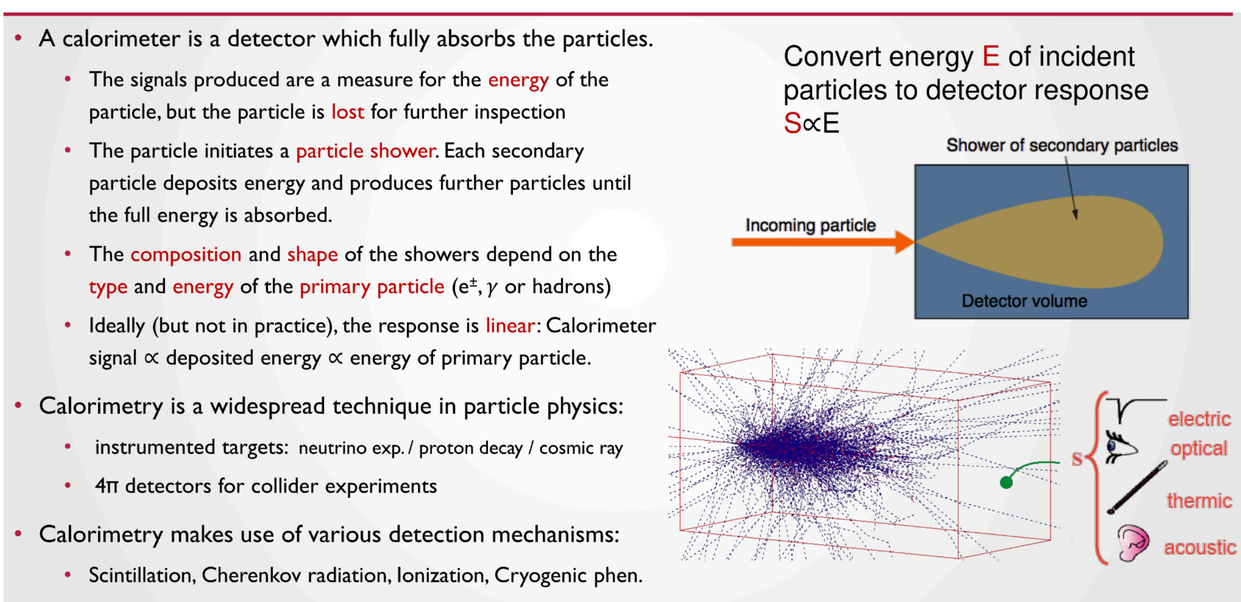


Figure 2. This figure shows how particles interact with the calorimeter components. The incoming particle creates a show of secondary particles. For speed's sake, the measurement is not

done thermally (it takes time for thermal equilibrium), Instead, the detector measures penetration. In other words, one can measure the effect of the particle shower on the different layers of the detector and use that to create a penetration profile. This penetration profile is modeled using Relativity, which creates a biased measurement.

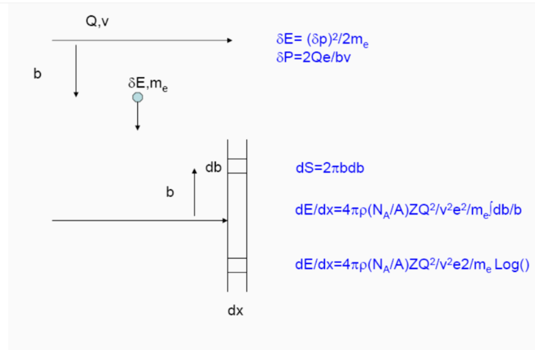
3

1.Fundamental Phenomena

1.1 Interactions of electrons,positrons and photons with matter

Interactions of charged particles with electrons of matter

A classical treatment gives a hint of what is happening; note $1/v^2$ and log term→ there is a (flat) "minimum dE/dx" for $\gamma\beta\sim 3$ ie $\beta\sim 0.95$



Interaction of electrons and positrons with electrons of matter: **dE/dx**

electrons

$$-\frac{dE}{dx} = k\frac{Z}{A}\frac{1}{\beta^2}\left\{\ln\frac{\gamma m_e c^2\beta\sqrt{\gamma-1}}{I\sqrt{2}} + \frac{1}{2}\left(1-\beta^2\right) - \frac{2\gamma-1}{2\gamma^2}\ln 2 + \frac{1}{16}\left(\frac{\gamma-1}{\gamma}\right)^2\right\} \text{ (MeV/ (g/cm}^2\text{))}$$

positrons

$$-\frac{dE}{dx} = k\frac{Z}{A}\frac{1}{\beta^2}\left[\ln\frac{\gamma m_e c^2\beta\sqrt{\gamma-1}}{I\sqrt{2}} - \frac{\beta^2}{24}\left(23 + \frac{14}{\gamma+1} + \frac{10}{(\gamma+1)^2} + \frac{4}{(\gamma+1)^3}\right)\right]\text{(MeV/ (g/cm}^2\text{)).}$$

-A(Z) number of nucleons (protons) in the nuclei of the medium
- I mean excitation energy of the medium: often approximated by 16 $Z^{0.9}$eV
- $k=4\pi N_A r_e^2 m_e c^2 = 0.3071$ MeV/(g/cm^2)
- N_A Avogadro number
- $r_e = \frac{1}{4\pi\varepsilon_0}\cdot\frac{e^2}{m_e c^2} = 2.818\ 10^{-15}$ m   classical radius of the electron.

Figure 3. Particle Shower penetration modeling showing the use of Relativity. This is used for calibration. It creates circular reasoning.

However, under the Absolute Reference Frame (ARF) model, penetration depth could increase without a proportional increase in energy. This discrepancy arises because particle interactions diminish as velocity approaches the absolute limit ccc, reducing the rate of energy transfer to the detector material. In this scenario, particles could penetrate deeper into the detector with only minimal additional energy since the interaction cross-section decreases significantly at high speeds. This phenomenon challenges the assumption that penetration depth directly correlates with energy, as is typical in relativistic calibrations.

To detect the predictions of the ARF model accurately, calorimeters would need to measure energy deposition as thermal changes rather than relying solely on penetration depth, which may obscure the lower energy transfer rates predicted by the ARF hypothesis [2, 4].

4. Practical Implications: Shielding for Spacecraft

The ARF hypothesis derives a force that is dependent upon the Absolute Velocity. That force diminishes as the Absolute Velocity increases towards lightspeed c. At c, the force goes to zero. This would explain the higher penetration observed in high-energy physics experiments. This implies a shielding effect for particles approaching the speed of light relative to the ARF. This effect may aid in developing spacecraft shielding technologies, allowing high-speed travel without excessive particle interactions. **Notice that this is exactly the opposite of what Relativity predicts, and it would make a good test case.**

5. Gaps in Experimental Verification

Many experiments in high-energy physics implicitly assume relativistic models. Calorimeters are designed to measure penetration and shower length, which may mask discrepancies predicted by the ARF model. An unbiased test requires calorimeters that directly measure energy deposition as thermal changes.

5.1 Temperature-Based Calorimetric Test

A temperature-sensitive calorimeter could directly measure deposited energy without the influence of relativistic assumptions. Such a device could provide empirical evidence to support or challenge the ARF model.

6. Conclusion

The Absolute Reference Frame (ARF) model presents an alternative view of kinetic energy that deviates observably from relativistic expectations while recovering the Classical Mechanics definition of kinetic energy. Testing this hypothesis requires calorimetric techniques that measure pure thermal energy independent of the assumptions tied to relativistic calibration. If confirmed, the ARF model could fundamentally shift our understanding of particle dynamics, opening up new possibilities for aerospace applications.

The ARF model is integral to the Hypergeometrical Universe Theory (HU) [6,7]. Validating the ARF model would also validate HU, posing a direct challenge to General Relativity and established physics. Since Relativity is foundational to our current understanding of the Universe, confirmation of the ARF model would necessitate a reevaluation of the principles that underlie modern physics.

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