Kinetic energy

HOME: The Physics of Bruce Harvey

Non relativistic

It is our assertion that every elementary charged particle has an absolute velocity through the background and that it has an absolute kinetic energy stored in the magnetic field generated by its motion through the background. In the branch of applied mathematics called mechanics, we calculate kinetic energy using velocities measured relative to some arbitrary frame of reference. We find that the law of conservation of energy applies. How can that be true if our calculations of kinetic energy $E = \frac{1}{2} m v^2$ uses arbitrary velocities. The answer is simple. The kinetic energy of a system of particles is equal to the kinetic energy of the system as whole plus the kinetic energy of the particles within the system. If the particles of the system have mass and velocity denoted by m_i and $\vec{v}_i$ measured relative to the centre of gravity of the system which has a velocity $\vec{u}$ through the background, then:

$$\sum_i \tfrac{1}{2} m_i (\vec{u} + \vec{v}_i)^2 = \tfrac{1}{2}\left(\sum_i m_i\right) u^2 + \sum_i m_i \vec{u} \cdot \vec{v}_i + \sum_i \tfrac{1}{2} m_i v_i^2$$

$$\text{Now } \sum_i m_i \vec{u} \cdot \vec{v}_i = \vec{u} \cdot \sum_i m_i \vec{v}_i = 0$$

$$\therefore \sum_i \tfrac{1}{2} m_i (\vec{u} + \vec{v}_i)^2 = \tfrac{1}{2}\left(\sum_i m_i\right) u^2 + \sum_i \tfrac{1}{2} m_i v_i^2$$

The necessary condition for this to be so is that $\sum_i m_i \vec{v}_i = 0$. That is to say that the sum of the momentums of the particles measured relative to the centre of gravity of the system is zero. Since that is how the centre of gravity is defined, the condition is met. The principle of conservation of momentum as expressed by the equation $\sum_i m_i \vec{v}_i = 0$ is a direct consequence of conservation of energy.

This principle works in exactly the same way if we have multiple systems embedded within each other, so just as we might identify the velocity of an electron as its velocity within the atom plus the velocity of the atom relative to the earth plus the velocity of the earth around the sun plus........ there are corresponding systems of system of systems....... to which this principle can be applied.

In relating this to the laboratory situation where we equate $force \times distance$ to a change in kinetic energy, we are measuring only that part of the kinetic energy due to motion within the laboratory. We are also only measuring distance within the laboratory. In reality the distance the laboratory has travelled through the stationary system in that time needs to be added to give the real change in kinetic energy. The other end of the force is anchored in the laboratory and dose (or adsorbs) an equal, but opposite signed, amount of work changing the real kinetic energy of the earth. This is an interesting concept: forces on moving objects do work. Once we accept the idea of a background and absolute local velocity, then all forces are doing work. Fortunately, forces usually come in equal and opposite pairs so no net amount of work is done. It is only in situations where one of a pair of equal and opposite forces is an inertial force that we need to worry about the situation. Resolving the universe into systems and applying the law for calculating the kinetic energy, our worries are resolved.

Relativistic

The above analysis assumes that the velocities are small compared to the velocity of light. The theory of relativity which we present within our unified theory is based on the work of Lorentz, Poincaré and others. It takes from them the idea that the effects of near light speed motion are entirely due to the electromagnetic nature of matter. That the electric fields of elementary charged particles generate magnetic fields by virtue of their motion and that the same feedback effect by which photons and radio waves are propogated also effects elementary charged particles. The motion of electric flux generates magnetic intensity and the motion of magnetic flux generates electric intensity. The result is a contraction in length, in the direction of motion, of the elementary charged particle and its electric field as described by electric flux density and electric potential. This real physical effect increases the inertial mass of the particle. Both Lorentz and Abraham attempted a mathematical analysis of this.

In our unified theory, we have identified two mistakes, one in the integration of the energy content of the electric field and the other in the integration of the energy contained in the magetic field. This analysis would seem to suggest that the inertial mass appears to be increased by a factor of γ^4 when resisting linear acceleration and by a factor of γ^2 when resisting centripital acceleration. This is in line with Abraham's result which best fitted early experimental results. By 1915, experimental evidensce favoured factors of γ^3 and γ which have become part of the Special Theory of Relativity as taught and as derived in the author's original papers. However, when we try to explain why clocks run slow by a factor of γ dimansional analysis strongly points to inertial mass as measured within a moving system being increased by factors of γ^4 and γ^2.

We have three candidates for the kinetic energy of an electron moving with velocity v through the stationary system:

$$1, \qquad KE = (\gamma - 1)\, m\, c^2 \qquad\qquad 2, \qquad KE = \frac{1}{2}\gamma\, m\, v^2 \qquad\qquad 3, \qquad KE = \frac{1}{2}\gamma^2\, m\, v^2$$

The first is that taught in universities. The second is consistent with Lorentz's original theory and the third comes form correcting Lorentz's integration.

The first test is to differentiate each of the functions with respect to time because the rate of increasin in KE is equal to the force x velocity. But these are functions of the velocity, so we need use $\frac{d}{dt} f(v) = \frac{d}{dv} f(v) \frac{dv}{dt}$.

$$\frac{d}{dv}(\gamma - 1)\, m\, c^2 = \gamma^3\, m\, a\, v$$

$$\frac{d}{dv}\frac{1}{2}\gamma\, m\, v^2 = \gamma\, m\left(\frac{v^2}{2\,(c^2 - v^2)} + 1\right) a\, v$$

$$\frac{d}{dv}\frac{1}{2}\gamma^2\, m\, v^2 = \gamma^4\, m\, a\, v$$

It is clear that the second alternative is not viable.

The second test is to see whether or not an equivalent expression for the kinetic energy of a moving system of particles moving within the system: $\sum_i \frac{1}{2} m_i (\vec{u} + \vec{v}_i)^2 = \frac{1}{2}\left(\sum_i m_i\right) u^2 + \sum_i \frac{1}{2} m_i v_i^2$.

The problem is that the term $\frac{1}{2}\,m_i\,(\vec{u} + \vec{v}_i)^2$ becomes $\frac{1}{2}\,\frac{c^2}{c^2 - \langle\vec{u}+\vec{v}_i\rangle} m_i\,\langle\vec{u} + \vec{v}_i\rangle^2$ where the angular brackets indicate that the velocities must be added using the formula for composition of velocities which may one day be attempted. We have confined our efforts to the much simpler case of a sytem of two masses m and μ moving relative to their centre of gravity with velocities v and w parallel to the velocity u of the system:

$$1, \qquad \left(\frac{1}{\sqrt{1 - \frac{\left((u+v)\frac{c^2}{u\,v + c^2}\right)^2}{c^2}}} - 1\right) m\,c^2 + \left(\frac{1}{\sqrt{1 - \frac{\left((u+w)\frac{c^2}{u\,w + c^2}\right)^2}{c^2}}} - 1\right) \mu\,c^2$$

$$3, \qquad \frac{1}{2}\frac{1}{1 - \frac{\left((u+v)\frac{c^2}{u\,v + c^2}\right)^2}{c^2}}\, m\left(\left(u + v\right)\frac{c^2}{u\,v + c^2}\right)^2 + \frac{1}{2}\,\frac{1}{1 - \frac{\left((u+w)\frac{c^2}{u\,w + c^2}\right)^2}{c^2}} \mu\left(\left(u + w\right)\frac{c^2}{u\,w + c^2}\right)^2$$

The first may be expanded as a series in u, but with Mathcad 11 we can only get as far as the term in u^5. We find terms which can be expressed as values of γ dependent on various velocities and denote them as γ_u, γ_v and γ_w. The first three odd terms are multiples of $\gamma_v\,m\,v + \gamma_w\,\mu\,w$ indicating that this is the sum of the relativistic linear momentums.

The first 3 even terms are:

$$(\gamma_v - 1)\,m\,c^2 + (\gamma_w - 1)\,\mu\,c^2, \qquad \frac{1}{2}(\gamma_v\,m + \gamma_w\,\mu)\,u^2, \qquad \frac{3}{8}(\gamma_v\,m + \gamma_w\,\mu)\,u^4$$

We note that the expansion of $\gamma - 1 = \frac{1}{2}u^2 + \frac{3}{8}u^4 + \frac{5}{16}u^6 + \ldots$ but this series does not have a general term and our analysis is inconclusive. We can only speculate that the even terms sum to:

$$(\gamma_u - 1)\,(\gamma_v\,m + \gamma_w\,\mu)\,c^2$$

The test of our third possible definition of relativistic kinetic energy is far simpler to analyse. The expansion gives:

$$\frac{1}{2}\gamma_u^2(\gamma_v\,m + \gamma_w\,\mu)\,u^2 + \left(\gamma_v^2\,m\,v + \gamma_w^2\,\mu\,w\right)u + \frac{1}{2}\gamma_u^2\,\gamma_v^2\,m\,v^2 + \frac{1}{2}\gamma_u^2\,\gamma_w^2\,\mu\,w^2$$

While we can be sure of the maths in this case, the implication is that relativistic momentum is $\gamma^2\,m\,v$.

So it would be wise to consider the matter undecided.