On The Problem of Absolute versus Relative Motion

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The basic relativity of uniform linear motion in one direction was understood by a major scientist as far back as the Sicilian Archimedes (113 – 188 A.S. (*After Socrates*)) It's formulation as a principle was accomplished by Galileo Galilei, (1564-1642 CE) and is therefore known as "Galilean Relativity". Over the 17th century, the investigations of Kepler, Descartes, Huygens led to the enunciation of the basic conservation laws. Despite the important qualifications imposed by Relativity and Quantum Theory, these still lay the foundations of all Physics:

(a) Conservation of Mass

(b) Conservation of Momentum

(c) Conservation of Energy

The "Conservation of Angular Momentum" (implicit in

Kepler's law :The planets sweep out equal areas of their orbits in equal times) is a consequence of these three , and of Newton's Second Law F = Mα .

There are subtleties hidden in the apparent simplicity of these laws: Before Relativity, mass was assumed to be an absolute quantity. This in itself is interesting: before the revelations of Isaac Newton, mass could not be given an absolute unit, relative to the basic dimensions of space and time. Even as one can choose to treat the distance between two notches on a stick as the "unit of magnitude", so the measure of mass was determined by the response to a collision with some arbitrarily chosen "unit mass". Following Archimedes' investigations into balance and moments, if one were to double the quantities of every mass in the universe, one would in theory, detect no change.

However, once the law of gravitation was uncovered, this relativity of mass was no longer applicable: "weight" is intrinsically different from "inertia". If all the masses of the

universe are doubled, the gravitational force between two masses increases 4-fold, and the acceleration of each mass towards the common center of gravity doubles.

Therefore quantity of mass, unlike distance, can be given an absolute value once one sets the value of g , the universal gravitational constant, to "1". (Of course one could say that the mass of the electron is a universal unit for mass, but that involves the elementary particles and is not relevant to this discussion.)

This gives μ, the momentum, a somewhat ambiguous character. Momentum, $\mu = mv$, is the product of two quantities, one of which (mass) is absolute (in the $g = 1$ system), and the other of which (velocity) , is a relation between localized objects for $v < c$ = the speed of light (which, by Special Relativity can also be set equal to "1"). Note that "velocity" changes when one moves from one reference frame to another, but that mass (or "rest mass" in Relativity), in theory, is an absolute quantity. In this ambiguity lies the root of the classical equation $E = mc^2$.

Thus, momentum has an uneasy status, being partly an absolute quantity, and partly only a relation between moving objects. Motion itself, therefore momentum, can be reduced to 0, but nothing can reduce mass below the rest mass.

The Motion of Massless Particles?

The question remains open, whether one can speak of anything "moving" if it is massless. Galilean Relativity only addresses the relativity of velocity, v: indeed, the traditional distinction between "kinematics" and "dynamics", has to do with the absence or presence of matter in a physical system.

This question was answered by Quantum Theory, which identified quanta as massless particles moving at an absolute velocity, c. In fact , the quantum restored the Conservation of Energy, which seemed to have been violated in Blackbody Radiation and other phenomena.

That mass, momentum and velocity are all fundamentally distinct can be seen in the cliché:

(E) "No observer can perform an experiment to detect his own motion."

Apart from the very difficult problem of defining the meaning of the term "Observer", "Experiment" and "Motion", the expression leaves open the possibility of at least three interpretations:

(a) Is this itself an "observation" proclaimed on the basic of millions of sense experiences and attempts to detect motion when one is at rest?

(b) Or is it some kind of principle, derived from a set of first principles which are, for one reason or other, deemed self-evident?

(c) Or is it simply a definition of what is meant a physical state known as "rest"?

The issue most urgently in need of being addressed is the definition of *An Observer* in the context of universal kinematics. Certainly we will not get anywhere by casting the

definition into the language of "observations on the existence or non-existence of one's own observations of oneself as a possible observer"! The very construction "I am an observer", which really means, "I observe that I am an observer", is too circular to be legitimate.

The best way to define "rest" is to make an *appeal to external objects* that, by measurements of velocity, position, momentum and energy, can be acknowledged to be part of *an observational rest frame* . To state that "one is at rest" means that one observes oneself to be motionless within an observed rest frame. The famous expression (E) can now be restated as:

(F) "Within a given observed rest frame, one cannot determine, by direct or indirect means, any absolute or objective quantity of motion, as defined by velocity, momentum or energy."

This is almost circular, but escapes being so because of the qualifying phrase "Indirect means of observation". An analysis of this phrase shows that it is by no means obvious that one should

conclude, from observations on one's own rest frame, that an intrinsic motion is absent.

An analogy may be helpful: I am as certain of the fact that the mind/body complex known as "Roy Lisker" will not last forever, but eventually die, and indeed that this will happen within the next 50 years.

No amount of personal "observation" on "myself" has led me to this conclusion, for example I have never exactly seen myself die, all the same I am sure that it will happen.

Why do I say this? It derives from a basic principle, which asserts that

(1) I am constituted like all other living beings, plants and animals

(2) In particular, there is nothing in my physical constitution that is not also found, in some form, in all other human beings

(3) Millions of observations have shown that all living creatures die sooner or later, even elephants, crocodiles and turtles.

(4) Basic principle: If I find no meaningful difference between two objects X and Y, and it is the case that some change always occurs in X, under all circumstances, then I am justified in concluding that this change will also occur in Y. (A modification of Leibniz's Principle of Indiscernables)

(5) Conclusion: If X refers to any and all living creatures apart from myself, and if these always die, then I will also die.

The same logic can be applied to kinematical motions. In theory, it allows for the possibility that one can assert that one's reference frame has an intrinsic motion that cannot be detected directly, but that must exist because it exists in all physical bodies apart from that which one designates as "one's own".

(6) In particular, if

(a) One has derived a series of physical laws which have

never been violated after millions of observations

(b)One observes that one's observations about one's own system do not satisfy these laws, so that

(c) Positing a state of rest for one's own frame requires that one's local environment operate under laws different from the rest of the universe

THEN:

(d) One can conclude, through indirect observation,\ that one's system does possess an intrinsic motion that cannot be observed directly.

It was this line of reasoning that led the astronomers and mathematicians such as Aristarchus, Erastosthenes, Copernicus, Bruno, Galileo, Huygens , Newton to conclude that the Earth is, in an objective sense, turning around the Sun and not the converse.

Otherwise, laws applicable to the universe as a whole would not apply on Earth, a point of view quite acceptable to philosophers, priests, potentates and popes, who wanted everyone to believe (and

who may have believed it themselves) that God was unique, the Bible was unique, Adam and Eve were unique, Christ was unique, the Church was unique, Mankind was unique and, of course, the Earth was unique with its own physical laws that apply nowhere else.

The historical succession goes somewhat as follows:

The phenomenon of inertia was understood as early as the 3rd century BCE by Archimedes, in his researches on balances and moments. Galileo extended his ideas to include the acceleration caused by gravity, and the Galilean principle of the relativity of uniform linear motion. These ideas were misunderstood by Rene Descartes, but fully clarified by Christian Huyghens and Isaac Newton.

One of the basic features of Galilean Relativity is that it is essentially "kinematic" rather than "dynamic". That is to say, the relativity of linear uniform motion is unconditionally applicable in the absence of massive interactions. Two massless objects can be

assumed to pass through each other without collisions. Indeed this is the Principle of Superposition that applies universally to wave motions.

Without mass or alterations by collisions, there is no momentum and no momentum exchange. There is, in fact, no way of giving a velocity (or acceleration!) to any "massless object".

This issue is of importance even in today's cosmologies. If one is to believe the proposed model for the Hubble expansion of the universe, namely that the galaxies are being dragged along by the "expansion of space" and not by any intrinsic motion (yet, if this is so, why are they not being bent into increasingly eccentric ellipses by this 'space expansion'?), then one would not expect any indirect, symptomatic effects (such as the Coriolis force), that would signal the presence of the Hubble expansion.

If, however, the acceleration is intrinsic to the masses, and not to space, then [1] ***one ought to be able to detect and measure a kind of***

[1] Conjecture!

***"Hubble wind" on the solar system*, and even on planet Earth, due to this expansion.**

At any rate, the Galilean Principle of Relativity no longer applies in an absolute form whenever masses are present. The two phenomena that violate it are

(1) Collisions

(2) The force of gravity

Galilean Relativity was restored to Electrodynamics by Special Relativity, and to Gravitation by General Relativity. Both of these provide for "rest", reference frames that cancel uniform velocity (less than light) and cancel acceleration in a homogeneous gravitational field via the phenomenon of "free fall"

Collisions

That the seemingly passive phenomenon of inertia constitutes a genuine force is apparent in the force, power and energy generated by heat. Heat drives engines, lifts winds, energizes bodies. Since Carnot, Clausius and Boltzmann, we understand that

heat is generated by the collisions of massive bodies. Here one cannot speak of a reference frame, or a kind of free fall, in which heat energy is cancelled. This is because it is not based on velocity, per se, but on the changes in velocity, that is to say, the accelerations caused by collisions of billions of molecules in a confined space.

The ambiguity of Inertia as a force field of its own reflects the ambiguity of momentum as a mixture of quantities, mass and velocity, both partly relative and relatively absolute. Massless objects cannot collide, so how can they generate heat? (There is of course the study of Quantum Thermodynamics, but this is based on a different kind of statistics, known in fact as "exotic statistics") On the other hand, if massive objects remain motionless, they also cannot generate heat. Heat is a kind of energy created by the "jumps" in velocity produced by collisions. This is consistent with Newton's Second Law $F = m\alpha$, once acceleration is distributed in

the form of a random collection of Dirac-delta function at discrete points of space-time.

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