How the Æther creates Inertial Forces

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1. Introduction.

This is the second paper in a series examining the origins of inertia. Readers of the first paper "The Case for an Active Æther, Inertia as an External Force" will find the classical Newtonian viewpoint challenged, with evidence from gyroscopic experiments demonstrating that inertia must be considered, not as an internal property of matter to oppose acceleration, but as an *external* force induced by that acceleration. In this paper we explore how space can apply force to matter, leading to an alternative view of the æther and what it contains.

2. Æther Particles.

If the æther is to supply a force on matter we must fill space with some substance. We cannot give this substance any properties that we wish to derive, so it cannot have mass. Fortunately present science already recognizes the existence of particles having zero mass, more exactly zero rest-mass, so we can adopt this philosophy. We might note that such particles (photons, neutrinos etc.) do already interact with matter to effect forces, so we are treading on safe ground. According to current relativity theory our mass-less space particles (let's call them S particles, Sp's for short) will travel through our space at light velocity c, but what other properties can they have? It is accepted that they can have energy E_0, and they can also have momentum of magnitude $p_0=E_0/c$ (note that $\mathbf{p}_0$ is actually a vector quantity pointing along the velocity vector). We can have vast quantities of these particles in transit through our space, traveling in all possible directions. This leads to another property, that is the density (more properly the number-density) N_D, the number of particles per unit volume present within that volume at any instant in time. Note that N_D might not be a constant, it could vary for different regions of space and it could vary with time, however at this point in our development we will consider it to be a universal constant.

The Sp's reach us from distant regions of space, coming in from all directions, so there could be another property defining the arrival numbers from different directions. We wish to keep things simple at this early stage so we will consider our space to be isotropic in this regard, we will assume that on average the particles arrive in equal numbers from all directions. Now what about these particles crashing into each other? We can avoid this consideration by making that probability low, and that brings in particle size. So let us assume the particles to be extremely small. This last feature also allows most of them to pass through inter-atomic space without collision with matter particles, as neutrinos are already known to do. In fact the reader might think we are describing a vast continuum of neutrinos, which might well be the case, but for the moment let's keep our S particle separate and consider it as a new fundamental constituent of space.

We are doing OK! In just two paragraphs, and without violating any of the laws of physics, we have created an active æther with all the ingredients necessary to supply a force onto a matter particle. Before moving on to the next stage, deriving the force equations, let us summarize these æther properties.

S-particles with the following characteristics

- Zero mass
- Velocity **c**
- Energy E_0
- Momentum $\mathbf{p}_0$
- Number Density N_D (very large)
- Small size ($<< \sqrt[3]{[1/N_D]}$)
- Uniform arrival directions

3. Interaction with Mass.

We intend to show that inertia is simply a form of momentum exchange with the æther. Although the Sp's are very small, with the majority passing through inter-atomic space without colliding with electrons or nuclei, some indeed do collide and it is these that are responsible for forces. The colliding Sp can be absorbed by the matter particle, giving up its momentum $\mathbf{p}_0$, then a continual sequence of collisions results in a force given by the rate of momentum absorption. Matter can also emit Sp's, giving another force proportional to the rate of momentum lost.

We will now consider an arbitrary matter particle which will have the well known property of inertial mass, but at this stage we will not assume that property. For brevity we will however call the particle m. In momentum exchange m must absorb a colliding Sp, so we must consider the probability of that event. That brings in the *collision cross section* of m. Let us call this A_c. It is now quite simple to derive the collision frequency as

$$F_{collision} = N_D A_c c \qquad (1)$$

This defines the collision rate (hence also the absorption rate) for S-particles coming in from all directions. Later we will consider how m reacts to each collision, but even at this early stage the reader will recognize that it is unlikely to remain static, that space will play a 3-dimensional game of ping-pong with m, so its position is erratic. This uncertainty is already an established feature of atomic quantum theory.

For m to be stable, it must emit Sp's at the same rate as they arrive, so we need rules for this emission. Let us assume that for each absorbed Sp, one is emitted from the opposite side of m, the emitted one traveling in the same direction (and at the same speed c) as the arriving one. The net momentum exchange is then zero. We now need one more m property, the time delay between the absorption on one side and the emission on the other, let us call this τ. We might care to think of this absorption—time-delay—emission procedure as due to a wave-front traveling across the diameter of m, see Figure 1. The initial collision-absorption starts the wave, this takes finite time τ to travel across, where the wave-front then initiates the release of another Sp.

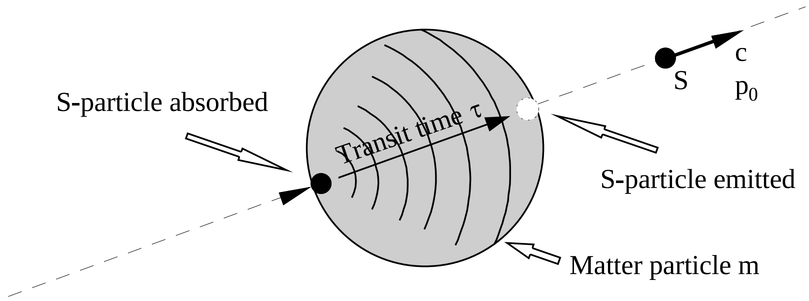

Figure 1. Absorption and Emission of S-particle.

We now have all the features necessary to explain inertia. To do so we will consider a simple unidirectional space, i.e. one in which movement occurs only along a single dimension (note this is solely for ease of illustration). Figure 2 shows a space where the Sp's arrive uniformly at a stationary m from just two opposite directions, shown by the red and blue colors. At a total density N_D, the density for each opposite flow of Sp's is $N_D/2$. Mass m gains momentum $\mathbf{p}_0$ at each absorption, only to lose it at time τ later. Thus over a period of time much greater than τ the net exchange of momentum is zero.

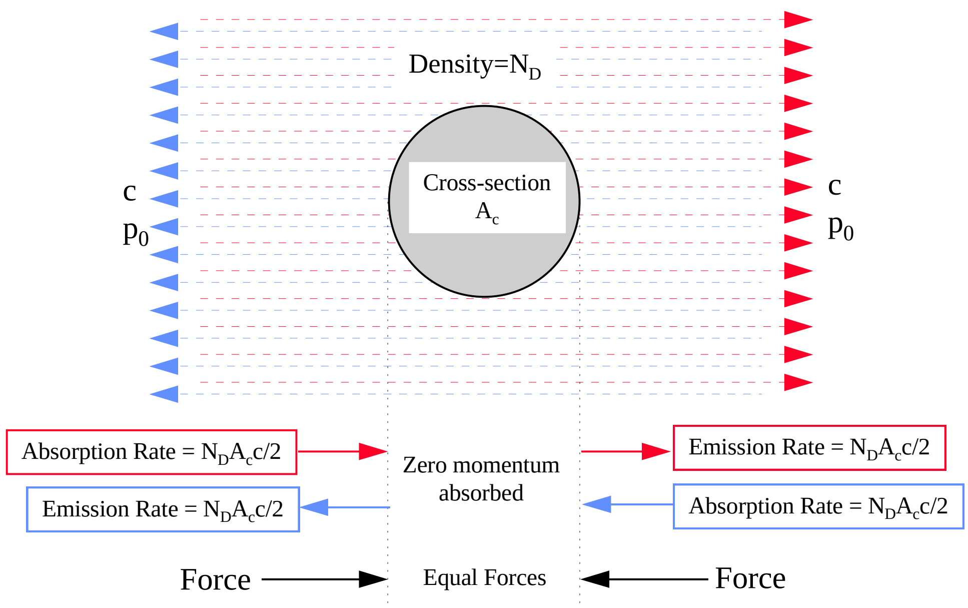

Figure 2. Stationary m.

Put another way, using the fact that Force=rate-of-change-of-momentum, at the surface facing the blue arrivals the blue momentum gained and the red momentum lost add up to an inward force $F=N_DA_ccp_0$. On the opposite surface the inward force is the same magnitude. Apart from an inward pressure attempting to compress m, the net force on the body is zero.

Next consider Figure 3 where m is moving to the right at constant velocity. Although there is now a difference in momentum arriving at opposite surfaces, the forward face absorbing at a greater rate than the rear face, this is countered by the different emitting rates on each surface. The net force on the body again cancels to zero.

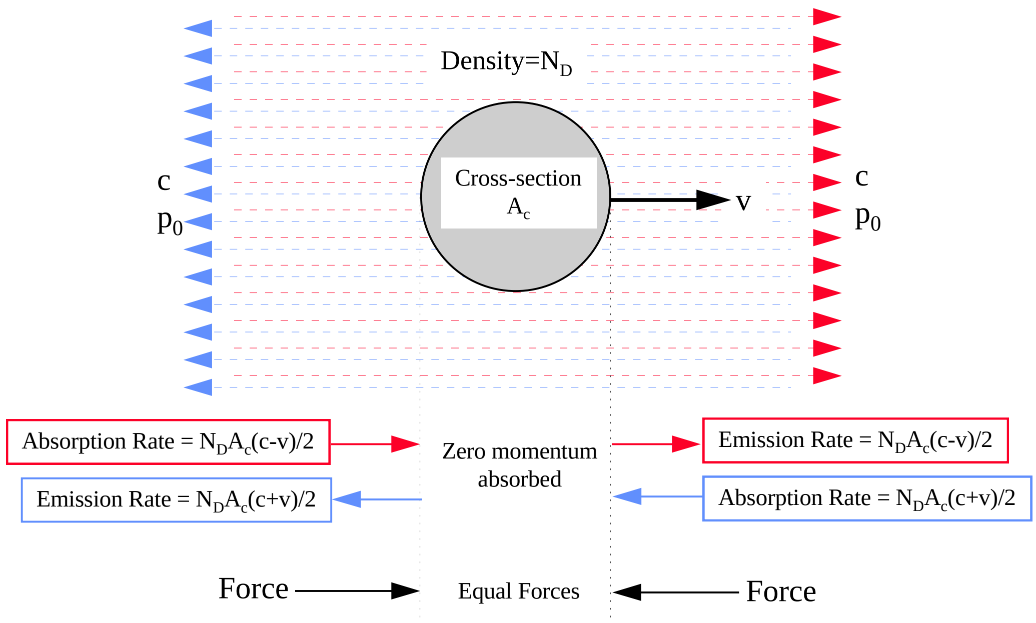

Figure 3. m moving at constant velocity.

Finally we reach Figure 4 where m is accelerating. We find that the change of velocity during time t influences the momentum balance. Although at time t the absorption rate at the front surface is directly related to velocity at time t as before, the emitting rate is now related to the velocity at the earlier time t-τ, similarly for the rear surface. We see that the front surface has a greater inwardly directed force than the rear surface.

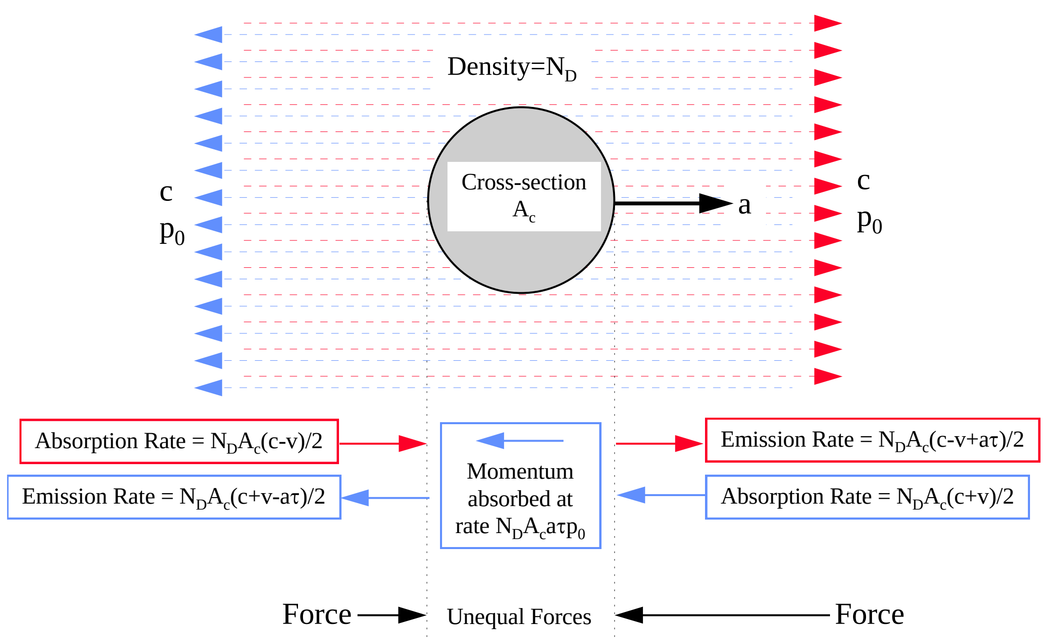

Figure 4. m accelerating

The net force on the body is given by

$$\mathbf{F} = -N_D A_c p_0 \tau \mathbf{a} \tag{2}$$

When this equation is compared to the inertial reaction of the mass m

$$\mathbf{F} = -m\mathbf{a} \tag{3}$$

it is apparent that we can express mass as

$$\boxed{m = N_D A_c p_0 \tau} \tag{4}$$

This equation is significant, it shows that mass is not solely an internal property of a body. We can describe mass as a product (body property) × (space property) where the body property is $A_c \cdot \tau$ and the space property is $N_D \cdot p_0$. Note that the space property $N_D \cdot p_0$ is a *momentum density*, space is full of momentum, but the isotropic nature of the arrival direction of the S particles carrying that momentum delivers zero momentum to a stationary body. It does however deliver an inward pressure, space exerts an inward force. *Perhaps this is one of the nuclear binding forces of Nature*. We might also note that the space isotropy is an assumption we made earlier. We could have a degree of anisotropy where space would then impress external force even on a stationary mass. That is the subject for a later paper where we recognize the external force as gravity, the anisotropy being supplied by another mass. Relativists might recognize isotropic space as equivalent to "flat space", whilst anisotropy describes "curved space".

We started by defining S particles as having energy E_0 related to their momentum by

$$E_0 = p_0 c \tag{5}$$

Thus space has an energy density E_D

$$\boxed{E_D = N_D p_0 c} \tag{6}$$

We will see later that this represents an enormous energy density. Space contains an abundance of energy not yet utilized by mankind.

It is instructive to consider the quantity of this space energy which is stored within mass m as a result of its "storage" time τ. The number of S particles stored in m is found to be

$$N_{stored} = N_D A_c \tau c \tag{7}$$

which leads to the stored energy as

$$E_{stored} = N_D A_c \tau p_0 c^2 \tag{8}$$

Combining with equation (4) shows (8) to be the Einstein equation E=mc². *This puts a new interpretation to this famous equation, a particle's mass-energy is a quantity of energy "borrowed" from space*. Take away the space properties, make space truly empty, then mass has no energy.

4. Conclusion.

The æther contains zero-mass particles (S-particles) which are continually absorbed and emitted by matter, giving rise to the inertial property of mass, which is now seen to be an *external* force caused by acceleration through the æther. When the scalar energies of the S-particles are summed the æther is seen to contain an enormous energy density E_D. There is also an enormous momentum density E_D/c but space isotropy with regard to vector direction of these momentum quanta yields zero force on stationary mass or mass moving at constant velocity.

Inertial mass is not solely an internal property of a body. An expression for mass has been derived as the product of (body property) × (space property) where the body property includes collision cross section and an internal transit time, and the space property is the momentum density E_D/c. S-particles stored in the mass as a result of the transit time yield stored energy meeting Einstein's $E=mc^2$, thus placing an alternative interpretation on what this means. Also there is a new meaning for Einstein's flat v. curved space in the isotropy v. anisotropy of the momentum quanta.

At this stage no attempt has been made to put values on the new components of æther and mass, this will be done in a later paper, suffice to say here that we have the starting point for bringing together inertia, gravitation, electric, magnetic and atomic quantum phenomenon.