Origin of inertia by James F Woodward Fullerton.edu 1998

Notes

http://physics.fullerton.edu/~jimw/general/inertia/index.htm

The cause of inertial reaction forces has been understood to be the action of gravity for quite some time now.

in 1953 Dennis Sciama showed that gravity could account for inertial reaction forces as long as the interaction of local stuff with the gravity field of distant matter was like the interaction of electric charges and currents with the electromagnetic field. It turns out, as a matter of fact, that this is true in general relativity theory, but it took a while to show this.

$$\boldsymbol{E} = -\nabla\phi$$

For static electric fields: Electric field strength = - gradient operating on scalar electric potential

When electric charges are in motion -- that is, when electric currents are present -- the electric field has to be modified to include a term that takes account of the motion of the charges:

$$\boldsymbol{E} = -\nabla\phi - (1/c)(\partial \boldsymbol{A}/dt)$$

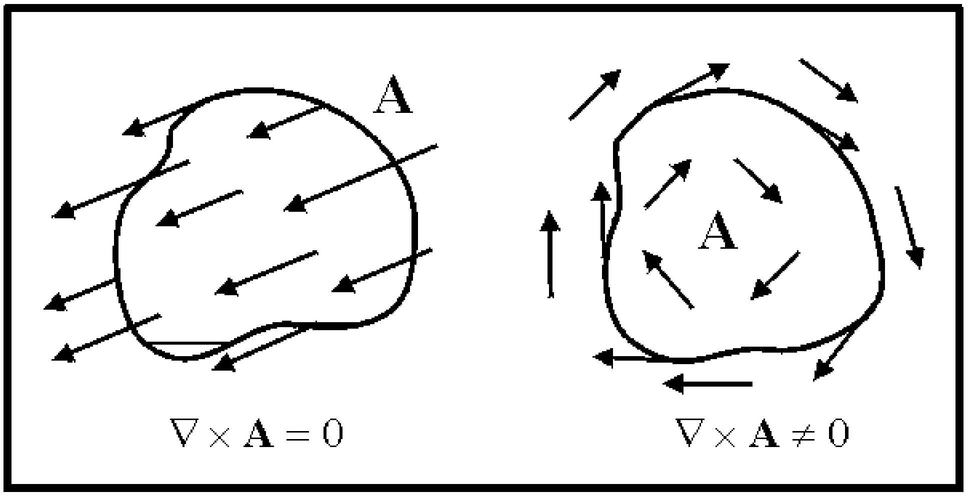
Where A is vector potential.

In general, the influences of charges and currents are not felt instantly over large distances.

In the simplest case, of a test particle traveling uniformly in a universe filled with distributed “stuff”, gravity is analogous to electromagnetism.

What is the force of gravity on the test particle due to the rest of the stuff? In general, both "gravito-electric" and "gravito-magnetic" fields, the gravitational counterparts of electric and magnetic fields, may act.

Since the surrounding “stuff” does not circulate, its curl is zero, so the curl of the vector potential which is just the "gravito-magnetic” field, is zero, so the "gravito-magnetic” force does not act.



The gravito-electric field is given by

$$\boldsymbol{E} = -\nabla\phi - (1/c)(\partial \boldsymbol{A}/dt)$$

But $\nabla\phi$=0. If gravity is to account for inertia, it must be due to the vector potential part of the gravito-electric force.

NOTE: in scalar energy controversy, expert says vector potential don't have macroscopic effects

"From Newtonian mechanics we know that the gravitational force acting on a planet must act along the instantaneous line of centers of the planet and the Sun if an elliptical orbit is to be recovered. (That is, the force exerted by the Sun must propagate to the planet instantaneously. This fact is the reason why Newtonian gravitation is called an "action-at-a-distance" force. Newton privately thought this preposterous; but he never found a way around it.) If relativity is right, then the gravito-electric field (i.e., Newtonian gravity) must propagate at the speed of light, and the corresponding gravitational force on the planet wouldn't point along the instantaneous line of centers. So, if the gravito-magnetic contribution to the total force weren't included, the force of the Sun on the Earth, for example, would point in the wrong direction and its orbit wouldn't be elliptical."

Non-argument:

"Nordtvedt arrives at this conclusion by a variant of this argument. He shows that the motion of a test particle around the Sun is elliptical for an observer at rest with respect to the Sun. In this frame of reference the field is stationary and everywhere points toward the Sun at all times, so the force is always along the instantaneous line of centers."

“If the observer moves with respect to the Sun [for example, with the planet], however, and doesn't take into account the gravito-magnetic vector potential, the predicted orbit "blows up". [This example is a neat illustration of the fact that "coordinate transformations" in general relativity theory are equivalent to "gauge" transformations in electrodynamics. The observer at rest with respect to the Sun is effectively in the Coulomb gauge, and the one moving with the planet in the Lorentz gauge.])

This means that gravito-magnetic forces must exceed the speed of light.

Google gravito-magnetic theory

gravito-magnetic vector potential

Raine showed that Sciama's argument was true for all realistic universes in general relativity theory, the gravitational origin of inertial forces (that is, Mach's principle) ceased to be an area of active work for more than a decade. Some subtleties attendant to Mach's principle, however, weren't fully appreciated and worked out in the 1970s. They began to attract attention in the early 1990s. Some of them are related to the business of transient mass fluctuations.

Given that Sciama and Raine’s attribution of inertia to gravity is correct, problems arise when we ask how, in detail, inertial reaction forces are produced by the distant matter in the cosmos.

Only seem to be three answers to this question:

1) Relativity notwithstanding, the force really is propagated instantaneously. The occurrence of so-called "non-local" interactions in quantum phenomena (reported even in the popular press of late) might make such a scheme seem plausible.

2) Some sort of a local field, maybe not our A field, is really the cause of inertia; ie, the Haisch, Rueda, and Puthoff (HRP) hypothesis of the ZPF as responsible for inertia.

3) When you push on an object a gravitational disturbance goes propagating off into either the past or the future. Out there in the past or future the disturbance makes the distant matter in the universe wiggle. The wiggling stuff out there makes up the currents that cause disturbances to propagate from the past or the future back to the object. They all arrive from the past or future just in time to produce the inertial reaction force you feel.

“If you've had a course in electromagnetism, you'll probably recall that the equations for the electric and magnetic fields and the scalar and vector potentials, by themselves, aren't enough to let you calculate much of anything. The problem is that the field equations are so general that they aren't completely defined. In addition to the field equations you have to specify a choice of "gauge" (within certain broad constraints) if you want to actually do any calculations. [You'll find all this explained in any good text on electromagnetism.] As long as the gauge is selfconsistent, you can choose any gauge you like. In practice, two gauges are commonly used. One is called the "Lorentz" gauge [after H.A. Lorentz who created much of this theory around the turn of the century]. In this gauge both of the potentials and both of the fields explicitly propagate at the speed of light. The other gauge is called the "Coulomb" or "radiation" gauge [after C.A. Coulomb because in this gauge the scalar potential propagates instantaneously, as does the force between electric charges at rest according to "Coulomb's law"].”

The scalar potential propagates instantaneously in Coulomb gauge, but as we have seen, vector potential is what causes inertial effects from gravity, and it is limited to the speed of light.

I Ciufolinni and J.A. Wheeler in their book, Gravitation and Inertia (Princeton, 1995)] propose that inertia arises in a similar, but more subtle way, via “constraint conveyance”, which Woodward sees as implausible.

Roughly, the modern instantaneous action argument goes as follows. In general relativity theory matter "there" tells space "here" how to curve, and space "here" tells matter "here" how to move. (Matter "here" also tells space "there" how to curve.) Thus, in order to talk about any situation in dynamics we must specify the distribution and motion of matter throughout space. (Strictly speaking, we must provide "initial data" on some suitably chosen "three dimensional spacelike hypersurface".) The usual field equations for gravity (Einstein's equations) are not enough, by themselves, to do this it turns out. Because of the finite propagation velocity built into them, we might specify some distribution of matter that subsequently leads to idiotic results. To make sure this doesn't happen, our distribution of matter has to satisfy some additional equations called "constraint" equations. The neat thing about these constraint equations is that, unlike the field equations, they're instantaneous. (Technically, they're "elliptic" rather than "hyperbolic" differential equations.) It's then claimed that inertia is conveyed by the constraint equations -- instantaneously. The use of constraint equations to communicate real physical influences instantaneously is justified by appeal to the instantaneous propagation of stationary electric fields in the Coulomb gauge.

Woodward believes the answer is 3) In support of this belief, he notes that “the ‘wave’ equations that describe the propagation of radiation have two equally valid types of solutions: ones that propagate forward in time, and ones that propagate backward in time. (Technospeak: the equations have the symmetry of "time reversal invariance".)”

Waves that move backward in time are called "advanced" waves because their "effects" in the past occur in advance of their "causes" in the future.

“You may think the whole idea of advanced waves coming from the future pretty preposterous, but they solve some rather nasty problems. P.A.M. Dirac used them in an epochal study of the nature of electrons in the 1930s, and R.P. Feynman and J.A. Wheeler elaborated their "absorber" theory of electrodynamics in the 1940s on the basis of them. It turns out that electromagnetic radiation reaction (the reaction force on a source produced when radiation is launched) is neatly accounted for in terms of a combination of "retarded" waves (normal waves propagating forward in time) and advanced waves. [Radiation reaction, intimately connected to transient mass fluctuations, is addressed in another document.] Precisely the same thing evidently happens with inertial reaction forces. The act of pushing on something causes a disturbance in the gravitational field to go propagating off into the future. It makes stuff (the "absorber") out there wiggle. When the stuff wiggles it sends disturbances backward (and forward) in time. All the backward traveling disturbances converge on what we're pushing and generate the inertial reaction force we feel. No physical law is violated in any of this. And nothing moves faster than the speed of light. It only seems so because of the advanced waves traveling at the speed of light in the backward time direction."

Woodward believes the ZPF hypothesis or origin of inertia is not plausible. Does not agree with the "high energy" ZPF hypothesis; if the energy density were that high, since energy is a source of the gravitational field, the universe would be curled up into a miniscule little ball according to general relativity theory.

If inertial reaction forces are electromagnetic forces that accelerating electric charges experience as they interact with a zero point field, one would expect that inertial reaction on protons and neutrons would depend on how much charge they contain. Based on charge, the inertial mass of the proton should be 1.56 times as large as that of the neutron. In fact, the neutron is very slightly more massive than the proton.

In order to make a real local field explanation of inertia work we have to use vacuum fluctuations, or their equivalent, since the usual field approach has the weird gauge properties that we've already looked into. This has strange consequences because of something called the "fluctuation-dissipation theorem". Roughly, what this theorem says is that fluctuations and dissipative forces are opposite sides of the same coin. For example, frictional forces are dissipative since they act to slow down the motion of normal objects. They are always accompanied by microscopic thermal fluctuations. In the case of electromagnetic quantum vacuum, Peter Milonni [in The Quantum Vacuum (Academic, 1993)] has shown that this means that zero point fluctuation processes can equally well be regarded as due to radiation reaction (or some combination of the two). Since radiation reaction can be viewed as a Wheeler-Feynman "absorber" interaction with the distant matter in the universe in the far future, it seems that vacuum fluctuation schemes are really no different from the simple field approach. Indeed, the absorber interpretation is to be preferred because it doesn't load up the vacuum with a lot of energy that quite obviously isn't there.