Review of: "The Electric Field as a form of Acceleration"

Thomas Voigtmann[1]

1 German Aerospace Center (DLR)

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The submission by Moshe Segal, entitled "The Electric Field as a Form of Acceleration," is built on a fundamentally flawed understanding of basic theoretical physics, and for that reason, its main conclusions are unjustified.

The author has noted a very interesting structural similarity between Newton's law of gravity and Coulomb's law for electrostatic forces between two charges at rest. Both depend on distance as 1/r^2. This is indeed a very, very deep observation, and one that physicists should continue to marvel at. It is, however, well understood.

I have read the other reviewers' comments, and I am baffled. Perhaps Qeios is not a scientific journal after all. Please read my review as one that would be likely if you tried to publish this in a journal dealing with physics. Nothing personal, but one has to be aware that the internet is already full of half-baked explanations of fundamental physics concepts, and the task of a reviewer is to be harsh here and to make sure that we stick to the logic underpinning the current principles of science.

In this sense:

The author does not appear to have any expertise in publishing in scientific outlets. The repetition of trivial statements is not generally accepted in scientific publications, and literature references should preferably point to peer-reviewed established publications, textbooks, or similar items, and not exclusively to Wikipedia and some of the more dubious online learning resources (that in at least one occasion here are manifestly wrong).

The paper opens with the statement that the "issue of Mass Bodies' attraction was initially investigated by Newton." This is historically incorrect: certainly, Galileo preceded Newton (and Galileo experimented on the way objects fall in the gravitational field of Earth), as well as Kepler. What could be said is that Newton was among the first to discover the inverse-square dependence of the gravitational force on the distance. The phrasing "Mass Bodies" chosen by the author is unusual and imprecise. More in line with accepted terminology would be "massive bodies," to distinguish the property of a body (massive) from a fundamental concept (mass).

Second sentence: Newton's gravitational law, as stated here, does not refer to any two massive bodies, as claimed by the author. For example, two massive cubes will not follow this law at all center-of-mass distances r. (For two cubes, one will obviously have forces that are not spherically symmetric, while Newton's law, as stated in the paper, is; this is also just one specific example.) What the author intends here is to refer to spherically symmetric massive bodies, or the theoretical concept of point particles. Wikipedia [1] is not a good reference to place here; any undergraduate textbook in physics will do.

The quoted law by Newton, in fact, also provides the direction of the attractive force between two (spherically symmetric) massive bodies, not just "the amount" (third sentence). (Why it holds not just for the theoretical concept of a "point particle" but also for extended spherical bodies, and thus for things like planets to a reasonable approximation, is a very interesting solved question in Newtonian physics.)

These are minor points, but they indicate to me a certain sloppiness in the presentation of the paper's arguments that one has to keep in mind when reading the rest.

The author then argues that "Newton could not provide a complete explanation" for the cause of this force. This is true, but entirely philosophical: Newton's law is a hypothesis deduced from countless observations and has to be taken as one of the postulates of classical mechanics. Questions regarding the origin are relayed to metaphysics. The "explanation," if one wishes, is really just that matter appears to have an intrinsic property, called its "(gravitational) mass," and this property causes an attractive force.

The concept of a "gravitational field" (no need to capitalize) was most likely not invented by Newton; it probably goes back to Leibniz or later mathematicians.

The author then reveals a first fundamental misunderstanding: what the author calls the "gravitational field," g = G m/r^2, is just the acceleration due to gravity, because by definition, it is just the gravitational force per mass, which according to the fundamental principles of Newtonian mechanics is an acceleration. The way the author introduces "gravitational field," the quantity g is not a new concept compared to the force, and any statements that Newton sought to explain the force by the field or vice versa are meaningless.

The fundamental misunderstanding is that the "gravitational field," as used successfully in theoretical physics, is proportional to 1/r and not to 1/r^2. This is because the force is the gradient of that field, and behind this statement (that the gravitational force is what is called a conservative force), there is a lot of insight. Just factoring out one of the masses from the gravitational force is trivial and does not lead anywhere.

The equation "F = m*g" appears prominently in many introductions to physics, but the way the author uses it, there is at least an unfortunate clash of notations. The symbol "g" is commonly used to represent the gravitational acceleration due to the Earth, measured on Earth's surface (and is approximately 9.81m/s^2, slightly depending on where exactly on Earth one is located). It is understood as a quantity that does not depend on distance because it applies to the motion of bodies near the Earth's surface, where both the distance to the center of the Earth (causing the gravitational field) and Earth's mass are huge compared to any changes in position (maybe some 10km in height compared to the 6370km distance to Earth's center) or any particle masses. The symbol "g," as used by the author, is a quantity that depends on the distance r. It is at least advisable to not re-use commonly used symbols with different meanings.

It is also very confusing that the author uses the same symbol "m" with three different meanings: first, in "g = G*m/r^2," the symbol "m" stands for the gravitational mass of an object that creates a gravitational field. In "F = m*g," "m" stands for the mass of another object that probes this gravitational field. In the later "F = m*a," "m" stands for the inertial mass of that probe particle. The latter distinction should at least be mentioned in a text that purports to unravel deep explanations about gravitational acceleration, as the equivalence principle (which holds that inertial and gravitational mass are identical) might be of interest when discussing the motion of massive charged particles, as the author later does.

The confusion between the gravitational masses of the two particles (the one creating the field, the one probing it) shows a very fundamental lack of understanding in the text. A lot could (and should) be said in this context about the concept that in classical field theory dealing with particle motion, there is an important conceptual subtlety lurking there: the introduction of "probe" or "test" particles that are supposed to measure the field without disturbing it. This makes the initial formulation of Newton's gravitational force subtly different from the gravitational-field formulation.

The quantity "g," which the author introduces as proportional to 1/r^2, seems to be taken from [2], which contains the same error and is hence a very dubious reference. For such reasons (not to perpetuate conceptual mistakes someone made once somewhere on the internet), scientific publications seek not to quote exclusively from such online resources.

In fact, all the author's statements pertaining to "a form of acceleration" are based on this simple misunderstanding: of course, in Newtonian physics, any force divided by the (inertial) mass of the probe particle results in an acceleration (or "is" an acceleration). For massive particles, this has been known for about 300 years, and for electrically charged particles, arguably for almost 250 years (Coulomb's law was published in 1785), or if we want to be more critical, for about 125 years (the Lorentz force was derived in 1895). It is thus somewhat confusing to claim that "nowadays the Science of Physics does not recognize (yet) the Electric Field also as a form of Acceleration" (first sentence of the abstract).

The author claims that "Einstein succeeded in explaining the origin of the attraction forces ... by concluding that Newton's Gravitational Field is a form of Acceleration." Many parts of this sentence are confusing at best, wrong at worst. As should be clear from above, what the author calls the gravitational field is, in fact, not the gravitational field in the sense of Newton/Hooke/Leibniz, but simply the acceleration due to gravity, and not just "a form" of acceleration. Einstein did not explain this because it was already well known before his time. What Einstein explained could not at all be "derived directly from Newton's work" (as the author claims). What Einstein explained is not even featured prominently in the present paper, which is another fundamental problem (see below). If anything, an explanation that the author is looking for was given by the equivalence principle and dates back to Galileo.

The fundamental new insight of Einstein was that gravitational forces are just a geometrical effect, since they can be understood simply as the consequence of curved space-time once one postulates that gravitational mass induces curvature in space-time. This sets gravitational forces somewhat apart from others such as electrostatic forces. The reason they are different is connected to the fact that they are proportional to the gravitational mass of the moving object, and that due to the equivalence principle, this cancels with the inertial mass. For electrostatic forces, which are not proportional to the gravitational mass (why should they be? they couple to charge, not mass), this cancellation does not occur. Any text that wishes to stipulate a discussion on the fundamental equality between electric and gravitational fields should at least provide some discussion on how the two are treated very differently in relativistic physics.

The author argues that the equivalence between what they call "gravitational field" and "acceleration" can be derived only from the force law, not at all using Newton's second law. This is untrue, and also the author's derivation uses Newton's second law implicitly. First of all, one should recognize that a derivation without Newton's second law cannot be possible just by logical consistency: with F=mg, one postulates a "force", and at this stage, one does not know yet what such a mysterious "force" (or "action at a distance" as contemporary critics of Newton called it) does to a particle. One needs another postulate, one that links the abstract concept of "force" to something observable, like a change in velocity. This is Newton's second law. (If one distinguishes carefully between gravitational mass and inertial mass, the conceptual difference between F=mg and F=ma becomes even clearer.) In the paragraph that the author starts by claiming to present a derivation "without using Newton's Second Law of Motion", they also write that "during the attraction process, the velocities of the attracting Mass Bodies also continuously increase", which is exactly Newton's second law in words.

The confusion of "gravitational field" (which should be proportional to 1/r and proportional to one mass) with "acceleration" (which is just force divided by the other mass) also leads to strange statements like "the Gravitational Field itself ... also continuously increases during the attraction process". A "gravitational field" is a quantity associated with each point in space (or space-time), and it has a given value for each point whose distance to the origin is denoted as r (if the mass that creates this field is placed at the origin of the coordinate system). As such, it does not change if we do not change that central mass. The only thing that changes is the acceleration of the second mass towards the central one; the value of the gravitational field that the moving mass probes changes - the moving mass always "measures" the value of the field at its current location, and it experiences the slope of the field as a "force".

The problem with the author's treatment of electrically charged particles is already indicated in reference [5]: Coulomb's law applies to electric charges "at rest". The experiment that the author envisions thus has to be carried out differently: one has to place two charged (point) particles with a known distance between them and measure the force that is required to keep the particles there (so that they do not move). By Newton's third law, this will be equal (and opposite in direction) to the Coulomb force between the particles, plus the gravitational acceleration between them. The latter will, as the author points out, typically be much, much smaller, so an experiment is unlikely to be able to detect this tiny extra contribution.

Accelerating charges radiate electric and magnetic fields, and in this case, Coulomb's law is no longer applicable. One would at least need to replace this law with the Lorentz force law for a moving charged particle. But a more fundamental issue arises when combining this with gravitational forces: this can no longer be done on the level of Newtonian mechanics. One needs to resort to full general relativity theory in this case because the theory of electromagnetism is fundamentally at odds with Newton's theory of gravity. (Maxwell's equations, which combine all our current knowledge of non-quantum electromagnetic phenomena, are Lorentz-invariant just as Einstein's relativity theory is, but not Galilean invariant like Newton's law.)

The argument made by the author, that for motion in an electric field, "F=ma should be replaced with ... F=kqa", is conceptually wrong. First of all, the "F" obtained from Coulomb's law does not replace the "ma", but the "F" from "F=ma": Newton's second law says that whenever we observe acceleration, it must be the result of a force, but we do not know yet what specific force. Coulomb's law, or rather a proper electrodynamical force law, would specify this force as the result of charges. So, "ma = F = q*e + mg" would somehow make sense in the world of Newton and Coulomb - if we assume that the forces acting on a particle are additive, so that a charged massive particle feels both electrostatic and gravitational forces. Please note that this law would, as explained above, run into inconsistencies soon enough because Coulomb's law ceases to be valid when the acceleration causes a velocity that is not zero, and Newton's second law needs to be replaced by the relativistic form if one wants to be precise. Although it is, in my opinion, not the best textbook on electrodynamics, the book by Jackson (John David Jackson: Classical Electrodynamics) could be recommended here, as it contains some discussion on all the problems one runs into when one simple-mindedly applies these textbook formulas to the problem posed by two accelerating charges in the field generated by themselves. (Nothing that cannot be consistently solved, but there are pitfalls because one leaves the regime of validity of the simple "F=q*e" rather quickly.)

The author indicates that additional papers are in preparation based on this present one. I would urge the author to carefully reconsider before misrepresenting standard physics concepts that have been carefully and consistently sorted out during the past 200 years of modern physics.