"Here Comes the Sun"

How the new geocentrists persist in scientific and logical errors

by Alec MacAndrew

Introduction

Karl Keating, founder of Catholic Answers, posted a short piece at Catholic Answers Forum[1] in a thread about geocentrism, discussing the difference between *kinematics* - calculating motion as viewed from different viewpoints without regard for causes of motion - versus *dynamics* - calculating the motion of bodies by considering the forces acting on them - as a basis for thinking about and calculating the motion of celestial bodies. Bob Sungenis, who is a prominent proponent of geocentrism[2], replied with a long article posted on his website[3] attempting to refute Keating's argument. This gives us a good opportunity to discuss some of the scientific and logical errors that Sungenis and some of the other new geocentrists have been making for years.

The first part of Sungenis's article is a discussion in his own words of Keating's post. The second longer part is a series of loosely connected papers written, at least in part, by other people. They contain mathematical treatments of various aspects of Newtonian celestial mechanics which purport to show the dynamic as well as the well-accepted kinematic equivalence of heliocentric and geocentric descriptions of the solar system. I show that not only does Sungenis fail to demonstrate this dynamic equivalence in the first part of the paper, but that the second part, mainly written by others, also fails to show it, and moreover contains several substantial but basic errors. I also point out that moving from a Newtonian to a General Relativity framework, as the geocentrists must do if they are to demonstrate the dynamic equivalence of Earth-static and Earth-moving systems, results in the concepts of being central and absolutely static becoming meaningless, thereby completely undermining their basic claims.

Kinematics and Dynamics

The discussion point between Keating and Sungenis centres on whether both kinematic and dynamic descriptions of celestial motions are equivalent.

Keating's point is that, although you can view any motion from the point of view of any arbitrary frame of reference by applying a co-ordinate transformation (this kind of calculation is known as *kinematics*), the actual causes of motion (forces leading to accelerations and so on) are not revealed by these co-ordinate transformations. They do not tell us anything about why the body is moving as it is nor allow us to predict its motion. For that you have to turn to the science of *dynamics* in which the motion is derived by using particular physical laws, such as the inverse square law of gravity.

Sungenis disagrees and attempts to demonstrate that the geocentric claim (that the Earth is completely static at the centre of the universe) is both kinematically *and* dynamically equivalent to the situation in which the Earth rotates daily on its axis and revolves annually around the Sun. His arguments in this paper fail because they are mainly based on classical mechanics, in which there is no such dynamic equivalence. In classical mechanics, rotating and accelerating frames can be

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[1] http://forums.catholic.com/showthread.php?t=851392&page=2 accessed 8th Feb 2014

[2] The new geocentrism is a religiously motivated belief that the earth is completely static and located at the exact centre of the universe.

[3] http://galileowaswrong.com/wp-content/uploads/2013/06/Answer_to_Keatings_orbits.pdf/ accessed 8th Feb 2014

absolutely distinguished from non-accelerating or inertial frames, and according to classical mechanics, the Earth is *unambiguously* rotating and accelerating. But there's more – in pushing his point Sungenis makes several elementary errors. For example he is wrong about the strength of the gravitational attraction of various celestial bodies at the Earth, and he confuses two different physical concepts – the centre of mass of a system of bodies and a point in space with zero gravity.

A potentially successful way to arrive at a physical equivalence between an Earth-static geocentric frame and a rotating, orbiting Earth frame is by invoking Mach's Principle which states that inertia is determined by some influence of the cosmic matter and energy. A consequence of Mach's Principle is that rotation is relative and not absolute. According to Mach, it is as valid to say that the universe rotates around the Earth once a day as it is to say that the Earth rotates once a day on its axis; they are equivalent and the choice is arbitrary. The same could be said not just for the Earth but for any object in the universe. General Relativity is the current best physical theory of gravitation and it might incorporate Mach's Principle, although this is still a matter of debate. However, invoking General Relativity, as geocentrists do to attempt to get the equivalence they need, makes meaningless the concepts of being absolutely static and of a centre to the universe, thus demolishing the fundamental hypothesis they are trying to prove. So, depending on which argument they use, their claims are either wrong or meaningless.

The relationship of maths and physics

In an attempt to demonstrate the equivalence of Earth-static and Earth-rotating systems, Sungenis begins his paper with some thoughts on the relationship between mathematics and physics, making assertions that could not possibly be made by a professional physicist or mathematician:

> ***If the math of either system works, it is because the physics of either system works****, for physics is measuring how things move by using mathematics, not intuition or magic. [My emphasis]*

The bolded part of the statement depends entirely on what he means by "works". Maths is a tool in physics – it is used to describe and model the behaviour of the world. It is trivially easy to write down perfectly acceptable mathematical expressions which "work" as far as mathematicians are concerned, but which do not describe the physical world correctly, and which are therefore wrong, as far as physicists are concerned. (For example, an expression that gives the gravitational field magnitude of a body decreasing as the cube of the distance from it, $g = Gm/r^3$, is perfectly good mathematically, but is demonstrably wrong as a physical description of reality.) The maths of kinematics (co-ordinate transformations) "works" perfectly to describe the motion of bodies from different perspectives, but tells us nothing about the underlying causes for the motion, just as Keating stated. Sungenis continues:

> *Physics is little more than math. If the math doesn't work, then neither will the physics. The problem with physics is that it can provide more than one viable math solution, and different* math solutions yield different physical explanations..

"Physics is little more than math" – this is a grotesque misunderstanding of the scope of physics. Physics is substantially different from maths – as we have seen, maths is used as a tool in physics to describe the behaviour of the world, but physics involves much more than writing down descriptions. The fact that physics descriptions are usually mathematical doesn't mean that "physics is little more than math". Historically, it has often been the case that existing mathematical techniques don't "work" to correctly describe various aspects of the way the world behaves and then new maths needs to be created, or adopted into physics. The fact that Newton was obliged to invent differential calculus in order to derive elliptical orbits using his law of universal gravitation is a classic case. There are many more examples in modern physics, including the adoption of tensor analysis in GR and the

development of gauge theories in particle physics. In any case, it is wrong to equate physics and maths.

So just because the "maths works" doesn't necessarily mean that it provides a good explanation of reality. Syntactically valid maths which follows correctly from its axioms does not, on its own, tell you whether it accurately describes reality – for that you have to turn to the physics and to Nature herself – does the model, i.e. the maths, accurately describe and explain the physical behaviour? Nature is the arbiter.

Does the Earth orbit the Sun or vice versa?

Sungenis, using entirely classical, Newtonian arguments, claims that the Earth can be static and orbited by the Sun because of the influence of the rest of the universe. Let's see why that is false.

He writes:

> *Notice how Keating seeks to limit that issue [the Sun-Earth dynamic system] to "the Sun and the Earth." If the issue were limited to the Sun and the Earth, Mr. Keating would be correct. That is, the Earth, being the smaller body, would necessarily orbit the Sun, which is the larger body. This is precisely what led Galileo to surmise that if small moons are orbiting Jupiter, then the smaller Earth should orbit the Sun, and thus the Earth moves.*

Remember what Sungenis asserts here, because it is very important for our discussion – it is an admission that if the Sun-Earth orbital system can be approximated to a two-body system (as Luka Popov does in a paper extensively cut-and-pasted later in Sungenis's article) then the Earth would necessarily orbit the Sun. I am going to show that the Sun-Earth system can be approximated very closely to a two-body system and therefore that Sungenis's claims that it can't be treated that way are wrong. He continues:

> *Where Mr. Keating goes wrong is precisely his attempt to limit the issue to a two-body system, the Sun and the Earth. I'm sure Mr. Keating has noticed that each night we see that there are countless stars the circle the Earth. Each of those 5 sextillion stars have gravity, and that gravity will affect how the Sun and Earth react to one another, especially if the Earth is put in the center of that gravity.*

So Sungenis's explanation for why he believes the Sun-Earth system cannot be treated as a two-body system is because of the gravity of the "5 sextillion 'countless' stars". Presumably, in his mind, this somehow forces the Earth to be at rest while the Sun revolves around it. To see whether he is even in the right ballpark, let's put some numbers on the magnitude of the gravitational field[4] at the Earth for various celestial bodies; i.e., let's calculate the gravitational attraction of these bodies as experienced by the Earth. If Sungenis is right we should expect the gravitational field of the Sun at the Earth to be at least matched by that of the other bodies.

I have normalised the universal gravitational constant, G, to unity so that the gravitational field of the Sun at the Earth is normalised to 1 in the table below in order to easily compare it with other bodies[5].

[4] In classical mechanics, the magnitude of the gravitational field of a body is proportional to how strong the gravitational attraction of that body is at any point in space; it is the force per unit mass that would be felt by a second body at that point.

[5] I use the well-known equation for the gravitational field, where g is the magnitude of the gravitational field, G is the universal gravitational constant (normalised to unity in the table below), M the mass of the celestial body and r its distance from Earth:

Body	Mass - solar masses	Distance from Earth - astronomical units (light-years)	Gravitational field magnitude at Earth
		Solar System bodies	
Sun	1	1	1
Moon	3.68×10^{-8}	2.7×10^{-3}	5.04×10^{-3}
Venus [a]	2.45×10^{-6}	0.277	3.2×10^{-5}
Jupiter [a]	9.5×10^{-4}	4.95	3.8×10^{-5}
		Extra-solar bodies	
Proxima Centauri	0.123	2.68×10^{5} (4.24 light years)	1.71×10^{-12}
Sgr A* black hole [b]	4.2×10^{6}	1.64×10^{10} (25,900 light years)	1.57x10-^{14}
Milky Way* [c]	1.25×10^{12}	1.64×10^{10}	3.19×10^{-8}
Andromeda galaxy	1×10^{12}	1.61×10^{11} (2.54×10^{6} light years)	3.88×10^{-11}
Virgo supercluster	1.2×10^{15}	3.40×10^{12} (5.38×10^{7} light years)	1.84×10^{-10}
Virgo-like supercluster at z=0.1	1.2×10^{15}	8.22×10^{13} (1.3×10^{9} light years)	1.77x10-^{13}

Table 1

[a] The gravitational field of the most influential planets – Venus because it is close and Jupiter because of its relatively large mass: the gravitational field of planets varies greatly depending on their distance from the Earth as a consequence of the Earth's and planets' orbits. The calculations here represent the closest approach of these planets to the Earth, i.e. their maximum gravitational influence.

[b] Sgr A* is the location of the supermassive black hole at the centre of the Milky Way which has a mass of over 4 million Suns. We can see that its gravitational field at the Earth is only slightly more than a hundred trillionth that of the Sun's.

[c] Calculated by the ratio of the centripetal acceleration of the Earth around the Milky Way (period 240 million years, radius 2.57×10^{20} m) to centripetal acceleration of Earth around the Sun (period 1 sidereal year, radius 1.5×10^{11} m)

As you can see, because of the inverse square relationship of gravitational field magnitude with distance, the Sun has by far the largest gravitational attraction at the Earth compared with all other

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$$g = -\frac{GM}{r^2}$$

bodies in the universe. Even the closest galaxy cluster, which consists of hundreds of galaxies (the Virgo cluster with the mass of a thousand trillion stars), has a gravitational field at the Earth *of less than a billionth that of the Sun*. The gravitational effects of extrasolar bodies are so low that it is quite acceptable to regard Sun-Earth as an isolated two-body system with small perturbations from the other solar planets. The gravitational influence of the universe at the Earth is completely dominated by the Sun.

Geocentrists might argue that although the attraction of individual entities (even entities like galaxy superclusters that contain the mass of a thousand trillion stars) is vanishingly small, the sheer number of stars in the universe can compensate for this. But this argument doesn't work. Let's combine the total number of galaxy clusters within 2.5 billion light years which is about 16,000 clusters[6], average richness[7] ~17, each of average mass ~2.4×10^{13} solar masses. Let's suppose that we put them *all* at the distance of the Virgo cluster—which is closer than *any* of them and 50 times closer than the furthest of them. And let's put them all in the direction of Virgo so their gravitational fields *add,* rather than spreading them all around the sky to cancel each other out, as they actually do. The total gravitational field of all these clusters, placed much closer to the Earth on average than they really are, and all acting in the same direction, is still *30 million times less than the Sun's gravitational field at the Earth*[8]. And the further out you go, although the total number of galaxies that we have to consider is still larger, their gravitational attraction becomes even less because of the inverse square law.

Furthermore, Sungenis's claim that the stars have *"gravity [that] will affect how the Sun and Earth react to one another,* ***especially*** *if the Earth is put in the center of that gravity"* [my bolding] is wrong, not just because the gravitational field at the Earth of all these stars is vanishingly small compared with that of the Sun, as we have seen, but because gravitational fields of individual bodies are vector-additive—that is, they can cancel each other out if they act from opposite directions—so that if the Earth were to be at the centre, these already minuscule gravitational fields from the stars would tend to sum to zero.

Sungenis has already been shown by Gary Hoge[9], that there are no observable motions in the universe that could offset the overwhelming gravitational attraction of the Sun, moon, and planets on the Earth. Why do the new geocentrists and Bob Sungenis in particular constantly repeat the same old errors? Not only is he often wrong, but he is incorrigibly wrong. Even when he has been corrected about his errors, he persists in wheeling them out. It suggests either unwillingness or an inability to learn - or a determination to use arguments that appear to support his case, even if they are based on a fundamental misunderstanding of physics.

Let's consider two further arguments which Sungenis has made elsewhere[10] to attempt to counter the fact that the Sun overwhelmingly dominates the gravitational field at the Earth:

In the first one, he points to the fact that the solar system orbits the Milky Way galaxy, and implies that the gravitational attraction required to be the cause of this motion must be enormous. But we have seen that the gravitational field of the rest of the Milky Way at the Earth required to balance the centrifugal force arising from the orbit around the Milky Way (period 240 million years, radius

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[6] Wen, Han and Liu, A Catalog of 132,684 Clusters of Galaxies Identified from Sloan Digital Sky Survey III, ApJS, 199, 34

[7] The richness of a cluster is the number of galaxies within it

[8] The gravitational field at the Earth of these 16,000 clusters all at the same direction and distance as Virgo is, in the same normalised units as Table 1, is given by: $(16{,}000 \times 2.4 \times 10^{13})/(3.4 \times 10^{12})^2$

[9] http://www.geocentrismdebunked.org/as-the-universe-turns/
http://www.geocentrismdebunked.org/308-2/
http://www.geocentrismdebunked.org/dialogue-on-the-center-of-mass-of-the-universe-part-2/

[10] http://galileowaswrong.com/the-universes-barycenter/

2.57×10^{20} m) is some 31 million times *less* than the gravitational field of the Sun at the Earth[11], so he is mistaken in this respect.

Second, he claims that Mach's Principle, the conjecture that the influence of the mass-energy in the universe determines the compass of inertia at a local frame, shows that the gravitational influence of the rest of the universe is not minuscule compared with that of the Sun, but significant. He confuses central forces, which act purely in the direction of the relevant mass, with off-centre forces which appear only in General Relativity where, in addition to the central attractive forces directly analogous to Newtonian gravity, Coriolis and centrifugal-like off-centre forces appear in the presence of rotating masses. This effect is extremely small compared with the central forces – for example the frame dragging effect at the earth is only 220 milli-arcseconds per year. So it's the central forces that are relevant to calculating orbits, and in GR the central forces are of the same magnitude as I quote in Table 1 (at the Earth they are overwhelmingly dominated by the Sun's gravitational field as I have shown above). This is necessarily so, because in low gravitation regions such as exist in the solar system GR must be closely approximated by SR and Newtonian mechanics. In other words, the acceleration of the Earth as a consequence of central gravitational fields is overwhelmingly dominated by the Sun, and this is true *both* in classical and GR cases.

The next quote from Sungenis's paper takes us briefly beyond classical mechanics into General Relativity. In his writing, Sungenis often drifts from a classical to a relativistic framework and back again without acknowledging the profound consequences of doing so. Here he is quoting Fred Hoyle:

> *"…we can take either the Earth or the Sun, or any other point for that matter, as the center of the solar system. This is certainly so for the purely kinematical problem of describing the planetary motions. It is also possible to take any point as the center even in dynamics, although recognition of this freedom of choice had to await the present century"*

When Hoyle talks about awaiting the present century to take any point as the centre of the solar system in dynamics, he is, of course, referring to the development of Einstein's General Relativity. And GR is fatal to any project which seeks to make any point or object in the Universe privileged in an absolute sense. Einstein aimed his programme, which culminated in his famous 1915 series of papers in which he presented the Einstein field equations[12], at a formulation in which the forms of the laws of physics are the same in *all* frames of reference, whether they are translating, accelerating or rotating. In Newtonian mechanics and Special Relativity, there are universal privileged frames of reference, called inertial frames, which are the only frames in which the so-called fictitious forces to explain the apparent accelerations of bodies in the universe (when observed from non-inertial accelerating or rotating frames) do not appear. General Relativity however does away with universal frames altogether, since in GR all motion can be described by reference to a local curved spacetime in which all frames are equivalent and no frame is privileged (this property of GR is known as general covariance). Furthermore, because the curvature depends on the presence of mass-energy, it is no longer possible to refer to universal unchanging co-ordinate systems. This is what Hoyle is referring to when he says that we can take any point as the centre even in dynamics. The GR concept of the equivalence of all frames of reference, the principle that the forms of the laws of physics are the same in them all, and the idea that there is no privileged frame undermines the geocentric proposition of a single absolute special frame. (However, see the following section on Earth versus universe rotation for a discussion about whether we must regard rotation as purely relative or whether it can be defined absolutely even within General Relativity; and what we are able infer about phenomena by considering causation and non-local evidence.)

[11] The expression for the acceleration of a body in circular orbit is $a = 4\pi^2 r/T^2$ where r is the radius of the orbit and T is its period.

[12] Einstein, Albert "Die Feldgleichungen der Gravitation", *Sitzungsberichte der Preussischen Akademie der Wissenschaften zu Berlin*: 844–847

Next, Sungenis suggests that classical mechanics can only deal with two bodies at a time. This is hilariously wrong. Sungenis writes:

> *Newton's laws work fine if we limit the components to two bodies, but when we have three, four or billions of them, Newton's laws are quite limited in their scope and need to be supplemented. Newton was supplemented by Mach and Einstein*

Newtonian mechanics is not limited by the number of bodies for which it is valid. You can write down the equations of motion using Newton's laws for any arbitrary number of bodies[13], and although analytical solutions (i.e. exact mathematical expressions describing the answer) are not generally to be found for more than two bodies[14], it is perfectly possible to solve the equations numerically and get results which match reality to a very high degree of precision. Where GR predictions differ significantly from those of Newtonian mechanics is in the vicinity of massive bodies with strong gravitational fields, and where bodies have relative velocities which are a significant fraction of the speed of light. In low-gravity, low-speed situations, GR reduces to Newtonian mechanics for any number of bodies. The rather complicated calculations that are required to plan satellite orbits and other space missions[15] are based on Newtonian mechanics and treat many more than two bodies. Sometimes relativistic corrections are applied, not because of the number of bodies in the calculation but because that specific analysis requires very high precision and the tiny differences between purely classical treatments and those with relativistic corrections matter – and this would be true even when calculating the solution to a two-body problem that requires extreme precision.

Now Sungenis introduces a centre-of-mass argument based on a cosmological model which is naïve and physically problematic – a ball of stars with a spatial boundary:

> *…we can envision a universe of stars spaced all over the sphere of the universe, and somewhere in the middle of all those stars will be a "center of mass" around which those stars will revolve.*

Let us ignore, just for the moment, the fact that the universe is unlikely to be a sphere or any other shape with a spatial boundary, and grant *for the sake of argument,* over the next few paragraphs, the idea that the universe is spatially finite, flat, Euclidean and spherical with a spatial boundary (i.e., a ball) and therefore in possession of a definable and unique centre of mass. Let's also note that Sungenis is attempting a classical (Newtonian) analysis. Then "those stars" will revolve around the Earth only if they are gravitationally bound and the universe as a whole has non-zero angular momentum. Moreover they should revolve in a way that is predictable by the laws of celestial mechanics.

What do we observe? In the first place, we see that the universe as a whole is not gravitationally bound (the expansion of the universe is accelerating and parts of the universe are moving apart at greater than escape velocity which means they are not gravitationally bound); furthermore we do not measure a non-zero angular momentum for the universe (i.e. it does not measurably rotate)[16]; and finally the motion of the galaxies and galaxy clusters looks nothing like they would look if the universe

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[13] Danby JMA, *Fundamentals of Celestial Mechanics,* ISBN 0-943396-20-4, Chapter 9, *The n-body problem*

[14] The accuracy of the theory is not determined by whether analytical solutions can easily be found. In fact, in GR, exact analytical solutions are even more restricted than in Newtonian mechanics and there is no general analytical solution even to the two-body problem. The analytical solutions to the GR two-body problem are valid only when one body is much more massive than the other.

[15] See for example the draft Mathematical Specification for Release R2013a of NASA's General Mission Analysis Tool, Chapter 4, particularly the section on force modelling, available here: http://gmat.sourceforge.net/docs/R2013a/GMATMathSpec.pdf

[16] S.-C. Su and M.-C. Chu, *Is the universe rotating?,* 2009 *ApJ* **703** 354

were a gravitationally bound set of free falling bodies revolving around a centre of mass, in which the angular velocity of galaxies should decrease as a function of distance from the centre of mass.

Sungenis suggests that the Earth could "occupy" the centre of mass as though the centre of mass is a house where the Earth lives. Then he proceeds to make one of his more egregious errors whereby he confuses the centre of mass with a point of zero gravitational field:

> *Logically, there is no reason why the Earth cannot occupy that center of mass.* ***If the Earth occupies the center of mass, then according to Newton's laws, there are no gravitational or inertial forces at that point****, and thus there is no force with which the Sun needs to interact*[17]*. The Earth is neutral.* [My emphasis]

Sungenis speculates about the physics at his hypothetical centre of mass, relying on purely classical mechanics. He claims that there is no reason that the Earth should not coincide with the centre of mass, and in his ball-universe model, indeed there isn't, *temporarily*. But he fails to recognize that there is nothing to keep the Earth there. The centre of mass of a system is a point in space and there is no reason to identify it with a particular body – no physical body has to "act as the centre of mass" or "be it" or "occupy it", all phrases that Sungenis has used in various places in the past, and which show that he fails to understand the concept. His most serious mistake is that the bolded statement above is wrong. Sungenis is conflating the centre of mass with a point where the gravitational field is zero. A body at the centre of mass is still subject to the gravitational fields of other bodies – and in general, contrary to Sungenis's claim, the gravitational field is *not zero* at the centre of mass (it can be zero in certain symmetrical systems, such as a uniform spherical shell or a spherical ball of perfectly uniform density, or a two body system of exactly equal masses - but it is not generally so). *See Appendix 1*.

And the Earth is not near to being in a gravitationally symmetric situation – it is not, even in Sungenis's "ball universe" model, positioned in the centre of a ball of uniform density and gravitational attraction, because it is relatively close to a massive body (the Sun) with the next equivalently massive body, Proxima Centauri, ~270,000 times further away – and, remember, gravitational field goes as the *inverse square* of the distance. The Earth is primarily subject to the relatively enormous gravitational field of the Sun; secondarily to the gravitational field of other solar bodies which are about 1,000 (for the moon) – ~30,000 (for Venus and Jupiter) times less than the Sun; and then to the gravity of the entire Milky Way galaxy of a trillion stars which, in spite of its immense mass and because of its vast distance from the Earth, is *31 million times less than that of the Sun*, as we have seen in Table 1 above.

All of these bodies cause some acceleration of the Earth – in the case of the Sun, its gravity results in the acceleration of the Earth which keeps the Earth in orbit around it; the moon's gravity causes an acceleration of the Earth that results in a monthly perturbation or wobble on the Earth's annual orbit (the gravity of the other planets cause further perturbations). The acceleration due to the gravitational field of the Milky Way explains the orbit of the Earth, Sun and other planets of the solar system round the galaxy at a radius of 25,900 light years) and so on. The gravitational fields (and Earth's resulting accelerations) of the rest of the galaxy are very small compared to the Sun's field, but are sufficient to explain the orbit of the solar system around the galaxy because of the very large period of the solar system's galactic motion as we have seen above.

Together with the Sun's field, the accelerations caused by these bodies, all in constant motion, result in time-changing velocities so that the Earth cannot be stably at rest in an inertial frame. A finite acceleration, which the earth must have because it is in a non-zero gravitational field, is the same as

[17] "…*and thus there is no force with which the Sun needs to interact. The Earth is neutral*": this statement is simply incoherent.

a time-varying velocity – that's the definition of acceleration– and if a velocity is time-varying it cannot be zero indefinitely, even if it is zero for a moment. Even if at one instant in time the Earth just happens to coincide with the centre of mass, it cannot remain so[18].

Sungenis speculates about the differences between systems near to and far from the universe's hypothetical centre of mass and asserts that small bodies orbit big ones except at the centre of mass where big orbits small:

> *We can certainly grant to Mr. Keating that, with local systems that are far away from the universe's center of mass, it will always be the case that the smaller revolves around the larger, such as is the case of smaller moons orbiting the larger planet Jupiter. But if we include the whole universe, then there is one place in which the larger will revolve around the smaller. The smaller, in this case, is at the universe's center of mass, which the Earth occupies.*

Apart from obviously Begging the Question, what do we have here? It's an assertion that less massive bodies orbit more massive ones, unless they are at the universe's hypothetical centre of mass when the opposite is true. So let's ask: does this supposed inversion of normal orbital mechanics occur only at the exact centre of mass? If so, why do satellites and the moon orbit the earth? Or does this inversion occur in an extended region near the centre, with a gradual transition to a normal state of affairs? In that case how big would the transition region be? What happens in the transition region as we move from anomalous to normal physics – is there a zone where neither more massive nor less massive body orbits the other? Can we see the mathematical treatment in support of this hypothesis? Such a treatment is unlikely to be forthcoming as we have seen that the second part of Sungenis's assertion is entirely a figment of his imagination and has no basis in physics.

You will remember that I have temporarily granted for the sake of argument the hypothesis of a spherical universe with a boundary and a centre of mass. Enough of that – let's revert to physically feasible universe models.

Sungenis now suggests that Newtonian physics is invalidated by the universe outside the solar system:

> *[Newton's] only problem was that in the 1600s when he developed his gravitational equations, he didn't realize what part the stars and the rest of the universe played in the calculations.*

What part do they play? I have shown in some detail above what part the rest of the universe plays in the calculations; I have done the calculations (and shown them above) and Sungenis obviously has not. If the reader takes one thing away from this paper, it should be ***that the gravitational field of the Sun at the Earth is 200 times bigger than the next most influential object (the moon) and 31 million times bigger than the most influential extra-solar object (the entire Milky Way galaxy).*** We have seen that the Sun's gravity vastly dominates the Earth's motion and to that extent the Sun-Earth can be regarded as a two-body system (in fact because the Sun is so much more massive than the Earth, the calculation of the Earth's orbit can be reduced to the one-body problem as an excellent approximation).

Remembering Sungenis based this discussion on the framework of Newtonian mechanics, let's remind ourselves that Sungenis granted that if the Sun-Earth system could be regarded as a two-body system, then the much less massive Earth would orbit the much more massive Sun *("If the issue were limited to the Sun and the Earth, Mr. Keating would be correct. That is, the Earth, being the*

[18] Sungenis et al have claimed elsewhere that, according to GR, a rotating universe would stabilise the Earth at the centre of rotation – there are many reasons why this is a nonsensical idea, but we'll leave that discussion for another time.

smaller body, would necessarily orbit the Sun, which is the larger body.") Well, I have demonstrated, with detailed quantified reasoning, that it is the case that we can regard the Sun-Earth system as a two-body system, because of the overwhelmingly dominant gravitational field of the Sun at the Earth, and therefore Sungenis should accept that the Earth orbits the Sun[19].

But what about General Relativity and Earth/Sun orbits?

So let's leave classical mechanics temporarily and move on to General Relativity. Surely, everyone has been taught that in GR all motions are relative and the descriptions, "Earth orbiting Sun" and "Sun orbiting Earth", are equivalent? It is true in GR that *local* experiments cannot distinguish between the cases, but we are also allowed to invoke non-local observations and causation to make reasonable inferences.

So for example, let us consider an observer at rest relative to the surface of a planet. If the observer is in a box and able to perform only local experiments within the box he cannot say whether the constant force that he feels on the soles of his feet is because he is standing in the gravitational field of a planet, or because he is undergoing constant acceleration by the application of an external non-gravitational force to the box – this is completely compatible with the GR equivalence principle. But let him make non-local observations and consider causation: he will observe that the planet is not expanding ever more rapidly, his colleague on the opposite side of the planet tells him that she is feeling a force on the soles of her feet of similar magnitude and he can see that he is on the surface of and at rest with respect to a massive body – he can therefore reasonably infer that the force on his feet is mainly because he is in the gravitational field of the planet and not because he is being accelerated. Similarly, considering non-local observations and causation can justify inferences about relative rotation and revolution.

Let us look at just one of those observations[20]. We observe that the light of the Cosmic Microwave Background which arose in the very early universe and the light from other very distant celestial bodies is Doppler shifted annually by just the right amount that we can conclude that this is caused by the Earth's annual orbit[21]. This phenomenon is called the annual Doppler shift modulation and has to be corrected in all earth station based astronomy where accurate spectral characteristics matter. A Doppler shift is caused by the relative velocity between source and observer arising either by motion of the source, motion of the observer or both.

Geocentrists will tell you that the annual modulation can be interpreted by the annual revolution of the Earth around the Sun, but *equally* (and preferably as far as they are concerned) by a static Earth around which the entire universe, centred on the Sun, revolves once per year (in their neo-Tychonian model, the mass-energy of the universe is centred on the Sun which revolves around the Earth annually taking the cosmic matter with it). They will propose that given a static Earth, it is the annual motion of the CMB and other celestial bodies that causes the observed annual Doppler shift modulation.

That's fine so far as it goes until one considers the finite speed of light and causation. The light from the CMB was emitted from the post-Big Bang plasma 13.8 billion years ago, and from quasars

[19] Note that the exact solution in classical mechanics is that both Sun and Earth have elliptical orbits with the ellipses' foci at their centre of mass and with some perturbations from the other bodies in the solar system and that, with reference to their centre of mass, the semi-major axis of the Earth's orbit is about 330,000 times that of the Sun's – so, in classical mechanics, it is a very close approximation to say that the Earth orbits the Sun.

[20] Another observation which supports the dynamical proposition of Earth's annual orbit is the measurement of stellar aberration.

[21] G. Hinshaw *et al., Five Year WMAP Observations: Data Processing, Sky maps and basic results,* 2009 *ApJS* **180** 225

between 0.5 and 12.5 billion years ago. So the geocentrists are asking us to believe that the motion of all of these bodies, including the CMB plasma, the quasars and every other extra-terrestrial body, at the time the light was emitted, was an ellipse of the same dimensions as the Sun-Earth orbit, and which has all its characteristics, local features and variation, such as variations in the orbital eccentricity and ecliptic obliquity, apsidal precession and ecliptic precession. In some cases such as the CMB and the more distant quasars, the light was emitted at a time long before the formation of the solar system. How can that be? How can the current Sun-Earth orbital characteristics reach out backwards in time to the source of the CMB and to the early, distant quasars to cause a corresponding motion of the CMB-emitting plasma and the quasars more than ten billion years ago, before the sun had even condensed? Moreover, the annual CMB and quasar Doppler modulation (along with the annual Doppler modulation of all other extrasolar bodies) is synchronised in such a way that no matter how far away the bodies are and how long the light has been travelling, their annual Doppler shift modulation arrives at the Earth precisely in phase – all celestial bodies are blue shifted when, in the Earth-moving model, the Earth is moving towards them and red-shifted when it is moving away. If the universe moves round the earth annually with the sun, we would expect the phase of the Doppler shift modulation to be a function of the distance to each body and the time it has taken for the light from that body to reach us. But that's not what we see – they are all in phase and the phase depends only on the direction of the light's source. I will leave readers to decide whether it is tenable to believe that the source of the annual Doppler shift modulation is the motions of the stars, galaxies and other celestial phenomena, not moving together but all perfectly orchestrated backwards in time so that by the time the light reaches the Earth the modulation is exactly in phase and exactly reflects the Earth's orbital variations.

Does the Earth rotate once a day or does the universe rotate around the Earth? Is the universe Machian? Is GR a Machian theory?

Since the Earth is unquestionably rotating according to Newtonian and Special Relativity frameworks, geocentrists turn to General Relativity to save their case, so let's see how they fare:

> *As for Einstein's equations, which are merely a "relativistic" expansion of Newton's equations, they perfectly agree with the idea that the whole universe can revolve around a fixed Earth in the center.*

General Relativity is far more than the "'relativistic' expansion" (whatever that might mean) of Newton's equations. GR arises from a fundamentally different way of reasoning about the world. It is based on the realisation that acceleration is equivalent to gravitation and that physics should be identical in all co-ordinate systems. GR's postulates include the novel concept that mass and energy distorts space itself, so that space is not generally flat and there is no absolute universal reference frame, and that the motion of free falling bodies are geodesics (the equivalent of straight lines) in curved spacetime. Newtonian mechanics approximates to General Relativity under conditions of low gravity and low relative velocity (as it must do given the accuracy of Newtonian predictions in those conditions). GR makes novel predictions about the behaviour of the world that go beyond Newtonian predictions. These novel predictions have so far passed every experimental test, indicating that GR is a good description of reality.

Sungenis introduces the concept of purely relative rotation.

> *In other words, Einstein's equations state that either the Earth can rotate in a non-rotating universe or the universe can rotate around a non-rotating Earth. The math AND the physics will allow such variation. The problem for General Relativity is that it can't tell us which one is correct.*

It is not true that this equivalence is implicit in the Einstein field equations of GR; although we will see that it might be true in some of their solutions. However, this particular equivalence *is* implicit in

Mach's Principle so let's explore this idea and its relationship to GR. A long standing question in physics is the origin of inertia, which was addressed by Newton in his famous rotating bucket thought experiment[22]. Newton thought that accelerations and rotations are relative to an absolute fixed space and that even in a universe devoid of all other matter we should be able to distinguish between rotation and non-rotation with respect to absolute space by the presence of rotational inertial forces – the Coriolis and centrifugal forces (which cause the water in the bucket to form a parabolic surface in the rotating case rather than a flat surface in the non-rotating case).

On the other hand Mach speculated that the influence of the total mass-energy in the universe is what gives rise to inertia – the famous, rather superficial dictum that "mass there causes inertia here". This view is supported by the observation that accelerations and rotations are closely relative to the "distant fixed stars". According to such a view, and contrary to Newton's idea, in a universe devoid of all other matter except the bucket, one would not be able to distinguish between rotation and non-rotation – in fact the concept of rotation would not exist because inertia would not exist. I call this a speculation because Mach proposed no mechanism or physics that would explain how the influence of mass-energy in the universe as a whole would define the local compass of inertia and, of course, we cannot test his idea that inertia would disappear in an empty universe. Furthermore "Mach's Principle" is a vague and ill-defined concept – indeed Bondi and Samuel list eleven different interpretations of what is meant by it[23].

Within a Machian universe, a rotating Earth and a rotating universe are equivalent and to say one is true and the other false is meaningless. Einstein was influenced early on by Mach's ideas, and indeed it was Einstein who coined the term "Mach's *Principle*". When Einstein began to develop his theory of General Relativity, his ambition was to make it Machian. The neo-geocentrists are fond of a particular quotation of Einstein's which is relevant here, so let's look at this very quotation in context. This is Einstein talking about the programme that he successfully completed with his publication of the field equations of General Relativity in 1915[24]:

> *"Can we formulate physical laws so that they are valid for all CS [coordinate systems], not only those moving uniformly, but also those moving quite arbitrarily, relative to each other? If this can be done, our troubles will be over. We shall then be able to apply the laws of nature to any CS. The struggle, so violent in the early days of science, between the views of Ptolemy and Copernicus would then be quite* ***meaningless.*** *Either CS could be used with equal justification. The two sentences, "the Sun is at rest and the Earth moves," or "the Sun moves and the Earth is at rest," would simply mean two different conventions concerning two different CS…Could we build a real relativistic physics valid in all CS; a physics in which there would be no place for absolute, but only for relative motion? This is indeed possible! . . . Our new idea is simple: to build a physics valid for all CS."*[25] [Note my bolding]

So, after all that, did Einstein succeed in developing a physical theory that is truly Machian? Is General Relativity a Machian theory? Strange as it might seem, nearly 100 years after the publication of the General Relativity equations, these are not settled questions, and Einstein himself changed his mind about them throughout his life. I think most biographers agree that in the second half of his life he subscribed to the idea of some sort of absolute rather than purely relative rotation[26]. In any case, it is clear that General Relativity satisfies the equivalence of inertial and gravitational mass, and that within GR, local experiments (which are confined to the local frame and exclude those that look

[22] http://en.wikipedia.org/wiki/Bucket_argument
[23] arXiv:gr-qc/9607009
[24] Einstein, Albert ,Die Feldgleichungen der Gravitation", *Sitzungsberichte der Preussischen Akademie der Wissenschaften zu Berlin*: 844–847
[25] Einstein and Infeld, The Evolution of Physics, *The Scientific Book Club and Company Ltd, p224*
[26] See for example: Isaacson W, *Einstein; His Life and Universe*, p 319 et seq, ISBN 978-1-84739-054-7

beyond it to the rest of the universe) cannot distinguish between inertial (i.e. non-accelerating) frames in a zero gravitational field and frames in free fall accelerating in a gravitational field. Similarly, local experiments cannot distinguish between rotation in flat spacetime (i.e. in the absence of a gravitational field) and non-rotation in the Coriolis metric which is like a gravitational field that causes Coriolis and centrifugal-like forces in a non-rotating frame. The form of the physics is the same in all co-ordinate systems, so does this mean that Mach was right about the origin of inertia; and if so is that concept built into GR?

To answer this question, the first step is to ask whether solutions to the Einstein field equations can result in Coriolis and centrifugal-like forces in a non-rotating frame. They can. This was shown to be so by Hans Thirring, within two years of the publication of the field equations, in a paper in which he calculated the gravitational fields inside a massive rotating sphere and showed that Coriolis and centrifugal-like forces arise inside the sphere[27]. Subsequently Thirring and Josef Lense calculated the effect of this "frame-dragging" externally near to a massive rotating body and predicted that in the vicinity of a massive rotating body the compass of inertia would be dragged round relative to the distant stars[28]. This prediction of GR has been confirmed experimentally by measuring the minute Lense-Thirring frame dragging near to the rotating Earth[29]. This provides a plausible framework in which Mach's Principle can be satisfied because the Lense–Thirring effect, or more generally the GR effects of what is called gravitomagnetism, allow for centrifugal and Coriolis forces to arise in a non-rotating frame if that frame is influenced by rotating mass-energy. (The term, gravitomagnetism, was chosen to emphasise the analogy with electromagnetism, because simplified forms of gravitomagnetism in General Relativity take the same mathematical form as magnetism does in the theory of electromagnetism.)

That's all well and good, and it shows that the mass-energy in the universe can influence and potentially contribute to inertial effects, but it is insufficient for us to conclude that the rotation of the universe around a non-rotating object would create exactly the same forces as the rotation of the object at the same angular velocity in a non-rotating universe. This is because the magnitude of the gravitomagnetic force predicted by these solutions to the Einstein field equations depends on the masses and distances of the rotating masses and it is not immediately clear that the universe as a whole, if rotating, causes forces which are exactly equal to those experienced by a body rotating with the same angular velocity in a non-rotating universe. Such a condition of exact equivalence is called "perfect dragging". Is it met by our universe? The rotating spherical shell derivation of Thirring has been extended by Brill and Cohen[30] to show that under certain conditions a massive rotating sphere can cause perfect dragging; and by Cohen et al that a massive rotating cylinder can do so and also satisfy other requirements for the metric that the spherical shell does not. But the universe is neither a spherical shell nor a cylinder, so is there perfect dragging in our universe?

We can already see that a definite answer to this question requires a good knowledge of the details of the total distribution and flow of mass-energy in the entire universe over all of spacetime, which we don't have. But what we can do is to turn the question around and indicate what conditions need to be satisfied in order to have a universe in which there is perfect dragging. In order to answer the question we need to avoid initial and boundary conditions which are simply not known. This can be done in the case of a compact spatially closed universe (such a universe is spatially finite and unbounded) such as a 3-sphere or a 3-torus. Schmid[31] and Grøn[32] show that perfect dragging can be present in a

[27] H. Thirring, Phys. Zeitschr.19, (1918) 33

[28] J. Lense and H. Thirring, Phys. Zeitschr.19, (1918) 156

[29] Everitt et al, *Gravity Probe B: Final Results of an Experiment to test General Relativity,* Physics Review Letters 106, 221101 (2011)

[30] D.R. Brill and J.M. Cohen, Phys. Rev.143, (1966) 1011

[31] Schmid C, Mach's Principle: Exact frame dragging via gravitomagnetism in perturbed Friedmann-Robertson-Walker universes with k=(±1,0), Phys Rev D, 79, 064007

physical universe under the strict condition of a closed universe (amongst other conditions) as described above. So in a spatially closed universe, provided other conditions are met, perfect dragging can occur.

Does this mean that the universe is Machian and that GR is a Machian theory? Well even if we can demonstrate perfect dragging of inertial frames there are good reasons to say that the universe is not Machian and that GR is not a Machian theory. One difference is that, in the Machian conjecture, the origin of inertia is necessarily determined by the entire mass-energy distribution of the universe – this is the substance of the conjecture. But it is not a necessary consequence of GR. As we have seen, solutions to the field equations do not generally give results in which inertial frame dragging is perfect, although they can do so. So GR is not Machian in the sense that perfect dragging should be implicitly built in to the theory and should necessarily follow in all physical solutions. Second, the Machian compass of inertia is determined by the action at a distance of the entire mass-energy in the universe by some undetermined means, whereas GR is a local theory, in which the world lines of particles (I.e. how particles move freely through space and time) are determined by the *local* metric – these are profoundly different kinds of hypothesis. Third, Mach postulated that in an empty universe, there would be no inertia, and so accelerative, centrifugal and Coriolis forces would never arise. But in GR, the metric for an empty universe is Minkowski spacetime in which GR reduces to Special Relativity, in which there are universal inertial frames and in which rotation and non-rotation can be unambiguously discriminated. This contradicts Mach's Principle. For these and for other reasons the consensus is that GR is not actually a Machian theory[33].

Although it is true that within GR, *local* experiments cannot distinguish between various manifestations of acceleration and gravity, it is wrong to say that one cannot make reasonable inferences based on non-local observations and on considerations rooted in causation (as we did for the annual Doppler shift modulation of the CMB and quasars above).

Is there any such evidence for the Earth's daily rotation? Let's look at Pioneer 10 and 11, two spacecraft that were launched in 1972 and 1973 respectively, to study the asteroid belt, Jupiter and Saturn. After completing their mission they continued on their trajectory out of the solar system at well above escape velocity. Pioneer 10[34] remained in contact with earth stations until 2003 when it was some 12 billion kilometres away. You will remember that the Sun has by far the biggest gravitational field in the solar system and for that reason both Pioneers were slowed down by the Sun's gravity as they flew away from the solar system. However measurements of the spacecraft position and speed indicated that both Pioneers were slowing down more than the models predicted and for several years this effect, known as the Pioneer anomaly, was a mystery. All we need to know about the anomaly is a) that it was tiny ($\sim 10^{-10}$ ms^{-2} - a hundred billionth of the acceleration due to gravity at the Earth's surface) and b) that it has been explained with perfectly conventional physics[35]. What is relevant to us is the fact that the anomaly was so small and therefore, in order to measure it, physicists needed to know the position (range and direction) of the satellites with extreme precision. These measurements are made by Doppler measurements and timing of radio signals sent to the satellites and returned to Earth ground stations. There is a daily modulation of the Doppler signals caused by the fact that Earth's rotation causes a daily change in the relative velocity between the spacecraft and the Earth which physicists must correct for. In fact this daily Doppler modulation is used to measure the direction of the spacecraft from the Earth (its amplitude gives declination and its phase gives right ascension).

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[32] Grøn OG, On the Relativity of Rotation, *Nuovo Cimento B*, (7), 861 - 874
[33] See for example L. Sklar, *Philosophy of Physics, Oxford University Press,* 1992, p76 et seq
[34] http://en.wikipedia.org/wiki/Pioneer_10
[35] Turyshev, Slava G., et al. "*Support for the thermal origin of the Pioneer anomaly*." Physical review letters 108.24 (2012): 241101.

But there's more – because the Pioneer anomaly was so small, perturbations in the Earth's daily rotation and in the velocity of the ground stations were significant and had to be taken into account. Corrections were made for[36]: Earth's precession, nutation, polar motion, tides, the Moon's, Sun's and planets' gravitational torque, Earth's mantle elasticity, Earth flattening, structure and properties of the core-mantle boundary, rheology of the core, underground water, oceanic variability, atmospheric variability, evolution of Earth's shape, and the location of Earth's centre of mass relative to the crust. Geocentrists would have us believe that the daily Doppler modulation was caused by variations in the velocity of the source (the spacecraft) and not by the Earth's rotation which they claim does not exist. In that case, shouldn't they explain why, according to them, the velocity of the Pioneer spacecraft, freely flying through space and several billion kilometres from Earth, cycled with a period of exactly one sidereal day? Can they explain why the details of the supposed Pioneer velocity cycle reflected all the subtle variations in the velocity of the ground station such as Earth's precession, nutation, polar motion, and so on? Can they give us one good reason to conclude that the daily Doppler modulation was caused by daily changes in the velocity of the spacecraft rather than by earth's rotation?

What does all this mean for the question posed at the beginning of this section? Does the Earth rotate once per day or does the universe rotate around the Earth once per day? If we follow the view of many physicists, which is that GR is not a Machian theory and that, in GR, rotation retains absolute characteristics[37], then we can say that the Earth rotates for the same reasons that we can say so within a classical or Special Relativity framework, viz. we measure the effects of centrifugal and Coriolis forces on the Earth's surface caused by its rotation. We can also infer the earth's rotation from considering causation and non-local observations as we did above with the Pioneer measurements.

However, if we insist that in the universe the mass-energy is distributed and the universe topology is such that perfect dragging occurs, so that it fully determines the compass of inertia at all points, and therefore that one important aspect of Mach's Principle is satisfied, then we would really be unable to distinguish empirically between Earth-rotating and universe-rotating models. All that we could then say is that the compass of inertia is aligned to the distribution and flow of mass-energy in the universe and that there is *relative* rotation between the Earth and the universe. But what would it then mean to make an absolute claim, like geocentrists do, that the Earth is absolutely not rotating and the universe is rotating around it? In the Machian scenario, the compass of inertia is aligned with the universe, so what would the universe be rotating relative to? It can't be rotating relative to itself. We should ask the geocentrists to define precisely what they mean by rotation and particularly by non-rotation, but my operational definition, and that of almost all physicists, is that dynamical rotation is determined relative to the local compass of inertia, which, in the case of perfect dragging, is relative to the average distribution of mass-energy. In this case, the claim that the universe rotates while the Earth does not rotate violates normal scientific and lay usage of the term "rotate". Of course, this definition of rotation is conventional, which is why it is so important for the geocentrists to define what they mean by the terms. This might be semantics, but in science the precise definition of the meaning of words is important.

But let's side-step the conventional usage of terms, and consider the consequences if the dynamic Earth- and universe-rotating scenarios are totally indistinguishable. Then saying that one or other is "correct" is meaningless. It's not that we are powerless to determine which one is correct, which implies that one is correct and the other is not; it's that they are equivalent by definition and therefore *neither* one is "correct" or "incorrect". We can take any frame as being non-rotating that we choose

[36] Anderson, John D., et al. "*Study of the anomalous acceleration of Pioneer 10 and 11*." Physical Review D 65.8 (2002): 082004.

[37] See for example Mashhoon, *On the Relativity of Rotation*, *in Directions in General Relativity: Vol 2: Proceedings of the 1993 International; Symposium: Papers in Honor of Dieter Brill*, Cambridge University Press, 1993.

and the choice is entirely arbitrary. Since, according to this view, there is no absolute rotation, then there is no absolute non-rotation; and therefore the claim that the Earth (or any object) is absolutely not rotating is inconsistent with the premise. It is an unfalsifiable unscientific claim.

So the geocentric claim that the Earth is not rotating is either meaningless or plain wrong depending on whether your interpretation of General Relativity is more or less Machian.

(For the sake of completeness, we should note that there is an exact solution to the Einstein field equations in which the universe does rotate. This solution was found by Kurt Gödel[38]. In a Gödel universe, the entire mass-energy does not rotate around a fixed axis as a rigid body as it does in the geocentric model. Instead, observers at rest with respect to the mass-energy in the universe find that they still experience rotational inertial forces such as Coriolis and centrifugal forces with respect to a preferred plane. If observers orient themselves so they feel no rotational inertial forces they will observe themselves and other inertial observers rotating with respect to the cosmic matter. The solution is profoundly un-Machian, demonstrating that GR is not an inherently Machian theory. It is also unphysical in that it has closed time-like curves, i.e. it allows time travel. Universe rotation of this kind has been ruled out by observation to very stringent limits – to less than 10^{-9} rads per year[39] so it is not a good description of our universe.)

According to GR, can the Universe have a centre?

In GR the concept of a centre to the universe is as meaningless as the centre of the surface of a sphere – such an idea carries no meaning. In General Relativity, the concept of the flat Euclidean space of classical physics is replaced with the pseudo-Riemannian manifold of 3+1 dimensions which can be distorted by the distribution and flow of cosmic matter. In GR, our familiar three-dimensional space is embedded in four dimensions (just as a two-dimensional sphere is embedded in three dimensions). According to GR, the topology of the universe as a whole is either compact (i.e. finite, like the surface of a sphere in one higher dimension but without a spatial boundary - this is the solution favoured by Einstein); flat and infinite and so extending indefinitely without boundary; or open with negative curvature and infinite, again without boundary. So in all of these cases, physical solutions to the field equations which approximate our local universe describe a universe with no spatial boundary. The concept of a centre is meaningless in all of these cases.

Because the Earth is unambiguously rotating in Newtonian mechanics and Special Relativity, the new geocentrists have been forced to invoke General Relativity, which, unfortunately for them, fundamentally undermines the very concepts of “static” and “centre” which they are trying to demonstrate. This is what I mean by the Great Inconsistency – they are forced to invoke a physical model which renders their claim meaningless, or admit that their claim is wrong. Moreover, Sungenis and many other geocentrists violently reject both Special and General Relativity[40]. Surely it is deeply inconsistent and illogical to invoke physics in support of their claims that they think is wrong-headed,

[38] K. Gödel, *An example of a new type of cosmological solutions of Einstein’s field equations of gravitation,* Reviews of Modern Physics 21(3), 447 (1949)
[39] S.-C. Su and M.-C. Chu, *Is the universe rotating?,* 2009 *ApJ* **703** 354
[40] See for example:
http://doxacommunications.com/Sungenis/the-private-lives-of-copernicus-galileo-kepler-newton-einstein/
http://galileowaswrong.com/darwin-newton-and-einstein-at-the-end-of-their-rope/
Sungenis, *Did Einstein Have Syphilis? The Link Between Science and Biography*, Culture Wars, January, 2006. Pgs. 18-30
See also: http://galileowaswrong.com/einsteins-relativity/
http://galileowaswrong.com/einsteins-theory-flawed/

atheistically motivated, a product of the author's moral degeneracy and medical ailments, and amounting to no more than science fiction[41] – to do so smacks of desperation.

So since the very propositions they are trying to prove are meaningless in GR, let us ask the geocentrists to define precisely just what they do mean by a body being unmoving, not rotating, or being at the centre, in a way that is physically falsifiable. They are making these physical claims about the universe, so they should be able to define what they mean. If they cannot provide an unambiguous definition of these terms, then the claims are not physical but theological or metaphysical. And, if so, we can dispense with all the pages of tedious geocentric argument and mathematics. It is ludicrous to argue for the truth of physical claims about concepts that are physically meaningless.

Sungenis cuts and pastes

At this point in his paper, Sungenis does a strange thing. He copies four more or less complete works mostly written by other people which appear, at first sight, to be serious mathematical treatments of orbital dynamics which apparently support the neo-geocentric system in the framework of Newtonian mechanics (they are all Newtonian because they contain no mathematical reference to the Einstein field equations or their solutions). He fails to acknowledge the author of the first two at all, although he acknowledges the "help" of the authors of the latter two. It's a strange thing to do because normally one would not copy others' work wholesale like this, but would refer the reader to the source. I can only assume that he hopes that the very length and apparent complexity of the maths will lend an air of respectability to his article; that people will think, "Look at all that complex maths that goes straight over my head. These people must know what they are talking about". They don't, as we shall see.

All of these papers are either erroneous or contain nothing more than co-ordinate transformations – i.e. kinematic transformations rather than dynamic equivalences. There is nothing new in them and they do not advance the geocentric case. Here we go:

Paper 1*:* Popov, Luka. "*Newtonian–Machian analysis of the neo-Tychonian model of planetary motions.*" European Journal of Physics 34, no. 2 (2013): 383.

Of the four papers, this is the only one which has been published in a peer-reviewed journal. It is also available[42] on the arXiv pre-print server. It is copied wholesale into Sungenis's article, minus its Introduction, starting at Section 2.

Note that the European Journal of Physics is a journal which accepts papers relevant to the *teaching* of physics, but does not publish original research[43]. It has a very low impact factor[44] and this paper has been cited only by its own author in further unpublished papers[45].

The paper purports to show, using an approach to calculating orbits called the Lagrangian method which relies on the invariance of the sum of kinetic and potential energy in a system, and by invoking Mach's Principle which we have discussed above, that the Sun orbiting the Earth can be shown to be equivalent to the Earth orbiting the Sun. The paper proposes that the centrifugal "pseudo-force" as

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[41] Dr Robert Bennett, PhD in physics and Sungenis's scientific consultant and co-author writes: *"Relativity, quantum mechanics, Big Bang cosmology...all science fiction." "...but the Einstein universe includes inconsistent/illogical premises; Newton's doesn't"* [Bennett's ellipses]
These bizarre quotes can be found here::http://doxacommunications.com/gww/Lucid/wordpress/wp-content/uploads/2013/05/NeilTysoninterview...pdf

[42] *arXiv:1301.6045*

[43] http://iopscience.iop.org/0143-0807/

[44] http://thomsonreuters.com/journal-citation-reports/

[45] http://adsabs.harvard.edu/abs/2013EJPh...34..383P

observed from the frame of the orbiting Earth is an actual force resulting from the actual acceleration of the universe which gives rise to an actual universal potential as observed from the static Earth. There is no support for this proposal in Newtonian mechanics.

The paper begins with and depends fundamentally on an elementary text book derivation of orbital mechanics using the Lagrangian. Unlike Sungenis, the author is not opposed to considering the two-body problem as a valid approximation for the Sun-Earth situation, and so the paper sets out a derivation of solutions to the well-known Kepler problem (solving the equations of motion in the central potential of a two body system where the force between the bodies varies as the inverse square of the distance). Early in the paper, Popov reduces the analysis to a one-body problem[46] based on the reduced mass of the system $(m1m2/(m1 + m2))$ to derive the relative orbits of the two bodies – i.e. the orbit of any one of the two, referred to the rest frame of the other, rather than to their centre of mass. In other words the reduced-mass one-body solution gives the motion of each body in the non-inertial rest frame of the other. For a system where one body is much more massive than the other (such as the Sun and Earth) this provides a good approximation to the motion of the less massive body (the Earth) in an inertial frame. But it does not give a good approximation for the motion of the more massive body (the Sun) in an inertial frame. It is peculiar that in a paper which attempts to show the dynamic equivalence of the Earth orbiting the Sun, and the Sun orbiting the Earth, the author reduces the problem to a form that is capable of calculating only *relative* orbits from the outset. After several pages of elementary textbook derivations, we eventually arrive at the orbits of Earth and of Mars in the Sun's rest frame, and of Mars in the Earth's rest frame. None of this work rises above undergraduate physics.

Having demonstrated in the rest frame of the Sun that this procedure yields the expected orbits, Popov calls on Mach's Principle, claiming that we must consider the Lagrangian of all the bodies in the universe. Clearly Popov and Sungenis don't communicate, because unlike Sungenis, Popov, having spirited up all the other bodies in the universe like genies, commands them all to disappear again - he is quite happy at this point to dispense with everything other than the Sun and Earth *("it's easy to notice that the dominant contribution in these sums comes from the Sun"*, he writes) and so makes the problem once more a two-body problem, and from there reduces it to a one-body problem as before. But we already know that the one-body analysis using the properly calculated reduced mass will yield an orbit for the Sun in the rest frame of the Earth that looks identical to the Earth's orbit in the rest frame of the Sun – the one body reduction yields relative orbits referred to the other body. So, the entire paper is trivial and does nothing more than derive the orbit of the Sun (and Mars) in the rest frame of the Earth – a pure kinematic co-ordinate transformation.[47]

[46] The solution to the one-body problem using reduced mass, $(m1m2/(m1 + m2))$ gives the relative orbits of two bodies; i.e. the orbital motion of one is given in the rest frame of the other. It reduces the problem to the orbit of one body around a fixed point.

[47] Additionally, I believe that the author makes errors in deriving the Sun's orbit in the Earth's rest frame. Equation 4.5 in Popov's paper is:

$$\mathcal{L} = \frac{1}{2} M_s \dot{r}_{SE}^2 - \frac{G M_S^2}{r_{SE}}$$

where the subscript SE denotes Sun to Earth motions and distances. You will note that the kinetic term in this Lagrangian has the solar mass, and the potential term has the square of the solar mass. In other words, this Lagrangian represents the orbit of the Sun around another body of the same mass as itself at a distance of Earth to Sun. The author goes on to set the reduced mass μ equal to the mass of the Sun; this substitution is incorrect for the Earth-Sun interaction. The correct reduced mass is approximately equal to the Earth's mass. In any case, all of this is pointless, as the original one-body solution arrived at in the paper gives the relative orbits for the Earth in Sun's rest frame and vice versa.

Paper 2: Popov, Luka. "*The dynamical description of the geocentric Universe*." arXiv preprint arXiv:1304.7290 (2013).

This copied paper starts on page 12 of Sungenis's article and is also not acknowledged. The paper has not been published. It purports to demonstrate the equivalence of geocentric and heliocentric dynamic analyses including the rotation of the Earth on its axis. To do so, Popov calls on the paper we looked at above and invokes the Machian influence of the rest of the universe to create a term called a vector potential in the Lagrangian which, when solved, yields Coriolis and centrifugal-like forces in the rest frame of the Earth. However, the vector potential is just invented out of thin air and is given the appropriate value to get the right result. Although Popov uses the term, gravitomagnetics, which implies the use of General Relativity concepts, there is no attempt to explain the physics which gives rise to this potential in terms of solutions to the Einstein field equations.

And indeed, Popov is on a hiding to nothing, because precisely this result has been derived more rigorously by starting with the Einstein field equations and then deriving the magnitude of the gravitomagnetic frame dragging, first of all inside a massive rotating hollow shell[48] and then more recently, to show perfect dragging under rotation of the universe[49] [50], as we have seen above. These results show, far more rigorously than Popov does, that under certain conditions, local inertial frames are dragged to be aligned with the mean star field (or average matter-energy distribution in the universe), subject to perturbations caused by local masses, whether we take that star field to be in a rotating or non-rotating frame.

Paper 3: Author unclear, "*Additional Kinematical/Vector Analysis of a Rotating Universe*"

This paper seems to be written by Gerardus Bouw or by Sungenis in collaboration with him, and is not published. Remarkably, it takes four pages of extremely tedious and elementary derivation to get to the trivial and ***wrong*** conclusion that in a geocentric universe the total force required to accelerate a star at distance R from the polar axis, declination δ, revolving once per day around the Earth's polar axis is:

$\boldsymbol{F} = -m\omega^2\left(\boldsymbol{R} - D\hat{\omega}sin(\delta)\right)$ (Bouw's or Sungenis's equation (12) which is wrong)

The reason this is wrong is the inclusion of the term $\omega^2 D\hat{\omega}sin(\delta)$ which has the form of a Coriolis acceleration acting on the star in the direction of the polar axis; the term should not be there. Bouw or Sungenis, or whoever derived this, has confused the velocity of the revolving star in the Earth frame, $\boldsymbol{v} = \boldsymbol{\omega} \times \boldsymbol{R}$, with the velocity used to calculate the Coriolis acceleration, which is also commonly designated as v (let us call it v') and which is referenced *to the rotating frame:*

$$\boldsymbol{a}_{coriolis} = -2\boldsymbol{\omega} \times \boldsymbol{v}' \qquad (1)$$

In this paper, the universe is assumed to be rotating with constant angular velocity ω around the Earth's polar axis. The velocity of the star with respect to that rotating universe (the rotating frame) is zero. In fact, Sungenis and Bouw say exactly this, "…we will use a single star since its co-ordinates are fixed in the sphere of the universe which carries the star." Therefore, $\boldsymbol{v}' = 0$ and so the second term above reduces to zero. The correct expression for the force required to accelerate the revolving star in its orbit is very simple:

$$\boldsymbol{F} = -m\omega^2\boldsymbol{R} \qquad (2)$$

[48] Brill and Cohen, Rotating masses and their effect on inertial frames, *Phys Rev* 143:1011-15
[49] Grøn OG, On the Relativity of Rotation, *Nuovo cimento B*, (7), 861 - 874
[50] Schmid C, Mach's Principle: Exact frame dragging via gravitomagnetism in perturbed Friedmann-Robertson-Walker universes with k=(±1,0), Phys Rev D, 79, 064007

and the acceleration is

$$\boldsymbol{a} = -\omega^2 \boldsymbol{R} \qquad (3)$$

These are simply the centripetal force and acceleration required to keep the star revolving once a day about the Earth's polar axis. It is remarkable that someone who claims to have a "scientific background" as Sungenis does can endorse such an elementary mistake.

And now that we've corrected the new geocentrists' maths, we still need to ask how this helps them make their case? In short, it doesn't.

Let's calculate what that force and acceleration might be for a solar mass star located at, say, redshift z=0.1 away from the Earth's polar axis and revolving around it. The co-moving distance of the star from the polar axis is 1.3×10^9 light years, which is 1.23×10^{25} metres. The angular velocity is 2π radians per day or 7.3×10^{-5} radians per second. The centripetal acceleration required is then 6.6×10^{16} ms^{-2} or 6.7 thousand trillion times the acceleration due to gravity at the Earth's surface. The centripetal force required to accelerate a solar mass star of 1.98×10^{30}kg thus would be 1.3×10^{47} Newtons which is a truly stupendous force.

Bouw (or Sungenis) claims that "every celestial object is held in place by this equation" (actually the incorrect one above; but in any case it doesn't matter.) The statement is quite nonsensical. What he or they would have calculated if they hadn't got the rather simple maths wrong, is the enormous centripetal acceleration and hence the vast centripetal force that would be required to maintain a celestial object in a circular diurnal orbit. The equation shows *what would be required* but, needless to say, does not propose a source for these enormous forces. The paper is riddled with error, is utterly trivial, and fails completely to achieve its aims.

Paper 4: M. Bernadic? "*The Geocentric Lagrange Points*"

This unpublished paper seemingly written by Milenko Bernadic, attempts to calculate the five Sun-Earth Lagrange points[51] from a geocentric perspective. The paper appears to be missing some material in the middle, and so is incoherent. The author also accepts that the Sun-Earth system can be represented as a two-body system, contrary to Sungenis's erroneous claims above. But in any case it does not seem to contain anything more radical than a kinematic transformation of the conventional derivation of the two-body Lagrange points to Earth-centred Earth-static co-ordinates.

Conclusion

I have shown that the Newtonian arguments marshalled by Sungenis to explain the equivalence of a static and a rotating, orbiting Earth are based on a misunderstanding of the relevant physics. In particular, we have seen that Sungenis's claim that the Earth is held in a static location by the gravity of the stars counteracting that of the Sun cannot be correct, because of the stars' very small gravitational field at the Earth relative to the Sun's. Classical mechanics arguments cannot support this equivalence because in the classical framework, rotation is absolute and can be unambiguously distinguished from non-rotation, and in classical mechanics the Earth is unambiguously rotating. The equivalence can be valid in General Relativity, but in that case, the claims that the Earth is static, non-rotating, and in the centre of the universe are all meaningless. I have shown that the apparently complex mathematical treatments that Sungenis uses to pad out more than half of his paper are trivial, erroneous or both.

[51] The Lagrange points of a two-body system are points in space where the gravitational potential is such that the force due to gravity provides the centripetal force which is required for a third less massive body located at those points to remain and to orbit with the same period as the other two.

Appendix 1

We can easily see that the gravitational field is not generally zero at the centre of mass of a system of n particles. The acceleration of a body which instantaneously coincides with the centre of mass will generally not be zero and so the body will not be able to occupy the centre of mass location other than instantaneously.

The coordinates of the centre of mass $\boldsymbol{R}$, of a system of n particles is:

$$\boldsymbol{R} = \frac{1}{M}\sum_{i=1}^{n} m_i \boldsymbol{r_i} \qquad \text{(A1)}$$

where M is the sum of the masses, m_i is the mass of the ith particle and $\boldsymbol{r_i}$is its location.

The gravitational field g_R at $\boldsymbol{R}$ is given by

$$g_R = -G\sum_{i=1}^{n} \frac{m_i}{|\boldsymbol{R} - \boldsymbol{r_i}|^2}\hat{r_i} \qquad \text{(A2)}$$

where G is the universal gravitational constant and $\hat{r_i}$ is a unit vector from the centre of mass in the direction of the ith particle.

Let d_i be the distance of the ith particle from the centre of mass:

$$d_i = |\boldsymbol{R} - \boldsymbol{r}_i| \qquad \text{(A3)}$$

Therefore the gravitational field at the centre of mass is:

$$g_R = -G\sum_{i=1}^{n} \frac{m_i}{{d_i}^2}\hat{r_i} \qquad \text{(A4)}$$

This gives the gravitational field at the centre of mass for any system of n particles in terms of the distances of the particles from the centre of mass and is not zero in general.

For example if we consider two particles then substituting in equation (A1), the centre of mass is at:

$$\boldsymbol{R} = \left(\frac{m_1\boldsymbol{r}_1 + m_2\boldsymbol{r}_{2)}}{m_1 + m_2}\right) \qquad \text{(A5)}$$

Substituting for $\boldsymbol{r}_1$and $\boldsymbol{r}_2$:

$$\boldsymbol{R} = \frac{m_1(\boldsymbol{R} - d_1) + m_2(\boldsymbol{R} - d_2)}{m_1 + m_2} \qquad \text{(A6)}$$

After some re-arrangement, we get the relationship between the masses and the distances of the centre of mass from them:

$$\frac{m_1}{m_2} = \frac{d_2}{d_1} \qquad \text{(A7)}$$

The gravitational field at the centre of mass is:

$$g_R = -G\left(\frac{m_1}{{d_1}^2} - \frac{m_2}{{d_2}^2}\right) \qquad \text{(A8)}$$

The field is zero if:

$$\frac{m_1}{m_2} = \frac{{d_1}^2}{{d_2}^2} \qquad \text{(A9)}$$

i.e. only if $\frac{d_2}{d_1} = \frac{{d_1}^2}{{d_2}^2}$, which is true only for $d_1 = d_2$, that is for $m_1 = m_2$. For all other cases, where the masses are not equal, the gravitational field is not zero at the centre of mass and therefore a body at that centre of mass at one particular instant will not remain there.