

GRAVITY AND ARISTOTLE'S AETHER

In principio creavit Deus caelum et terram...

Genesis 1, 1

"[T]he entire universe is to be considered prior to its parts, simple bodies before the compound, [and] among simple bodies the first, the heavenly body through which all others are sustained, is first to be considered..."

St Thomas Aquinas¹



Planet Earth from the probe Cassini viewed from the far side of Saturn [NASA/JPL]

I

When Sir Isaac Newton propounded his formula for the universal law of gravitation, he did not make the mistake of confusing its calculation with its causation.² Criticised for arguing to the existence of some external and undetectable

¹ *In I De Caelo*, Prologue.

² Cf. http://en.wikipedia.org/wiki/Newton%27s_theory_of_gravitation#Newton.27s_reservations

cause, he responded that it was enough that phenomena implied attraction but he had never “[sought to assign] a cause to this power”.³

For all the sophistication of its knowledge, modern science has yet to discover gravity’s cause. Treating gravity as a force of attraction between the relevant bodies satisfies the demands of the physical principles involved. The primal problem with the thesis of attraction, however, is that there is nothing in a body of matter *qua matter* that demands that it should attract another. There is, moreover, no medium of transmission whereby the immense centripetal forces involved could be conveyed from one celestial body to another body. Common sense would indicate that gravity’s cause is not to be found *within* celestial bodies but from some force *outside* them—not something intrinsic but extrinsic—but the business remains a mystery.

There have been many attempts to explain gravity as a species of extrinsic force. They have foundered over difficulties about the nature of the force and about the mode of its operation. In the late 1740s Georges Louis Le Sage, for example, proposed a mechanical explanation arguing that the force was constituted by particles of great rarefaction.⁴ But science revealed that material bodies are largely porous, ‘mostly empty space’. His hypothetical particles would be expected, then, to penetrate, rather than to bear upon, the surface of celestial bodies.

The philosopher Immanuel Kant raised a more fundamental objection. Le Sage’s particles must, he argued, have a ‘non-zero’ radius. This implied the existence of some sort of binding force to hold these particles together. Now, *that* binding force could not be explained by the gravitational particles themselves. Hence there had to be some additional force binding these, and so on, *ad infinitum*. This objection, addressing as it did the influence which provides extension and parts to a material substance, the metaphysical category *quantity*, demonstrated that one could not hope to discover an extrinsic cause of gravity and ignore the force that binds atomic and molecular structure. It also showed that a substance that could produce such a force must be superior to any of ordinary matter.

Modern science is concerned with things observable, with phenomena. Its theories, its determinations, its prognostications, are all grounded in measurable data. It notes effects, it looks for causes to explain them : and because its *modus* is almost exclusively inductive the causes at which it arrives are not necessarily the true causes or, if true, are not necessarily ultimate causes. For certitude in induction depends upon the discovery of a sufficiency of effects to exclude error about the cause. An explanation may ‘save the appearances’, as St Thomas remarked about Ptolemaic astronomy, and not exclude the possibility of another theory providing a better.⁵

³ *Principia Mathematica* Bk. III, General Scholium. “I have not been able to discover the cause of [the] properties of gravity from phenomena, and I frame no hypotheses... [I]t is enough that gravity... acts according to the laws which we have explained...”

⁴ Cf. http://en.wikipedia.org/wiki/Le_Sage%27s_theory_of_gravitation

⁵ *Summa Theologiae*, I, q. 32, art. 1, ad 2.

Modern science has another limitation. It is informed—and has been for some 350 years—by a defective philosophy manifest in two poles of thought, materialism and subjectivism. The one contends that if something cannot be detected experimentally, it does not exist ; the other that only that is true which the individual, or the majority, asserts to be true. These defects reflect the mentality of worldly thinkers who have long since turned their backs on any philosophy which addresses the part of reality which is not material. The result is that experimental science frequently fails to reach sound conclusions. Has there ever in the history of mankind been an age to compare with the present in knowledge, and in lack of wisdom ? T. S. Eliot put it succinctly :

Where is the wisdom we have lost in knowledge?
Where is the knowledge we have lost in information?
Endless invention, endless experiment
Brings knowledge of motion, not of stillness...
The cycles of heaven in twenty centuries
Bring us farther from God and nearer to the Dust..."⁶

The modern world is apt to dismiss the thinking of Aristotle and St Thomas Aquinas in the realm of nature because it can show their cosmology to be defective. But their cosmology was not so much defective as limited. Their analyses, grounded in reality rather than the limited vision of modern philosophies, more than compensate for shortcomings in knowledge. We propose to set out the principles they expounded concerning the behaviour of the heavens and gravity—though neither recognised this latter as the entity whose laws were codified by Newton—and to revisit their insistence on the existence in the natural world of an element which modern science refuses to acknowledge.

We will begin with a self-evident principle: *nothing, i.e., non-being, does not exist*. Its corollary is this : every material thing is surrounded by other material being however intangible. We may accept this readily enough in respect of the bodies we encounter in daily experience. Even if we cannot discern, we can imagine the proximity (taken literally here as ‘the next-ness’) of other material being to the very least of bodies : but what of celestial bodies in outer space ? What of the atoms and molecules of which material bodies are constituted but surrounded, so science tells us, by ‘empty space’ ? Neither of these ‘spaces’ can be empty : principle prevents it.

Modern science maintains that notwithstanding that light is a material reality it does not need a material medium in which to travel. How can this be ? If light encountered a somehow existing ‘nothing’, would not this ‘nothing’ be an impenetrable barrier to its passage⁷ ? Einstein tells us that the relationship between energy and the mass of a body is a function of the speed of light. But what on earth has that ethereal, if powerful, reality, light, to do with the relationship between those two ? The answers to these questions lie in the acknowledgement of the existence—and the remarkable characteristics—of an element of the material universe whose

⁶ *The Rock*

⁷ On the absolute impediment of void, if it did exist, to the passage of any material thing see Aristotle, *Physics*, Bk. IV, vi (213b 30 et seq.) and St Thomas’s Commentary, *In IV Physics* L. 10.

reality was exposed by Aristotle. He called it ‘the heavenly body’, or ‘first body’, or *aether* ; later thinkers have referred to it, perhaps dismissively, as ‘the quintessence’⁸.

Here are the relevant teachings of Aristotle in natural philosophy and cosmology with the additions of St Thomas, his greatest commentator. We refer to the two hereafter collectively as ‘the Philosophers’. For the purposes of this exercise the reader is asked to accept, for the moment, the limitations in their knowledge. The references for the most part are from St Thomas’s commentaries.

II

The Principles enunciated by Aristotle and St Thomas

- i. Anything that is moved is moved by another.⁹
- ii. Nature is the principle of motion in all moveable things, in two ways—
“[O]ne is active, i.e., the mover, as the soul is the active principle of the movement of animals ; the other [principle] is passive, according to which a body is apt to be moved. Such... [is present] in the heavy and the light, for these are not composed of a mover and a moved, for... it is plain that none of these moves itself; each has with respect to its motion, not a principle of acting, but of being acted on.” [*In I De Caelo*, L iii, 22]
- iii. The *passive* principle of the motion of the heavens is that body’s nature according to which it is apt to be moved with such a motion, but—
“the active principle of the motion of the heavens is an intellectual substance...” [*In I De Caelo*, L iii, 22]
- iv. There are four species of motion—generation, increase, alteration and local motion [*In IV Physics* L23, 631]—but the first, the more simple, and regular of motions is this last, local motion. [*In VIII Physics* L 14, 1094-5] All local motion is either straight (rectilinear) or circular, or some combination of these two. [*In VIII Physics* L 16, 1105] Straight motion is imperfect because it involves contraries ; for it must cease when it reaches its term, or return by reflex motion to its beginning. [*In VIII Physics* L 16, 1106] In contrast, circular motion—
“is more simple and perfect... [It] is not corrupted when it reaches the terminus (since its beginning and end are the same)... The perfect, moreover, is prior to the imperfect... in nature, in *ratio* and in time... Circular motion, therefore, must be prior to straight motion.” [Cf. *In VIII Physics*, Ll. 14-19 ; this from l. 19 towards the end.]
- v. The universe is spherical and, since all motion is founded upon something immobile [*In I De Caelo*, L iii, 36], its motion must be considered in relation to its

⁸ Literally, the fifth essence. The four material essences of philosophical antiquity were *earth, air, fire* and *water*. *Aether* was the fifth.

⁹ *Physics* Bk. VIII. This is clear for things inanimate ; not so clear for the animate differentiated precisely in the fact that they do move themselves. These have an interior principle, a soul, which causes their movement (whether as to *execution* only (plants), as to *execution* and *form* (brute animals), or as to *execution, form* and *end* (rational animals). But even the animate, Aristotle shows, is ultimately moved by another. This process of being moved cannot proceed to infinity : there must, therefore, be a first unmoved mover of all other beings.

immobile centre. Hence, reflecting their respective relations to the universe's centre, there can be only three simple natural motions—one *from* the centre, one *towards* the centre, and a third *around* the centre. [*In I De Caelo*, L iii, 36]

vi. It is impossible that the heavens be comprised of a void—

“[F]or there is no such thing as a self existing void.” [*Physics* IV, 8 (216 a & b)]

vii. A simple body is one that has a principle of natural motion. There are four simple elements : earth, air, fire and water. Fire and air have a principle of straight motion *away from* the centre (of the universe), as earth and water have a principle of motion *towards* its centre. Circular motion is perfect motion ; it has no contrary. Such motion, simple and distinct from straight motion, must be proper to some natural simple body other than these four. [*In I De Caelo*, L iii, 36]

“[F]or the contrary of one thing (under the same respect) is one [*Metaphysics* X] and the motion contrary to an upward motion is a downward one. Hence, circular motion cannot be its contrary... [*In I De Caelo*, L iii, 38]

“Prior motion naturally belongs to a prior body. Now straight motion naturally belongs to some one or other of the [four] simple bodies... And if it happens that straight motion is found in mixed bodies [bodies comprised of two or more of the four simple elements] that will be due to the nature of the simple body predominant in it. As a simple body is naturally prior to the mixed, so circular motion is proper, and natural, to some simple body which is prior to the elementary bodies that exist here among us.” [*In I De Caelo*, L iv, 41]

viii. This fifth element, as befits a substance with perfect movement, is perfect¹⁰. It is higher and nobler than the four simple elements. It is incapable of being generated or corrupted ; incapable of expulsion from its proper place by violence ; it has no lightness or heaviness ; it has no contrary ; it is prior to, and contains, all other bodies.

“[S]ince motion is proportionate to the mobile as act [to its potency], it is fitting that a body which is un-generable and incorruptible and incapable of expulsion from its proper place by violence should have circular motion... [*In I De Caelo*, L iv, 38]

“[I]n order for something to be partially perfect it must have the beginning, middle and end in itself ; but to be completely perfect it is required that there be nothing outside it. And this mode of perfection belongs to the first and supreme body which contains all bodies...” [*In I De Caelo*, L iv, 42]

ix. This element moves other bodies.

“[Aristotle's] fourth argument proceeds from two assumptions. The first is that every simple motion is either according to nature or outside nature. The second is that a motion which is outside nature for one body is according to nature for another... Now it is manifest that circular motion is present in some body which the senses observe to be moved circularly. And if such a motion is natural to it... there [must] be an additional body which is moved circularly. But if circular motion is outside the nature of the body so moved, it follows from the foregoing assumption that for some other body it is according to nature, and this body will be of a different nature from the four elements.” [*In I De Caelo*, L iv, 46]

¹⁰ Whence we get the colouration of the term 'quintessence'.

“Whatever is present in lower bodies from the impression of a higher is not violent or against nature, for they are naturally apt to be moved by the higher body.” [In I De Caelo, L iv, [39]]

Moreover, as it contains all other bodies, this element is to them as form to matter and as act to potency. [In I De Caelo, L iv, 50]

- x. But *this element* cannot be moved by *other bodies*. Aristotle teaches—
“While usually the thing touching is touched by what it touches... still it also occurs... that only the mover may touch the moved, while the thing touched does not touch the one touching it... [De Generatione et Corruptione, Bk 1, Pt. 6]¹¹

And St Thomas, commenting on Aristotle’s *Physics*, remarks:

“Bodies act upon each other by touching... But this should be understood [only] when there is mutual contact as happens in those things that share a common matter... The heavenly bodies, however, because they do not share a common matter with inferior bodies, act upon them in such wise that they are not acted upon by them ; they touch and are not touched.” [In III *Physics*, L. 4, n. 5]¹²

- xi. This, the heavenly body which St Thomas refers to as ‘first altering body’, is universal in the heavens. Following Plato, Aristotle and St Thomas, we call it *aether*.

xii. Here, in summary, are the characteristics of *aether* thus exposed :

- a. It is moved by an intellectual substance;
- b. Its proper motion is perfect, i.e., circular, motion;
- c. It is a simple natural body distinct from the four simple natural bodies, earth, air, fire and water, and any body comprised of two or more of these;
- d. It is perfect, higher and nobler than other simple elements;
- e. It is incapable of generation or corruption;
- f. It is incapable of expulsion from its proper place by violence;
- g. It has no lightness or heaviness;
- h. It has no contrary;
- i. It is prior to all other bodies;
- j. It contains all other bodies;
- k. It is to all other bodies as form is to matter and as act is to potency;
- l. It moves other bodies;¹³
- m. But cannot be moved by them.

To this list we must add the Philosophers’ insistence on the principle that all motion in the universe is founded on something immobile.

¹¹ Cf. Christopher A Decaen in *Aristotle’s Aether and Contemporary Science, The Thomist*, 68 (2004) 375, footnote 50.

¹² Cf. Christopher A Decaen in *Aristotle’s Aether and Contemporary Science*, op. cit., footnote 51. Apparently St Thomas did not comment on Bk. 1, Pt. 6 of Aristotle’s *De Generatione et Corruptione*. Note that here St Thomas includes with the heavenly substance, *aether*, the celestial bodies, Sun, Moon, stars and planets which seemed to be part of it.

¹³ Which must be understood rightly. Ultimately, every material thing, even the automotive (the living), is moved by the First Mover, God. Intermediately, things are moved by instrumental causes and under different respects, moved in as many ways as there are species of motion (cf. II, iv above). *Aether* is such an instrumental cause, perhaps the most fundamental in the material order.

III

Applying these Principles to the Facts exposed by Modern Science

i. The earth is a globe turning on its axis once each day. It circles the Sun each year, its rotational axis inclined some 23 degrees to the perpendicular of the plane of its orbital axis. The moon is a satellite circling the earth every 27.3 days, though taken with respect to the earth's motion around the sun it takes 29.5 days for it to return to the same place in the sky. These heavenly bodies and all the stars and planets that people the sky are immersed in an apparently empty sea of space. Sun, moon and stars do not rotate around the earth each day. Their apparent daily circuit is a function of the planet's rotation. The elements of which material bodies are comprised are not four but (at last count) 118.¹⁴

ii. Let us recall the very first words of Divine revelation: *In the beginning God created the heavens and the earth...* Notice that the sacred author first says that God created the heavens. This accords with philosophical principle. No material thing can come into being, can exist, save in a pre-existing material setting. The earth and its various component parts—the stars, the sun, the celestial bodies, and the elements of which these are comprised—none could have been created *in vacuo* ; for nothing (a void) does not exist. What, then, are we to understand by the expression 'the heavens' ? (The Latin Vulgate, incidentally, reads *caelum*, i.e., the singular, 'heaven') It is not unreasonable to conclude that 'the heavens' in the text signifies not the sun, moon, planets, stars and other celestial bodies, but *aether* 'the heavenly body' ; and 'the earth' signifies not just our own planet but all celestial bodies, indeed, all ordinary, or common, material being.

When the Philosophers say that *aether* is 'first body' they mean exactly that ; *first* in the order of reality, *first* in the order of time. The apparently empty void of space is replete with it. But let it be understood that 'replete with' is not convertible with 'filled', as if *aether* was a fluid poured into an empty vessel. *Aether*, not void, is first in the order of reality : where there is no other material being, there is *aether*. While imagination inclines us to view a void as reality's 'default setting' (to adopt modern computer jargon), intellect insists it is the first body, *aether*. *Aether* is the universe, the matrix in which every celestial body exists ; the universe is *aether*. St Thomas appears to acknowledge this in his second lecture on the first book of the *De Caelo*.¹⁵

iii. When it is said that *aether* is an element of the natural world this is not to be understood in the sense of 'a component'.

"It is to be noted that Aristotle here reckons the heaven [*aether*] among the elements, although an element is something out of which things are composed, as said in *Metaphysics* V. However while [*aether*] does not enter into the composition of mixed bodies, it is involved in the composition of the whole universe as being part of it.

¹⁴ One critic has suggested that the assertion of the fourfold constitution of the elements of the material world accepted by the ancient Greek philosophers is reflected in the modern division of material structures into solids, liquids, the gaseous and plasma.

¹⁵ *In I De Caelo*, L 2, 17.

Either that or he is using the word 'element' in a wide sense to designate any of the simple bodies... to distinguish them from prime matter..."¹⁶

Now what is said about *aether's* involvement in the operations of the celestial bodies is, in the view of this commentator, no less true of the substances of which they are comprised. These do not subsist, do not come into existence, save in *aether* as their proper matrix. Much as the sea is the medium and essential condition in which fish and other creatures exist, *aether* is the medium and essential condition of the existence and coming into existence (the *be* and *become*) of all material things. In the author's view *aether* cooperates with first metaphysical accident *quantity* in binding the atomic and molecular structure of each bodily substance.

iv. The Philosophers conceived of the celestial bodies as embedded in concentric spheres with their motions determined by this heavenly body. They were aware of the reality of gravity as 'heaviness' and that this involved a force or tendency downwards. They understood, too, that the earth was spherical, but held it to be fixed and its centre the centre of the universe. If certain bodies had a downward motion it was because that was part of their nature.

Modern science notes a number of effects universal among celestial bodies—spherical formation ; circular movement ; gravity. We know that the moon rotates about the earth ; that the planet circles the sun ; that the sun and stars circle in our own galaxy, the Milky Way, and that stars circle in other galaxies.¹⁷ If science has confirmed anything it is that circular motion is as characteristic of the bodies that people the universe as it is uncharacteristic of the mundane. Now this universal effect as those of spherical form and gravity must have a proportionate cause.

v. Many realities in nature are not scientifically detectable. Science cannot, for instance, detect experimentally the cause of life in a living being. This reality has no weight, no colour, no appearances, nothing which can be measured. One can only conclude to its existence from effects. Yet it is the essential element of the living thing.¹⁸ Notwithstanding its besotted-ness with materialism, science cannot, accordingly, object to some reality simply because it is unable to discern the presence of, or measure, its physical characteristics.

Now, cause and effect are always proportionate. The more particular an effect, the more particular its cause ; the more universal an effect the more universal its cause. If the thesis proposed here be accepted, it is clear that the only substance as universal as the effects of gravity, spherical form, and circular movement is *aether*. As a working hypothesis, then, let us assume that *aether*, the sea in which according to our thesis all celestial bodies subsist, is the cause of these effects.

¹⁶ *In I De Caelo*, L. xviii, n. 7

¹⁷ Notably M31, Andromeda Galaxy, and M33, Triangulum Galaxy. Those who contend that the motion of the earth and of other planets and satellites is not circular but elliptical are splitting hairs. Whatever the effects of the modifying influences, the motion is primarily and *per se* circular.

¹⁸ For if it is lost the thing ceases to be. For living things, Aristotle teaches, to live is the same as to be.

vi. Let us recall what the Philosophers have to say of philosophical principle and the attributes they ascribe to this element, and weigh these against the realities science cannot explain.

-) *All motion is founded on something immobile.*
-) *Nothing moves that is not moved by another.*
-) *Nature is the principle of motion in all moveable things.*
-) *Two principles underlie all motion, the one of acting, the other of being acted on.*

The Philosophers' contention that the immobile thing on which the mobility of the universe was founded was the physical centre of what they perceived to be its sphere is now shown to be problematic.¹⁹ In perceiving the heavens (i.e., *aether*) as in motion the Philosophers were, of course, misled by the limitedness of their knowledge derived from the rotation of the planet on its axis. In the Michelson-Morley experiment (1887), science demonstrated that *aether* is undetectable.²⁰ While it is certain that *aether* moves *per accidens*, for it adapts to the movement of all other bodies, *per se* it would seem to be immobile. Indeed, careful reflection on the curious nature of this substance indicates that *aether* is immobile with respect to every element of common material being. Hence, even with respect to heavenly bodies moving at great speed in opposition to each other, the *aether* in which each subsists is immobile.²¹ In summary we contend that *aether* is the immobile 'something' on which the motion of the heavenly bodies is founded and, to this extent, we would depart from the Philosophers' teaching on *aether's* proper motion and argue, instead, that circular movement is the proper effect *aether* induces in these bodies.

vii. In line with our thesis, *aether* is the principle of acting, the *active* principle, of heavenly motion but *as instrument*, not as principal. For the principal *active* principle is, as the Philosophers teach, an intellectual substance. The *passive* principle of the motion of the celestial bodies is embodied in their nature as comprised of the elements of common material being. Consistent with this is St Thomas's assessment that, since it contains all other bodies, *aether* the heavenly body is to them as form is to matter, as act is to potency, i.e., is their determinant. [*In I De Caelo*, L iv, 50]

¹⁹ Though, for each celestial body there remains 'a still point of the turning world', to quote T S Eliot [*The Four Quartets*]. While no such body is absolutely immobile due to the influence, as science perceives it, of other celestial bodies, each such body is yet relatively so. St Thomas sheds light on the issue where he deals with an objection to Aristotle's view that circular motion is a simple motion.

[*T*]he parts of a sphere which is in circular motion are not in uniform motion but the parts near the poles or near the centre are moved more slowly because they traverse a smaller circle in a given time; consequently the motion of a sphere seems to be composed of fast and slow motions. His answer is instructive: *But it must be said that a continuum does not have parts in act, only in potency. Now what is not in act is not in actual motion. Hence the parts of a sphere, since they form a continuous body, are not actually being moved. Hence it does not follow that in spherical or circular motion there is diversity actually, only potentially.* [*In I De Caelo*, L iii, 26].

Transported on the surface of the Earth at a rotational speed of 465 metres per second (at the equator), we are quite unconscious of the motion. One critic has advanced against this that the reason is that the earth's motion is uniform, not bumpy. We leave this to others to resolve.

²⁰ This experiment, deemed a failure because it failed to produce a result that accorded with modern science's materialist preconceptions, was in fact a success. It proved what the Philosophers had maintained for centuries, *aether's* superiority to the limitations of ordinary matter.

²¹ This characteristic may offer an explanation as to the uniformity of *C*, the speed of light. As is well known, in every frame of reference its speed is constant at 299,792,458 metres per second.

Had the Philosophers known of the discoveries of modern cosmology and those of science concerning the elements and their periodic table they would have had no difficulty adapting their teaching to encompass 118, rather than four, elements, to maintain that the quintessential body to whose existence they had concluded was—

“of a different nature from [those]... elements.” *In I De Caelo*, L iv [46]

For the motion proper to each of the 118 elements, as to the almost infinite number of their compounds, is rectilinear motion, and—

“if circular motion is outside the nature of a body that is moved circularly... for some other body it is according to nature...” *In I De Caelo*, L iv [46]

This last requirement is satisfied, in our view, if rather than being *aether's* proper motion, circular motion is its proper effect ‘according to nature’.

viii. Therefore the motion of each celestial body about its own axis, as of its movement about another, is governed by some body whose proper effect according to nature is the induction of circular motion in other bodies, a body different from, and superior to, those other bodies.

IV

How does Aether operate

“What put you on to this...?”

“Aristotle chiefly... He says, you know, that one should always prefer the probable impossible to the improbable possible.”

Lord Peter Wimsey²²

i. Here is Sir Isaac Newton’s challenge to those who would follow him :

“It is inconceivable that inanimate Matter should, without the Mediation of something else, which is not material, operate upon, and affect other matter without mutual Contact... That Gravity should be innate, inherent and essential to Matter, so that one body may act upon another at a distance thro' a Vacuum, without the Mediation of any thing else, by and through which their Action and Force may be conveyed from one to another, is to me so great an Absurdity that I believe no Man who has in philosophical Matters a competent Faculty of thinking can ever fall into it. Gravity must be caused by an Agent acting constantly according to certain laws ; but whether this Agent be material or immaterial, I have left to the Consideration of my readers.”²³

Gravity (as every other created reality) has four causes ; two are intrinsic to the effect (the *material* and the *formal* causes) and two extrinsic (the *efficient* and *final* causes). Its *formal* cause is the inclination of the parts of the globe whether actual or potential (i.e., above, or on, or within it) of which a celestial body is comprised towards its centre : the *material* cause is the globe and those parts. The *final* cause, taken as the *ultimate* end of the operation, is the ordering of the globe and its parts to the good of the whole. Taken as the *immediate* end it is its focus or centre. The *efficient* cause is the agent that produces the gravitational effect : it is duple, *principal* and *instrumental*.

²² Dorothy L. Sayers’ fictional detective in *The Unpleasantness at the Bellona Club*, London (Victor Gollancz Ltd.), 1921, Ch. XV. This (admittedly flippant) citation is from Aristotle’s *Poetics* (cf. Bekker 1460a) where the context is human making (the artificial) rather than some element of the natural order.

²³ Letters to Dr Richard Bentley, 1692-3.

The *principal* efficient cause is an intellectual substance, the *instrumental* cause the means the principal uses.

Clearly the *instrumental* efficient cause of gravity cannot be the globe itself for the efficient cause is *extrinsic* to the effect, while the globe, the subject of gravity, is *intrinsic*. It is impossible, moreover, that the same can be both intrinsic and extrinsic causes under the same respect of the same effect.²⁴ Just as clearly the cause must be an agent as universal as is the effect.

ii. Aristotle remarks on the contrariety to be found in nature.²⁵ There should be no surprise, then, that the superiority of *aether* to bodies of ordinary matter involves contrariety. A body of ordinary matter acts *from within* for nature is an intrinsic principle providing determinate powers, acts and ends to its subjects. In contrast, *aether*, as befits the container of all other bodies, acts *from without*. If pressed, *aether* offers no resistance ; it is wholly pervious to extrinsic influence.²⁶ *Aether's* operations in respect of gravity are completely counter-intuitive.

Let us recall that the problem of *celestial* centripetal force (gravity) is that no medium has ever been detected or even suggested whereby the immense centrifugal forces dictated by the innate tendency of a celestial body to rectilinear motion could be overridden to compel it to circular motion. This is the reason gravity is treated as an innate force of attraction.

The problem of the medium can only be solved if it is understood that the contrariety in the way mundane and celestial circular motions occur corresponds to a fundamental difference in the natures of the relevant acting bodies. *Do follows be*²⁷ : difference in *modus operandi* reflects a difference in *modus essendi*. In bodies of ordinary matter centripetal force *precedes* circular motion ; centripetal force must be secured before circular movement can be achieved. Before a wheel can turn spokes must be in place ; before dancers can spin around a common axis hands must be interlocked. Though the two realities, centripetal force and circular motion, occur together in time, *ontologically*, i.e., in the order of reality, circular motion depends on centripetal force. The dynamic is *from within to what is without*.

In contrast to this, Aristotle teaches that the agent that produces circular motion among celestial bodies *operates at the circumference* of the circles of motion.²⁸ That is, in *aether's* realm circular motion is initiated *not at the centre but at the periphery*. The dynamic is *from without to what is within*. Celestial circular motion does not depend

²⁴ It may be objected that magnetic attraction between two bodies of iron involves an efficient cause which is intrinsic to the effect, but it is not so. The efficient cause of magnetic attraction is that extrinsic influence establishing in its nature the property that one body of iron will attract another.

²⁵ The constitution of a body involves two contrary principles, one of being determined (prime matter), the other of determining (substantial form). St Thomas addresses the issue directly in II, ix above when he says this element is to all other bodies as form is to matter, as act is to potency.

²⁶ A point well made by Christopher A Decaen in *Aristotle's Aether and Contemporary Science*, op. cit., Part I and footnote 40. This is also the reason why we cannot detect the substance, for every sense requires some reaction to the sense power in the thing sensed.

²⁷ The nature of a thing determines how it operates.

²⁸ In Book VIII of the *Physics*. Cf. St Thomas's Commentary *In VIII Physics*, L 23: 1168

on centripetal force : centripetal force (i.e., gravity) depends on circular motion. Moreover, it does not seem necessary that there be *actual* motion, the *potency* to *aether's* influence is sufficient to generate gravitational force.

iii. It may be objected that the rotation of celestial bodies about an axis and the orbiting of satellites about a celestial body each occurs in one plane only whereas gravity operates in every possible plane about a celestial body's centre. The answer seems to be that *aether* is not constrained by the limitations of bodies of ordinary matter. Whereas *they* operate particularly and in one plane, *aether* operates universally and in every plane. Thus does *aether* produce spherical form, for a sphere, which is the mark of gravity, is simply a compound of every possible circle about a centre. *Aether's* proper effect is circular motion, perfect motion, and the form it produces is spherical form, perfect material form.

iv. The influence *aether* exercises falls within the metaphysical category *action*, an accident. To understand this we must understand what is meant by *accident* and by the reality to which it is the essential accompaniment, *substance*.

In metaphysics *substance* does *not* mean what the modern scientist means when he uses that term—a material body without regard to nature or quiddity.²⁹ A *substance* is something which exists in itself (*be-in-self*) not in another.³⁰ In contrast, an *accident* is something which exists not in itself but in another : it cannot exist *save in some substance (be-in-other)*. The sky is a substance (or a mix of them) ; that it is lit is an accident. The sea is a substance ; that it is blue is an accident. A horse is a substance; that it is galloping is an accident. A dog is a substance ; that it is clothed in a coat is an accident. That this man, a substance, is standing under a tree is an accident.

The hardest thing for the modern mind (immersed, as it is, in materialism) to grasp is that *substance* is *per se* immaterial, i.e., something real yet not comprised of matter. The word 'substance' means 'that which stands under'. Stands under what? Stands under the body's physical characteristics, the first of which is *quantity*.

Every substance has nine *accidents* ; the first, *quantity*, provides physical extension and parts, i.e., provides the substance with a body.³¹ The next accident, *quality*, makes the body be of *what kind (qualis)*, giving it density, permeability or impermeability, hardness or softness, texture, colour, heat, and so on. The remaining accidents *relation, when, where, action, passion, habitus* and *situs*, determine it in every other possible fashion.

"Among all... accidents it is proper to *quality* to render the subject formed and qualified... because *quality* among all the accidents properly ennobles and qualifies the subject. For *quantity* quantifies and rather materialises its subject by extending it

²⁹ Descartes is the philosopher responsible for the shift of meaning so that it has become synonymous with first accident, *quantity*. Cf. D. G. Boland LL. B., Ph. D., *God and the Theory of Everything*, 2012; the text will be available shortly from Sydney's Centre for Thomistic Studies whose website is <http://www.cts.org.au/>

³⁰ And, be it noted, not all substances are *corporeal* substances. Some have no bodies.

³¹ In his text, *God and the Theory of Everything*, (2012), Dr D. G. Boland of Sydney's Centre for Thomistic Studies, points out that that Descartes rejected the metaphysical understanding of *substance* and substituted for it first accident, *quantity*. The text will be available shortly; cf. <http://www.cts.org.au/>

and ordering its material parts. The remaining [accidents] either order their subject towards another, as does *relation*, or depend upon something extrinsic ordering it, as do the last six..."³²

Substance is the reality that underlies the appearances on which science concentrates its energies yet confuses with *quantity*.

v. The sixth accident *action*³³ is, as the commentator quoted above [John of St Thomas] remarks, depends upon something extrinsic. *Action* entails the production by some agent of an effect in another, called a *patient*, with movement from one to the other.³⁴ There are different species of *action*. That which concerns us here is called 'transitive'. An illustration : when something such as a spoon is placed in hot water the heat of the water (the agent) transfers into the spoon (the patient) ; *action* in the water is *passion* (seventh accident) in the spoon. *Action* is really distinct from the movement involved as a line is distinct from its curve. *Action* adds to motion the respect 'from agent'. *Passion*, really distinct from the movement involved and adding to it the respect 'unto patient', is the reception of the effect. *Action* is an accident in the agent ; *passion* another, separate, accident in the patient.

Now much as hot water produces heat in a spoon, *aether* produces the *passion* of circular motion in a celestial body and the consequent centripetal force of gravity.

vi. The experiment of Henry Cavendish in 1797-8 involving two sets of lead spheres of differing masses, 1.6 lb and 348 lb each separately suspended some 9 inches apart and on alternate sides, established that there is an apparent force of attraction, albeit infinitesimal, even among mundane bodies. The smaller spheres moved towards the larger causing the supporting arm to rotate : the twisting of the suspending wire enabled the force to be measured against the wire's torsion coefficient. Now if, as we assert, the force at work is not one of attraction between, but of extrinsic action by *aether* on, these bodies the experiment demonstrates that *aether's* action is not confined to the heavens but is universal.

Examples of *aether's* influence among the mundane may, perhaps, be seen in various earthly phenomena we ascribe to other causes. One is the soap bubble. When a pocket of air is captured by a soapy solution competing centripetal and centrifugal forces produce the evanescent miracle of spherical form. [Note, we are not using 'centrifugal' here in the sense of a force at right angles to the radius of the circle of motion but in the proper sense of 'flying away from the centre'.³⁵] While the source of the centrifugal force is the trapped air, that of the centripetal force may be ascribed to the surface tension of the soapy water but only as instrument of a higher cause. Another instance may be that occurring in the manufacture of shot where small quantities of molten metal forced through a sieve fall into water and solidify as tiny spheres.

³² John of St Thomas, *Cursus Phil.*, I, p. 609b, quoted in *Ostensive Metaphysics, Treatise One, Ontology*, A. M. Woodbury Ph. D, S.T.D., a text of Sydney's Aquinas Academy, n. 1161.

³³ It is not clear just how many of the nine accidents are properly to be attributed to *aether*. We remarked in the earlier paper the difficulties presented by the nature of this substance.

³⁴ This analysis is reproduced from the text of A. M. Woodbury Ph. D, S.T.D., of Sydney's Aquinas Academy, *General Natural Philosophy and Cosmology*, c. 22, 1, nn. 334 et seq.

³⁵ This, the proper sense of 'centrifugal', is illustrated in the operation of an explosion.

Cause and effect are always proportional. If spherical form in celestial bodies is the mark of *aether's* influence, why are these earthly instances not also ?

vii. Let us recall the Philosophers' teaching (III. iii above) that, while not a component, *aether* is an essential element of material being ; that "it is involved in the composition of the whole universe as being part of it." The 'space' that, science tells us, makes up most of atomic and molecular structure of the elements and compounds of material bodies can, no more than that between celestial bodies, be 'nothing somehow existing'. According to our thesis *aether* is involved intimately in the structure of each celestial body : it cooperates with first metaphysical accident *quantity* in binding atomic and molecular structure. Since, as the Philosophers teach, *aether* acts but cannot be acted on, the dilemma that confronted Le Sage's thesis does not arise : *aether's* extrinsic force bears not only on the surface but on the whole body.

This *passion* of inclination towards the centre of its mass of a celestial body resembles somewhat the *passion* of compression in a body submerged in the sea. Yet the analogy limps for, regardless of the depth and the intensity of its pressure, the creatures of the sea under nature's edict retain their native forms.

V

i. But if gravity is produced by an efficient cause *extrinsic* to a celestial body, why does it give the appearance of a force of *attraction*, i.e., of something *intrinsic* ? If the *matter* (i.e., the subject) of gravity's centripetal force is the globe of the celestial body and all its parts, the *form* (that which makes gravity be what it is) is the inclination towards its centre. But gravity's strength or weakness, according to proven scientific principle, is a function of the *mass* of the heavenly body. In breach of metaphysical principle, then, gravity seems to be determined by its *material* rather than by its *formal* cause.

The native motion of every element of common matter, as of the bodies they comprise, is straight (*rectilinear*) motion, as Newton makes clear.

"A centripetal force is that by which bodies are drawn or impelled, or in any way tend, towards a point as to a centre. Of this sort is gravity by which bodies tend to the centre of the earth ; magnetism by which iron tends to the loadstone ; and that force, whatever it is, by which the planets are continually drawn aside from the rectilinear motions which otherwise they would pursue and made to revolve in curvilinear orbits."³⁶

ii. Science treats circular motion as an application of Newton's Second Law.

"Whenever an object moves in a circle with uniform velocity, it has an acceleration pointing toward the centre of the circle. This may seem confusing at first; we do not expect to encounter acceleration when the speed is constant. Remember that while the speed is constant, the direction of the velocity vector is continually changing, and it is because of this change in velocity that we have acceleration.

³⁶ Sir Isaac Newton, *Principia Mathematica*, Definition V; Axiom I. (Transl. from the Latin by Andrew Motte revised by Florian Cajori, University of California Press, 1934). My copy, a reprint in *The Great Books of the Western World*, vol. 34, for Encyclopaedia Britannica, Inc. 1952.

“We know then, from Newton’s second law ($F = ma$), that an object moving in a circle must have a net force on it, which points in the same direction as the acceleration, i.e., toward the centre of the circle. The force associated with this centre-pointing acceleration is sometimes called the centripetal force. The centripetal force might be provided by a rope or by gravity or some other means; the designation ‘centripetal’ just means it is the net force that is associated with an object moving in a circle.

“Combining Newton’s second law and the equation for acceleration in terms of the speed around the circle, we have—

$$F = \frac{mv^2}{r} \quad \text{''}^{37}$$

Velocity is speed + direction. A change in direction is a change in velocity and since circular motion involves constant change in direction, science regards a circling body as accelerating towards the centre of its motion.

The gravitational force ‘of attraction’ (F_g) between two bodies is calculated according to Newton’s celebrated formula as follows—

$$F_g = \frac{m_1 m_2}{r^2} \times G$$

—where m_1 and m_2 are the masses of the relevant bodies, G is a fixed ratio called the gravitational constant, and r is the distance between the centres of mass. For the purposes of the present discussion we will not explore the subtleties elaborated by Einstein. Gravitational force depends radically, then, on what science calls *mass*. But what is *mass*?

iii. Newton understood mass as convertible with quantity :

“The quantity of matter is the measure of the same arising from its density and bulk conjointly. Thus air of double density in a double space is quadruple in quantity...

This quantity I designate hereafter everywhere by the name of body or of mass...”³⁸

Some say *mass* is constant proportion between force and acceleration, others constant proportion between weight and acceleration, a quantitative measure of an object’s resistance to its change of speed. While this force varies from place to place, a body’s *mass* remains unchanged—*pace* Einstein’s theories. Another view has it that *mass* depends on the number of atoms a body contains. This is problematic because atoms are not uniform across the elements as the periodic table shows. A further view says mass is proportional to the volume a body occupies.³⁹ *Mass* is clearly not volume for volume is variable under the influence of pressure and temperature. It is not weight for weight is an effect of gravity and varies with altitude, i.e., distance from the centre of the earth (or other celestial body).

Perhaps the most objective assessment, at least for the purposes of Newton’s Laws, is that it is a measure of the force necessary to deflect a body from the straight motion natural to it, in other words, a measure of its inertia. While the definition of each of these categories seems constrained by another in a bemusing circularity, it should be

³⁷ University of California, Irvine. I have rewritten the final formula to reflect the earlier mode of expression <http://learn.uci.edu/oo/getOCWPPage.php?course=OC0811004&lesson=006&topic=10&page=1>

³⁸ *Principia Mathematica*, op. cit., Definition I

³⁹ Cf. The entry on *Mass* on the Wikipedia website, <http://en.wikipedia.org/wiki/Mass>

observed that science now expresses, in the unit the 'Newton', a measure of a body's lineal inertia, the force necessary to cause it to accelerate at a given rate.⁴⁰

iv. *Aether* operates, according to our thesis, universally and uniformly (via its proper accident of *action*) *in* and *about* each celestial body to produce in it the *passion* of circular motion. *In the body* it produces rotation on one of the infinite number of possible axes about its centre or focus and thereby generates internal centripetal force, gravity. The larger the body the greater the gravitational force generated and, it would seem, the more perfectly the body approaches spherical form. The inclination to the centre or focus, taken ontologically, is the formal principle of rotation of the celestial body, both actual and potential. But no celestial body exists alone in the *aethereal* sea. *About the body*, then, *aether* produces the *passion* of circular motion relative to each neighbouring body with an intensity that reduces in proportion to the square of the distance between them. Science treats gravity's operations on analogy with a magnetic field.

v. Consistent with Newton's principle, if a body of common or ordinary matter is moved circularly a consistent force must be applied to it by the relevant agent. The greater its mass, the greater the force that agent must exercise to overcome its rectilinear inertia. But in *aether's* realm *circular motion is prior to centripetal force*. The greater the force *aether* exercises in 'draw[ing] aside from the rectilinear motion which otherwise [the celestial body] would pursue', then, the greater the centripetal (gravitational) force generated. Thus, while gravity appears to be a force *intrinsic* in a body this is but a consequence of *aether's* undetected *extrinsic* action.

vi. As to the speed with which gravitational force is generated, we repeat certain points made in an earlier article, namely, that—

- a. light is a *quality* (an accident) not a *substance* ;
- b. it is the proper *quality* of *aether* ;
- c. *ergo C* , the speed of light, is not a property of light but of *aether*.⁴¹

To these we add the assessment that *aether* is immobile with respect to every body of ordinary matter. This last would explain why *C* is the same in every frame of

⁴⁰ The inability of science to plumb the nature of mass is understandable for science is not concerned with the natures of things. A *substance*, as we have noted, is something which exists in itself (*be-in-self*) not in another, an *accident* a reality which exists not in itself, only in some substance (*be-in-other*). The first accident is *quantity*. Metaphysically understood, then, the *mass* of a body consists in corporeal *substance* as affected by *quantity*. But there is, as Newton remarked, another influence too, that *quality* which is the substance's proper density. *Substance* explains the specific differences between masses, *quantity* explains the individual differences between them, while density, the *quality* proper to each substance, explains why one type of substance differs from another in specific gravity. "The action of a generant does not stop at the bare substance but produces it equipped with the accidents upon which the substance depends, that it may exist and operate." (John of St Thomas; *Curs. Phil. II, ed. Reiser*, p. 268b, quoted in A M Woodbury, *General Natural Philosophy and Cosmology*, op. cit., nn. 127 and 344.) The *substance* of copper (that immaterial reality which is copper), for instance, differs from the *substance* of water (that immaterial reality which is water), as the density which is the *quality* proper to copper differs from the density proper to water. One mass of copper differs from another, as one mass of water differs from another, through their respective *quantities*. [This analysis from A M Woodbury Ph D, S.T.D., *General Natural Philosophy and Cosmology*, op. cit., nn. 238 to 245.]

⁴¹ *Science and Aristotle's Aether* at http://www.superflumina.org/PDF_files/aether_science.pdf

reference. Einstein contended that *C* was the one fixity in the universe. What he attributed to light ought, on our thesis, to have been attributed to *aether* for it is *this body* which is the immoveable on which all celestial motion depends.⁴² In generating circular motion *aether* exercises over celestial bodies the accident *action*. Einstein's *General Theory of Relativity* has been proven by observation. It requires that any change in a 'gravitational field' take place also at the speed *C*. We were inclined to think Newton's view, that gravitational force is instantaneous, was to be preferred⁴³, but Einstein's view cannot be ignored. Moreover, principle demands that action be constrained by matter's inertia. [*This paragraph amended 1st September, 2015*]

vii. Newton confessed himself unable to explain gravity as action at a distance. Einstein thought he had solved the problem with his elaboration of a gravitational field theory but he had only provided a more precise explanation of how gravity operates. If it is understood that its cause is one body, one substance, that acts on all bodies of ordinary matter, the dilemma of 'action at a distance' disappears.

VI

The Problem of the Tides

i. But is this thesis not contradicted by what we observe of the influence of the moon and, to a lesser extent, the sun on the seas which cover some seventy per cent of the earth's surface? If gravity is caused not by something intrinsic to a celestial body but by this extrinsic influence, *aether*, how explain the clear influence of the moon and of the sun on the regular movements and alterations in movements of the tides? Science tells us that the moon's influence on the tides is the greater.

ii. The moon's involvement in the tides may be seen in the way the diurnal period between successive tides reflects the lunar day, about 24 hours 50 minutes. A cause *exercises influence unto the be (esse; existence) of a thing dependent in regard to its be*.⁴⁴ Causes may be distinguished according as they are essential, or not, to the effect; that is, a cause may exercise its causality *per se* or *per accidens*.⁴⁵ Of any effect there are four *per se* causes, no more and no less as outlined above. (IV, i).

Causes *per accidens* fall into three categories *condition, occasion* and *chance*. Of these one only concerns us here, *condition (removens prohibens)*, without whose operation a cause *per se* cannot act.⁴⁶ Now the moon is more than a *condition* of the motions of the waters that cover the earth; it is essential to their regularity. It must, then, be a cause *per se*. It is not a *formal* or *material* cause for these are always *intrinsic*, while the moon

⁴² Rather *C*'s fixity is a property of *aether* demonstrating its immobility and fixity.

⁴³ Newton seemed to treat 'space' as if it was an ethereal body while Einstein, at least until he amended his view in 1920, treated it as non-being somehow existing. His amended view did not seem to regard 'ether' as much more than an accident of 'space', albeit he was correct when he said that it was not to be considered as comprised of parts trackable through time or of ponderable matter.

⁴⁴ This principle is elaborated by St Thomas Aquinas in *Summa Theologiae* I, q. 104, art. 1.

⁴⁵ Aristotle *Metaphysics* Bk. V, ii. and *Physics* Bk. II, vii (198a 5 et seq.); St Thomas *In II Physics* L. 10.

⁴⁶ For a detailed analysis see the material under the heading 'The Mode of Aether's Involvement' in *Science and Aristotle's Aether* at http://www.superflumina.org/PDF_files/aether_science.pdf

is *extrinsic* to the earth and its motions. It is impossible that it be the *final* cause, their end or reason, for this is something intended by nature's author. It remains that the moon is an *efficient* cause, if subsidiary to the *principal* efficient cause, that intellectual substance the Philosophers have identified. Hence the moon operates in the capacity of instrument. But there are degrees of instrumentality.

iii. Science's explanation that the tides are caused by the 'pull' of the moon is problematic if for no other reason than that there is nothing in the mass of a celestial body *qua* mass which demands that it should attract another. Moreover, if the moon exercised a 'pull' on the waters of the seas of the earth at a point immediately opposite it, one would expect a general movement of the mass of surrounding seas towards that point, qualified by their inertia. But, given that that point on the earth's surface is rotating away from the moon at a steady rate (about 460 metres per second at the Equator) to the east, one would expect the two forces to produce a piling of the waters to the east and corresponding diminution in waters to the west. But this is not what happens.

A 'bulge' of waters, a high tide, occurs with the moon's passing, though not necessarily opposite the moon's meridian, but the waters mass uniformly and, as uniformly, diminish with the earth's rotation, albeit with amplitudes which differ from place to place. But, even stranger, the massing that occurs in the hemisphere adjacent to the moon is balanced by a corresponding massing in the opposite hemisphere. The total effect is a relatively even pulsation, analogous to an animal's breathing, with nodes on opposite sides which process steadily about the globe.

iv. Although we take the rotations of earth and moon as simple circles about their axes, their motions are more complex. The planet and its satellite each has an effect on the other, a function of their respective masses. The moon is 1/81st the mass of the earth, its relative density 3.36 to the earth's 5.5.⁴⁷ Its average distance from the earth is some 384,000 km. In accordance with Newton's laws it appears to influence the earth in direct proportion to its mass and inverse proportion to the square of the distance between their centre of masses. The earth appears to influence the moon in a similar fashion.

The combined masses, separated though they be by some 380,000 odd kilometres, circle about a focus (the centre of the two masses, *their* centre of gravity) called the *barycentre*. This is located within the body of the planet at a point opposite the moon an average 4,670 km from the earth's geometric centre (some 1,700 km beneath its surface).⁴⁸ The moon moves in the same direction the earth is rotating, anti-clockwise.⁴⁹ But in the time it takes the earth to rotate 360° the moon progresses only 12.2°.⁵⁰ The consequence of this disparity is that the *barycentre* beneath the earth's

⁴⁷ For this and what follows see for example Steve Massey, *Exploring the Moon*, Sydney, 2004.

⁴⁸ Cf. [http://en.wikipedia.org/wiki/Barycentric_coordinates_\(astronomy\)](http://en.wikipedia.org/wiki/Barycentric_coordinates_(astronomy))

⁴⁹ So, too, the motion of the Earth around the Sun is counter clockwise viewed from the north.

⁵⁰ Hence the Moon advances from west to east some 49 minutes every day. Taken with respect to distant stars, the Moon takes 27.32 days to orbit the Earth (sidereal month). But because the Earth is itself moving circularly around the Sun and, in one cycle of the Moon, traverses about 1/12th of its

surface moves in *the opposite direction to the earth's rotation*, somewhat after the fashion of the phenomenon known as mechanical precession.⁵¹ It moves slightly slower for its locus, aligned between earth's centre and that of the moon, traverses 348° in the time the earth rotates 360°.⁵²

v. The *barycentre* exercises on the components of the earth's surface a centripetal force *additional to* that exercised by the earth's centre of gravity.⁵³ This *barycentripetal* force resolves into two subsidiary forces on the waters to east and to west of a point above the *barycentral* focus, one directed towards the earth's centre and the other towards a point on the surface directly above it.⁵⁴ This horizontal component force draws the waters from east and west, from north and south, towards that point.⁵⁵ Under this influence the tides progress from east to west, though the interference of continents, the varying depths of the oceans, the *coriolis* effect and other factors, produce a complex of movements. These are manifest in a pattern of cotidal lines (lines joining points of identical tidal phase) radiating around centres which turn clockwise in the southern hemisphere and anticlockwise in the northern.⁵⁶

This contrariety in motions—of the earth's surface from west to east, of the *barycentre* from east to west at a slightly slower rate—produces a contrariety of forces which explains, i) why the sea wells and dissipates at a uniform rate with the passage of the *barycentre*, the momentum of the waters carried to the east matched by the march of the tidal node to the west ; and, ii) why the tides advance by 50 minutes or so every 24 hours. The moon moves progressively from *apogee* (furthest away) to *perigee* (closest) every 7½ cycles. As the moon moves closer the *barycentre* moves closer to the earth's surface and the horizontal component of the *barycentripetal* force, assumes greater magnitude. It is this greater force, not a stronger 'pull' of the moon, that explains why the tides at such times increase in amplitude.

vi. To the high tides induced by the ever-moving *barycentre* there correspond highs on the opposite side of the planet. Let us call the first set *primary* tides and the corresponding ones *secondary*. There is currently no satisfactory explanation for these *secondary* tides. All those proposed are premised on the thesis that the moon exercises a 'pull' on the earth. But no such hypothetical 'pull' on one side of the globe could account for the massing of the seas in the opposite hemisphere *away from* 'the pull'. The *barycentripetal* theory provides for the presence of a horizontal component force similar to that operating on the seas of the *primary* tides, but much diminished. For, as focus of the *secondary* tides, the *barycentre* is *beyond* the earth's

annual cycle, the Moon takes about 29.53 days (synodic period, or synodic month) to pass from new moon to new moon.

⁵¹ *Mechanical precession* is the movement of a round part in a round hole where the direction of rotation of the inner part is opposite to the direction of rotation of the radial force.

⁵² Cf. the title 'Tides' at <http://en.wikipedia.org/wiki/Tides>

⁵³ For it is a function of the two masses rather than the earth's alone.

⁵⁴ *The surface of a fluid of uniform density..., if at rest, is everywhere perpendicular to the lines of force ; for if this were not so, the force at a point on the surface could be resolved into two components, one perpendicular and the other tangent to the surface...* (Anthony & Brackett, *Elementary Text-book of Physics*, p. 127.)

⁵⁵ Though due to water's inertia this welling occurs some time after the *barycentre* has passed.

⁵⁶ Cf. <http://en.wikipedia.org/wiki/Tides> for the reproduction of these lines on a homolographic projection of the earth analogous to lines on a topographic map [M2_tidal_constituent.jpg] .

centre—some 6,500 km, rather than some 1,700 km, distant. Moreover, the *secondary* tides constitute a reaction to the *primary* tides. After a *primary* tide the seas dissipate, with a momentum which lowers them below the mean, producing a low tide. The *secondary* high rises to fill this gap somewhat as a second wave follows the trough left by displacement of waters of a pond by a boulder. For these two reasons, *secondary* tides do not rise to the same heights, or fall to the same depths as *primary* tides.

As with *primary* tides, these *secondary* tides have four causes. We need concern ourselves only with the *extrinsic* causes (*efficient* and *final*). Their *final* cause is clear. Without them the centre of mass of the planet would move and the resultant instability adversely affect the regularity of its rotation and its relationship to moon and sun. Again, the *ultimate efficient* cause is clear, it is the intellectual substance that ensures the planet rotates with due order to ensure the welfare of its parts.

The rhythm of this unremitting cycle—primary high, primary low ; secondary high, secondary low—is reinforced twice each *lunar month*, i) at the beginning when the moon is in the same quadrant as the sun (new moon), and ii) mid-month when it is in opposition to the sun (full moon).

vii. The moon is, thus, a subsidiary instrumental *efficient* cause of the movement of the tides in the following subordination:

Principal cause	<i>aether</i> ;
First subsidiary	the earth-moon <i>barycentre</i> ;
Second subsidiary	the moon according as <i>aether</i> constrains it to circular motion around the earth generating a centripetal force proportional to its mass which, with the earth's mass, produces the moving <i>barycentre</i> proximate to the seas.

viii. How does the sun affect the tides? Again there is no 'pull' exercised by the sun, although the analogy of attraction is closer than with the moon's involvement because the location of the sun-earth *barycentre* is within the body of the sun and close to its centre. The influence operating on the earth's seas is the centripetal force upon them focussed on the sun-earth *barycentre* generated by *aether's* causation of circular motion of the planet and the sun about that centre.

ix. An interesting problem arises over the relative influence of sun and moon. Notwithstanding its distance, some 149.6 million kilometres (93 million miles ; 8.32 light minutes) from the earth, the sun's influence, through its mass, is some 179 times that of the moon. Yet the sun's observed influence on the tides is less than half that of the moon. In an endeavour to solve the problem, current science—grounded, of course, on the thesis that the centripetal force of gravity is one of attraction—opines that the tides on one celestial body are influenced by another not according to the square but perhaps *the cube* of the distance from that other body.⁵⁷

⁵⁷ Cf. <https://en.wikipedia.org/wiki/Tide> under the heading 'Forces'

But if the tides are influenced not by the distances between the relevant bodies but by the distances of their respective *barycentres*, this modification of Newton's laws is unnecessary. For in respect of the tides the moon is not competing with the sun as—

mass of moon / distance ³	<i>is to</i>	mass of sun / distance ³ ,
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but as—

<i>vector</i> of earth-moon <i>barycentripal</i> force / the distance between seas & the earth-moon <i>barycentre</i> ²	<i>is to</i>	force of sun-earth <i>barycentre</i> / the distance between seas & the sun-earth <i>barycentre</i> ² .
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Despite the force generated as a result of the sun's much greater mass, the immensity of the distance from the earth's seas of the sun-earth *barycentre*⁵⁸ diminishes its influence accordingly.

x. As with the moon then, the sun is an instrumental, but subordinate, *efficient* cause of the movement of the tides. The subordination here operates as follows:

- Principal cause *aether*;
- First subsidiary the sun-earth *barycentre*;
- Second subsidiary the sun according as *aether* constrains the earth to circular motion around it generating a centripetal force proportional to the earth's mass which, with the sun's mass, produces a *barycentre* of great force but of great remoteness from the seas.

VII

The Conclusions Summarised

i. Gravity's *final* cause is the ordination and subordination, for the good of the whole, of the material substances that constitute the globe and, in the case of earth, its inhabitants.

Gravity's *formal* cause, operating to give effect to the final cause, is *the inclination towards* that centre or focus, the consequence of the circular motion induced in a celestial body and its component parts by *aether*, the heavenly body. Its formal cause explains why gravity appears to be a force of attraction. As the house-plan realised is the term of the work of construction of a house (its *final* cause) unless something (e.g., an obstruction ; defective materials) impedes it, so attainment of the centre of mass of the celestial body is *the term* of the work of gravity, unless something (other matter) impedes it.

Gravity's *material* cause is the celestial body and its component parts moved circularly, i.e., against their natural, rectilinear, inclination.

Gravity's *principal efficient* cause is the intellectual substance which orders the universe. Gravity's *instrumental efficient* cause is *aether*.

⁵⁸ Some 149.3 million km : close to the sun's centre.

ii. It is characteristic of natural things that the speed of progression increases as they approach their term. This is the philosophical reason why a body accelerates as it approaches the centre of a celestial body. It is this principle, too, working with the relative densities of the component elements of the celestial body, which assists the right ordering of its parts. For, were it otherwise, gases as the least dense of its components would not rise above all others ; and water, less dense than the generality of minerals, would not rise above them but be admixed with them in confusion. Hence, the *formal* cause of gravity, that which determines the matter so that the end (*final* cause) of the operation is achieved, ensures that the inclination towards the centre is greater the closer another body approaches it.⁵⁹

iii. In an earlier paper we remarked on the relationship between *aether* and light and offered the conclusion that *aether* is universally the vehicle of light's transmission.⁶⁰ In the performance of its function as *lucifer*, as in those functions that relate to the very structure of bodies and the conduct of celestial bodies, each of them essential to the works of creation, *aether* might be called a *pure instrument*.⁶¹ Consistent with our thesis, whether at the level of *the infinitesimally small*, where it assists in binding atomic and molecular structure, or at the level of *the infinitely great* where it holds together each solar system, each celestial body, the very universe itself, *aether* operates unobtrusively and in undetectable fashion.

Michael Baker

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⁵⁹ Which facility is recognised in the inverse square law.

⁶⁰ Cf. the author's study on the function of *aether* as the substance of which light is the proper accident at http://superflumina.org/PDF_files/aether_science.pdf

⁶¹ There is a parallel in philosophical psychology in the field of knowledge where the objective concept has no reality save as instrument to serve the intellect : it is a pure sign or a pure instrument.