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ISAAC NEWTON ON SPACE AND TIME: METAPHYSICIAN OR NOT?[1]

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But whereas we can blame Bohr, Schrödinger and Einstein for our problems, Newton has only God to blame for his. (Tamny, 1979: 58).
After all, if Newton does not believe in the reality of space and time themselves, over and above the material inhabitants of them, who does? (Sklar, 1990: 68).

1. Introduction

It has often been asserted that Newton's view on space and time was merely *representational* or *anti-realistic*, i.e. space and time were not considered as entities as such by Newton.[2] The opposite position, which I will defend here, holds that Newton's view on space and time was *ontological* or *realistic*. According to this view, Newton saw space and time as entities that exist over and above the objects and the events of the material world; he took reference to space and time literally (Bricker, 1990: 77). If Newton was a *reprensentationalist*, time for him was a mere mathematical 'idealisation' of clock time. Lawrence Sklar, who

[1] I am indebted to Jean Paul Van Bendegem and Erik Weber for their comments on an earlier version of this paper.

[2] For a thorough elaboration of this point of view see for instance the works of Bernard I. Cohen. He writes: 'Newton was quite aware of the difference between the mathematical properties of such simplified analogous constructs and the physical properties expressed in mathematical relations or rules or principles of the physical world as revealed by experiments and observations; but later readers and some scholars today have tended to blur Newton's usually clear distinctions.' (Cohen, 1980: 55). In 1959 Stephen Toulmin also defended such a view (Toulmin, 1959a & 1959b).

himself does not adhere to such a representational interpretation of time, gives us a description of such a time conception:

> the assertion of the existence of absolute time comes down to no more than the assertion that we can assign numbers to pairs of events (their "absolute time") in such a way that the periodic processes we call clocks will generally mark off an amount of clock time more or less proportional to the numbers assigned the pair. Deviation of a clock from the assignment of this ideal time intervals we assign in this way will be the numbers to take as time differences in our equations of motion. Absolute time will be, then, in this way, an idealization of clock time. And the assertion that absolute time exists will be nothing more than the assertion that there is such a mathematical function that will assign numbers to pairs of events in just this way. (Sklar, 1990: 70).

A representational view of space would entail that there does not exist an 'absolute' space above all existing things. Space then does only – theoretically – converge with Euclidean geometry, but is not mathematical in essence. Euclidean space does not exist; it is an *instrument* to describe physical space. Both are not the same. Though it is a view which is frequently defended, there are serious reasons to doubt the correctness of attributing such a representational view of space and time to Newton. In several articles James E. McGuire contributed to a better understanding of Newton's metaphysics. Fundamental notions within Newtonian metaphysics are indeed 'space' and 'time'. According to McGuire space and time are coexistent (='logically equivalent') with god. Newton's conception of space and time has a double status: (a) as *a kind of* predicate and (b) as *a kind of* substance (McGuire, 1995: 4-5). As one can suspect, the words '*a kind of*' are of crucial importance. They are predicates and substances on a different conceptual *and* ontological level. The ontological status of space and time is not an isolated problem. Intertwined are topics as the nature and necessity of god, the meaning of being ('*esse*'), the nature and the genesis of matter, etc. In his analysis McGuire mentions three sources:

(1) *De gravitatione et aequipondio fluidorum*[3] (earliest 1668 according to Richard S. Westfall (1998: 301), 1673-1675 according to Rupert and Marie Hall (1978, 187-189) and 1684-1685 according to Betty J. T. Dobbs and James E. McGuire (see 2.1.)),
(2) the *scholium* on space and time in the *Principia* (first edition of 1687), and
(3) the short *Tempus et Locus* (ca. 1692-93).[4]

In the present paper I agree with McGuire's objections to ascribing a representational view of space and time to Newton. There is, however, more. Let me, for the benefit of the reader, give a brief overview of this paper. *Firstly*, I will deal with McGuire's excellent analysis (section 2). In section 2.1 I will present it. In section 2.2 I will mention an incompleteness in McGuire's analysis with regards to absolute time. McGuire, in my opinion, misses a fundamental asymmetry between space and time. In section 2.3 I will add more source material and elaborate more on difficulties and possible (or just *prima facie*) inconsistencies in various texts of Newton. I will add: the Leibniz-Clarke correspondence (1715-1716) and the *Queries* in the *Opticks* (1717). I will show that McGuire's analysis also holds in these texts. *Secondly,* I will present a more global picture of Newton's metaphysics, linking crucial notions like 'matter', 'god', 'active principles', 'being' and of course 'space' and 'time' (section 3). All these notions are intertwined in, what I call, an *onto-theological network*. In 3.1 I briefly discuss the importance of active principles. In 3.2 I explore the relation between god, matter and space. In section 3.3 I discuss the relationship between god, time and space. *Thirdly*, I will stress the secularised features in Newton's conception of god (section 4). The conclusion (section 5) of this paper will be that Newton indeed was a metaphysician.

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[3] This text is part of the 'Portsmouth collection'. The Portsmouth family had inherited a great amount of manuscripts of a niece of Newton. One half was donated in 1950 to the library of Cambridge University. The other half was already sold in 1936. *De Gravitatione* was first published in Hall & Hall, 1978.

[4] The title comes from Newton scholar J.E. McGuire – the texts begins with '*Tempus et Locus sunt omnium rerum affectiones communes sine quibus nihil omnio potest existere*'. It was first published by McGuire in 1978 (with English translation).

2. McGuire's Analysis of Newtonian Space and Time

2.1. The Theology of the *Principia*

De Gravitatione

De gravitatione is the point of departure of the development of Newton's conception of space and time. It contains the ontological framework that underlies the *Principia*. We have already seen that Dobbs and McGuire have dated *De gravitatione* ca. 1684-1685. Both suggest a strong link with the *Principia*:

> *De gravitatione* is part of a creative process (begun in the mid-1680s) that includes the composition of the Principia. (...) De gravitatione expresses the theological world view that animates the Principia itself. (McGuire, 2000: 271).

Let me sum up the arguments that Dobbs and McGuire give in support of their thesis:

(1) Ca. 1684-1685 Newton produced the text *De motu corporum in spatiis non resistentibus*.[5] An early version of this text was entitled *De motu corporum in mediis non resistenibus*. The switching over from non-resisting *media* to non-resisting *spaces* is significant. In several experiments with *pendula* he proved that the ether did not exist (Dobbs, 1991: 144).[6] For him this was a fundamental new insight, a new premise. Previously Newton thought in terms of a material and mechanical ether (Dobbs, 1988: 122-129). An irreversible transformation within his reasoning was the result. In *De gravitatione* Newton mentions the possibility of a *vacuum* (Hall & Hall, 1978: 112, 146).

(2) Newton's description of a force as an internal principle by which the body endeavours to persevere in its motion along a straight line in *De*

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[5] *De motu* was written after a visit to Halley in August 1684. Some five version of it are known. It is considered the '*first draft*' of the *Principia* (Gjertsen, 1986: 161-162).

[6] When one assumes that the ether exists, one would expect a retardation of the motion of the *pendulum* proportionally to the mass (Dobbs, 1991: 136). This did not occur. Newton however stuck for some time to the idea of an ether. In 1684-1685 he already supposed the existence of great voids in space, without abandoning the (non-mechanical) ether (Ibid.: 139; Dobbs, 1988: 55).

motu fits in the conceptual scheme of the *Principia* (Dobbs, 1991: 243, 267; Westfall, 1998: 411; McGuire, 2000: 275). This conception is linked, as mentioned above, with Newton's discoveries with *pendula*. *De motu,* and *De gravitatione* are compatible. The *Principia* matches with the definitions in *De Gravitatione,* where space and body are respectively defined as 'pars quam res adaequate implet' and 'id quod locum implet' (Hall & Hall, 1978: 91).

(3) The attack on Descartes' system of *vortices* in book II of the *Principia* becomes more evident.

These arguments are, in my opinion, decisive. In what follows I will discuss the interrelationship between *De gravitatione*, *Tempus et Locus* and the *Principia*. I immediately start with a quote from *De gravitatione*:

> Space is an affection of being in so far as it is being. No being exists, or can exist, which is not related to space in some way. God is everywhere, created minds are somewhere, and body is in the space that it occupies; and what is neither everywhere nor anywhere does not exist. Hence it follows that space is an emanative effect of the primarily existing being, because when any being is posited, space is posited. The same way may be affirmed of duration: both are affections of being or attributes according to which the quantity of existence of each individual [being] is denominated as regards its amplitude of presence and its perseverance in existence. So the quantity of existence of God is eternal in relation to duration, and infinite in relation to the space in which he is present; and quantity of existence of a created thing is as great, in relation to duration, as the duration since the beginning of its existence, and in relation to its amplitude of presence as great as the space in which it is. (Hall & Hall, 1978: 136).

Some explanation. Newton asserts that time and space are 'affections of being'. This assertion is immediately specified: they are attributes of being of entities 'in so far as they are being'. Space and time characterise 'the being' ('esse') of all things which are - even of god. For Newton space is not identical with extension of matter. When Newton stated that space is a 'common affection of being', he did not mean that 'being' *per se* entails extension (McGuire, 1995: 4). As Newton himself declared:

> Mind also, according to its kind, can be diffused through space without

any thoughts of its parts. (Hall & Hall, 1978: 137).

There are entities which are in space, but which are not extended, nor material. One can find similar ideas in the writings of the Cambridge Platonist[7] Henry More (1614-1687). God also is present in space: he is nevertheless omnipresent (Burtt, 1967: 137). In this case one can also assume that god is immaterial. Thus what exists is somewhere in space, without necessarily being extended. It is this space – and time – which Newton viewed as 'common affection of being'. When he writes 'affections of being', he is aiming at the difference between: (1) attributes which characterise entities *qua* entities and (2) attributes which pertain to the fact that an entity exists (McGuire, 1995: 4). (1) contains all attributes which characterise essential or accidental properties of an entity. It is essential for a tree to have leaves (or needles), branches, a bark, etc. Accidental is for instance that this tree over here has yellowish leaves or the fact that a cat sits on one of its branches or that a nesting box is attached to it. '*Common affections of being*' coincide with (2) – they are attributes which pertain to the fact that an entity exits. Thus, space and time are not normal attributes of entities; they are attributes of '*the being*' of entities (McGuire, 1995: 3). They are transcendental or categorical predicates. Nor space, nor time can be grasped within the traditional dichotomy of 'predicate-substance'. They presupposes a higher conceptual level. McGuire speaks of 'second level predicates' (Ibid.:4). Let me add some things on what Newton called a 'quantity of existence'. The duration of something in time and the presence of something in space[8] determine the quantity of existence of an entity. It can be greater as this entity exists longer or/and is present in more places. Put differently: the quantity of existence of an entity is proportionally to the quantity of duration and space of this entity. McGuire writes:

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[7] This English 'Platonism' went back to the neo-platonic Renaissance philosophy of Marsilio Ficino (1433-1499) and the Christian Cabala of Giovanni Pico della Mirandola (1463-1494). Both philosophers were part of the group around the *de Medici's* in Florence. Ernst Cassirer considers Benjamin Whichcote to be the first exponent of the Cambridge school. The most important exponents are Ralph Cudworth and Henry More (Cassirer, 1970: 8, 26). This Platonism thus goes back to what Frances A. Yates called '*occult philosophy*' (Yates, 1979: 1, 17).

[8] Again: it would be wrong to switch '*presence in space*' with '*extension*'.

> So the duration of anything in time and its presence in space - the defining characteristics of which is extension - are to be said to characterize it's actual 'quantity of existence'. (Ibid.).

Contingent entities (e.g. trees or humans) have a finite quantity of existence with regard to their individual times and spaces. Only god has an infinite quantity of existence: he is omnitemporal and omnipresent.

Tempus et Locus

I now turn to *Tempus et Locus* (1692-1693). This text is part of several revisions of the first edition of the *Principia* (1687). As the reader can notice *Tempus et Locus* was written some 5 or 6 years after the first edition of the *Principia*. Newton wrote:

> Time and Place are common affections of all things without which nothing can exist. All things are in time as regards duration of existence, and in place as regards of amplitude of presence. And what is never and nowhere, it is not *in rerum natura*. (McGuire, 1978: 117).

We can easily trace parallels with *De gravitatione*. The importance of this text is that Newton explicitly examines the relation between time and space on one hand and god on the other. In one fragment he contrasts several opposite opinions on divine nature in reference to space. He always chooses the second half of each disjunction. I cite the entire fragment:

> Let them consider whether it is more agreeable to reason that God's eternity should be all at once *(totum simul)* or that his duration is more correctly designated by the names Jehovah and "he that was and is and is to come"; that the substance of God is not present in all places, or that the Jews more correctly call God Place, that is the substance essential to all places in which we live and (as the Apostle says [Acts of the Apostels 7: 27-28][9]) move and have our being; that God is everywhere as regards power and nowhere as regards substance, or that God's power should subsist everywhere in the divine substance as its proper substrate, and exists nowhere separately, and have no

[9] My insertion.

> medium by which it be propagated from its proper substance into external places; and that place itself and thus the omnipresence of God was created in finite time, or that God was everywhere from eternity; that all the properties created things are argue imperfections to the extent that they are absolutely removed from God, or that creatures share so far as possible the attributes of God as fruit the nature of the tree, and an image the likeness of man, and by sharing tend towards perfection, and to that extent God be discerned in the more perfect creatures as in a mirror; that the more perfect God is he who produces the more imperfect and fewer creatures, or that produces more perfect and countless ones; that the creator's power is infinite, and the possibility of creating only finite, or that the power of God in no wise extends to that what is impossible; that a dwarf-god should fill only a tiny part of infinite space with this visible world created by him, or that the best and greatest God willed everywhere what was good and did everywhere what he willed. (McGuire, 1978: 121, 123).

Allow me to paraphrase. God's existence is omnitemporal and omnipresent. He is substantially present everywhere and his intervention is direct and without intermediary.[10] He is not a 'dwarf god' somewhere lost in infinite space, but a universal ruler, a pantokrator (Manuel, 1974: 16). While some aspects recall of *De gravitatione, Tempus et Locus* already refers to the theological ethos in the *Scholium Generale* of 1713.[11] In *Tempus et Locus* Newton wrote the following on the epistemological status of (absolute) time and space:

> Time and Place in themselves do not fall under the senses, but are measured by means of sensible things, such as magnitudes of bodies, their positions, local motions, and any changes uniformly made. (McGuire, 1978: 117).

As we will see in a moment this sentence also refers to the *scholium* on space and time in the *Principia*.

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[10] We shall see in section 3.1. that there remains a certain tension with regard to the cause of gravitation between a god which acts directly and a god who acts by means of an intermediary.

[11] In the *Scholium Generale* Newton writes: 'In him all things are contained and move, but he does not act on them nor they on him.' (Newton, 1999: 941).

The Principia

The *scholium* on space and time may pose some difficulties when one considers it as such. I indicate the *scholium* is already included in the first edition and remained untouched in the following editions (Gjertsen, 1986: 471). I quote the most important part. Newton wrote:

> Thus far it has seemed best to explain the senses in which less familiar words are to be taken in this treatise. Although time, space, place and motion are very familiar to everyone, it must be noted that these quantities are popularly conceived solely with reference to the objects of sense perception. And this is the source of certain preconceptions; to eliminate them it is useful to distinguish these quantities into absolute and relative, true and apparent, mathematical and common.
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> 1. Absolute, true, and mathematical time, in and of itself and of its own nature, without reference to anything external, flows uniformly[12] and by another name is called duration. Relative time, apparent, and common time is any sensible and external measure of duration by means of motion; such a measure - for example a month an hour a day - is commonly used instead of true time.
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> 2. Absolute space[13], of its own nature without reference to anything external, always remains homogeneous and immovable. Relative space is any movable measure or dimension of this absolute space; such a measure or dimension is determined by our senses from the situation of space with respect to bodies and is popularly used for immovable space, as in the case of space under the earth or in the air or in the heavens, where the dimension is determined from the situation of the space with respect to the earth. Absolute and relative space are the same in species and in magnitude, but they do not always remain the same numerically. For example, if the earth moves, the space of our air, which in a relative sense and with respect to the earth always remains the same, will now be one part of the absolute space into which the air passes, now another part of it, and thus will be changing continually in an absolute space. (Newton, 1999, Definitions: 408-409).

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[12] This characterisation of time was influenced by Isaac Barrow's (1630-1677) (Burtt, 1967: 144f).

[13] Henry More had already attacked Descartes' doctrine of the relativity of motion, holding that an absolute, homogeneous, unchanging space was presupposed by motion and measurability (Burtt, 1967: 139).

As mentioned above: when one reads this fragment *'an Sich'* it is relatively difficult to unravel Newton's conception.[14] Nevertheless two things catch the eye. First of all Newton spoke of 'true time'. If time is merely representational why call this imaginary time 'true'? Secondly: he wrote on absolute space as 'immovable'. The question is how a purely mathematical and theoretical space can be ascribed the predicate 'immovable'. The problem seems to disappear when one supposes that Newton is merely talking metaphorically. This is an option I wish to reject. We – luckily – do not have to limit ourselves to internal arguments. When we take into account de dating of *De gravitatione* – written before the *Principia* – and *Tempus et locus* – written after the *Principia*, all doubt vanishes. Newton's conception has to be the same as in the texts above. Some sentences in the *Scholium Generale* (1713) also gain much clarity:

> He is eternal and infinite, omnipotent and omniscient, that is he endures from eternity to eternity, and he is present from infinity to infinity; (...) He is not eternity or infinity but eternal and infinite; he is not duration and space, but he endures and is present. He endures always and is present everywhere, and by existing always and everywhere he constitutes duration and space. (...) God is one and the same God always and everywhere. He is omnipresent not only virtually but also substantially; for action requires substance. (Ibid.: 941).

This is the only passage in the *Principia* where Newton links up god on the one side and space and time on the other: god constitutes space and time. *Nihil novi sub sole.*

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[14] I also wish to stress the 'platonic method' Newton used to arrive at such an absolute space. He wrote: 'But since these parts of space cannot be distinguished from one another by our senses, we use sensible measures in their stead. For we define all places on the basis of the positions and distances of things from some body that we regard as immovable, and then we reckon all motions with respect to these places, insofar as we conceive bodies as being changed in a position with respect to them. Thus, instead of absolute places and motions we use relative ones, which is not inappropriate in ordinary human affairs, although in philosophy abstraction from the senses is required.' (Newton, 1999: 411). This is indeed, as Burtt once noted, 'a peculiar observation from a philosopher of sensible experience' (Burtt, 1967: 243).

2.2 Intermezzo: time as an actual existent

I will now concentrate on an incompleteness in McGuire's analysis. The reader probably noted the asymmetry between space and time. Absolute space is easily visualised or ontologically interpreted – this is the reason why I will elaborate more on space in section 3. This seems not to be the case for absolute time. Time conceived as a thing – it is, however, difficult to do this – is a *nunc stans* ('an eternal now'), thus a single, isolated moment and not the process of time as such. Time is conceived by Newton as 'a mathematical *continuum'*, extending from the infinite past to the infinite future' (Burtt, 1967: 261).[15] Absolute time is more like an objective process in nature[16]; whereas absolute space is a true 'actual existent', i.e. *a kind of* thing. McGuire does not mention this difficulty/asymmetry. Sklar, however, does:

> It is bad enough to think of space itself as a kind of thing, like a meter stick or table against which comparisons can be made. Thinking of time as kind of quasi substance in this way seems even less intuitive to us. (Sklar, 1990: 63).

How do we know that Newton also had this asymmetry in mind? There is a – in my opinion – convincing argument for this. As I hinted in a footnote Isaac Barrow influenced Newton's view on time. For Barrow absolute time was no true existent. In his *Lectiones Geometricae* he wrote:

> Just as there was space before the world was founded, and even now there is an infinite space beyond the world (with which God co-exits) (...) so before the world and together with the world (perhaps beyond the world) time was, and is; since before the world arose, certain

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[15] This does not, off course, imply that Newton defended a *representational view of time.* This mathematical *continuum* is an objective process in nature. In this sense it really exits. In a *representational view of time* the mathematical *continuum* is invented by humans – it is not an objective feature of reality.

[16] As Bas Van Fraassen puts it: 'If time flows on its own, even tenor, independent of the physical world (...), then its topological structure is independent of world history.' (Van Fraassen, 1985: 60).

> beings were able continually to remain in existence [God and the angels presumably], so now things may exit beyond the world capable of such permanence. (...) Time therefore, does not denote an actual existence, but simply a capacity or possibility of permanent existence; (...) But does not time imply motion? Not at all, I reply, as far as its absolute, intrinsic nature is concerned; no more than rest; the quantity of time neither depends on neither essentially; whether things run or stand still, whether we sleep or wake, time flows in its even tenor. (Quoted from Burtt, 1967: 150).

Newton's assertion that 'time flows uniformly' is surely a reference to Barrow. Moreover, Newton wrote in the *Principia* that 'duration or perseverance of existence of things is the same' (Newton, 1999: 410).

2.3. The *Opticks* and the Leibniz-Clarke correspondence

Newton remained faithful to his conceptions on space and time at least to 1717. Proof of this can be found in the Leibniz-Clarke correspondence[17] and in *Opticks*. There may be a problem with the Leibniz-Clarke correspondence: how do we know with certainty that it expresses Newton's view? I do not see much problems with this.[18] Clarke was once described by William Whiston (1667-1752) as Newton's 'bosom friend'. He also translated Newton's scientific works (among which a

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[17] In a letter through Abbé Conti, Leibniz (1646-1716) had indicated his objections to Newton's *systema mundi*. Newton was probably distracted by the '*priority debate*' (= the debate on who was first to invent (or discover) calculus) and he did not respond - he did however note down Leibniz's objections. Caroline, *Princess of Wales*, who had received a similar list from Leibniz, ordered Samuel Clarke (1675-1729) to respond and to protect Newton's system. This famous correspondence took place from November 1715 until October 1716. Leibniz never was able to respond to Clarke's final letter: he died in 1716 (Westfall, 1998: 778; Gjertsen, 1986: 300-304).

[18] One indication might be this: Princess Caroline ensured Leibniz that the letters written by Clarke were not done so 'without the advice of the Chevalier Newton' (Alexander, 1970: 193). According to Koyré and Cohen Clarke's opinion and converges with that of Newton (Koyré & Cohen, 1961: 561). Manuel insists that although the concrete elaboration of the arguments were made by Clarke, Newton's dialectical abilities certainly can not be underestimated (Manuel, 1974: 76). Perl states that Clarke was 'a fairly reliable Newtonian on questions of theology' (Perl, 1969: 523). Westfall points out that Newton could not have been other than 'seriously interested' (Westfall, 1998: 779).

translation in Latin of the *Opticks*) and he lived within walking distance of Newton's house in London (Gjertsen, 1986: 117). Newton was not just accused of a tiny *lapsus*: he was accused of no less than atheism (Manuel, 1974: 77), *nota bene* by the man who already put him through the hoops in the priority debate. Leibniz was, as is well-known, a supporter of a relational theory of space and time (Funkenstein, 1986: 87). According to Leibniz space and time do not exist *an Sich*. They are not substances (Cassirer, 1970: 152). Statements on absolute time and space are meaningless: there is no criterion by which it is possible to distinguish an absolute movement from a relative one (Alexander, 1970: xxvi). There are two themes in the correspondence which are relevant to us: (1) space as a '*sensorium Dei*' and (2) the actual status of space and time. In his first letter Leibniz reacts to the assertion of Newton in the *Opticks* that space was an organ of god – '*sensorium Dei*' – of which god makes use to perceive all things.[19] From this it should follow that god actually needs an organ and thus is dependent of it. *Exit* divine omnipotence. Clarke responded to all this as follows:

> Sir Newton doth not say that space is the organ which God makes use of to perceive things by, nor that he has need of any medium at all whereby to perceive things; but on the contrary, that he, being, omnipresent, perceives all things by his immediate presence to them, in all space wherever they are, without the intervention or assistance of any organ or medium whatsoever. In order to make this more

[19] This is connected with the following unhappy coincidence. Some versions of the second Latin edition of the *Opticks* (1706) in *Query* 20 – in the later editions *Query 28* – stated 'Annon spatium universuum, sensorium est entis incorporei, viventis, et intelligentis?' (Cohen & Koyré, 1961: 555-566; Gjertsen, 1986: 301, 413). Newton probably realised the enigmatic character of this sentence – he did not give any further explanation. In the other versions of the second edition he added '*tanquam sensorio suo*'. In the English version this change remained – I quote from the fourth edition of 1730: 'And these things being rightly dispatch'd, does it not appear from Phaenomena that there is a Being incorporeal, living , intelligent, omnipresent, who in infinite Space, as it were in his Sensory, sees the things themselves intimately, and throughly perceives them, and comprehends them wholly by their immediate presence to himself: Of which things the Images only carried through the Organs of Sense into our Sensoriums, are there seen and beheld by that which in us perceives and thinks.' (Newton, 1979: 370). There are thus versions of the second edition without the addition of '*tanquam*'. Unluckily Leibniz had such a version.

> intelligible, he illustrates it by a similitude: that as the mind of the man, by its immediate presence to the pictures or images of things formed in the brain by means of the organs of sensations, sees these pictures as if they were the things in themselves, so God sees all things by his immediate presence to them, he being present to all the pictures of things themselves, to all things in the universe, as the mind of the man is present to all the pictures of things formed in the brain. (...) And this similitude is all that he means when he supposes infinite space to be (as it were) the *sensorium* of the omnipresent being. (Alexander, 1970: 12-13).

Newton only uses a metaphor. The aim of the metaphor was to explain how god is omnipresent in space. Let us now turn to the second theme. In the third letter we find an answer that is very Newtonian in spirit:

> Space is not a being, an eternal and infinite being, but a property, or the consequence of the existence of a being infinite and eternal. Infinite space is immensity, but immensity not God, and therefore infinite space is not God. Nor is there any difficulty in what is here alleged about space having parts. For infinite space is one, absolutely and essentially indivisible. And suppose it parted is a contradiction in terms, because there must be space in the partition itself, which is to suppose it parted and yet not parted at the same time. The immensity or omnipresence of God is no more a dividing of his substance into parts than his duration or continuance of existing is a dividing of his existence into parts. (Ibid.: 31-32).

Gradually Leibniz asked for more explanation. This followed in Clarke's fourth letter of June 26th, 1716:

> Space is not a substance, but a property; and if it be a property of that which is necessary, it will consequently (as all other properties of that which is necessary must do,) exist more necessarily, (though it be not itself a substance,) than those substances themselves which are not necessary. Space is immense, and immutable, and eternal; and so is duration. Yet is does not at all from hence follow, that anything is eternal *hors de Dieu*. For space and duration are not *hors de Dieu*, but are caused by, and are immediate and necessary consequences of his existence. And without them, his eternity and ubiquity (or omnipresence) would be taken away. (Ibid.: 47).

And further:

> Space is the place of all things, and of all ideas: just as duration is the duration of all things, and of all ideas. (Ibid.:50).

In the fifth letter of October 29th, 1716, Clarke added this:

> The Space occupied by a body is not the extension of the body; but an extended body exists in that space. (Ibid.: 103).
> (...)
> (...) his [God's] existence causes space and time. And when according to the analogy of vulgar speech, we say that he exists in all space and in all time; the words mean only that he is omnipresent and eternal, that is, that boundless space and time are necessary consequences of his existence; and not that space are beings distinct from him, and IN which he exists. (Ibid.: 104).
> (...)
> In the consideration whether space be independent upon matter, and whether the material universe can be infinite and moveable, the question is not concerning the wisdom and will of God, but concerning the absolute and necessary truth of things. If the material universe CAN possibly, by the will of God, be finite and moveable; (which this learned author [=Leibniz] here finds himself necessitated to grant, though perpetually treats it as an impossible supposition;) then space, (in which that motion is performed,) is manifestly independent upon matter. But if, on the contrary, the material universe cannot be finite and moveable, and space cannot be independent upon matter; then (I say) it follows evidently, that God neither can nor even could set bounds to matter; and consequently the material universe must not only be boundless, but eternal also, both *a parte* and *a parte* post, necessary and independently on the will of God. (Ibid.: 108).
> (...)
> The existence of God (...) causes space; and in that space all other things exist. It is therefore the place of ideas likewise; because it is the place of the substances themselves, in whose understanding ideas exist. (Ibid.: 108-109).

Again, nothing new under the sun. To conclude: if we compare *De gravitatione*, the *Principia Tempus et Locus*, the Leibniz-Clarke correspondence, and the *Opticks* with each other, the similarities

immediately compel attention. I sum them without further comment:
(1) Time and space are infinite;
(2) Space is not literally a *sensorium Dei*;
(3) Time and space are extra-mental entities: they exist independent of human conception;
(4) Space and extension are not identical hence there – literally – is also room for immaterial entities in space;
(5) God does not coincide with space nor time;
(6) Time and space are a consequence of the existence of god and *vice versa*; they are logically speaking equivalent and
(7) Space and time are properties which characterise entities *qua* being.

If one only considers the *Principia an Sich* it is a bit of a guess whether time and space are to be conceived ontologically. If one puts together the pieces, a coherent view emerges. So Dobbs and McGuire are absolutely right in asserting that *De gravitatione* is not just a youthful work. McGuire stresses that Newton's conception has a double status: an *epistemological* one and an *ontological* one (McGuire, 1995: 4-5). All sensible entities we grasp, exist in some time interval and in a certain place. We grasp them as being in a relative time and place. Relative time and space are the subject of sensory perception. They are quantitative measures through which we can conceive absolute space and time. Absolute space and time can not be the subject of direct sensory perception:

> They constitute the foundation for the intelligible order existing beyond the varieties of direct experience. Nevertheless, according to Newton, the mind is able to understand the infinite characteristics of absolute space and time, even though it may never have completely adequate grasp of all that is intelligible in this respect. In any event, relative measures of space and time should not be confused with their real natures.(Ibid.: 5)

This would mean that one confuses the 'real qualities' with 'their relations and sensible measures' (Ibid.). Absolute time and space are independent of human cognition and precede it. They are even more real than the relative space and time we know. Secondly, there is the ontological status. Entities in the world are separated from space and

time. Space and time are 'actual existents'.[20] As we have seen McGuire's analysis provides a strong case for an ontological interpretation of space and time. His analysis can be strengthened with further material.

3. The Onto-theological Network

3.1. Matter and Active Principles

In this section we start exploring Newton's *onto-theological network*. The most important feature of this network is that all fundamental entities are somehow caused or preserved by god. I begin with the relation Newton saw between matter and god. Newton often emphasised the passivity of matter (Dobbs, 1991: 80, 116). The reason for this is that he wished to seek the cause of activity outside matter, in the so called *active principles* (McMullin, 1978: 29). These principles are ultimately associated with the divine. Ernan McMullin points out two reasons why Newton sees nature as relatively passive:

> (1) The first reason was the matter-spirit dichotomy, so dominant in the neo-Platonic and the alchemical traditions, both very influential in shaping Newton's thought. "Spirit" was characterised as the cause of all movement. (...) 'Matter' was for him, first and foremost, an contrasting term with 'spirit', the latter being understood rather broadly to include not only God but also the natural agencies responsible for the "violent" motions of chemical and electrical action and even, perhaps accelerated motion in general. (...) Newton represents the spirit-matter relation at times as a sort of spectrum. (...) he is thinking of a continuum of possible blends in which the level of activity corresponds to the degree of "spirit".
> (2) The second consideration which may have influenced Newton in his decision to make matter as inert a principle as a consistent mechanics would allow was specifically theological in its inspiration. He believed the Christian doctrine of Creation to imply the total dependence of the world on God's activity, and he is often tended to interpret this to

[20] Of course, as mentioned in 2.2., time is more like a process; space more like a substance.

> mean that the activity in the world had to come directly from God, without any secondary intermediary.(Ibid.: 54-55).

In *Query* 31 of the *Opticks* Newton wrote:

> It seems to me farther that these Principles have not only a *Vis Inertiae*, accompanied with such passive Laws of Motion as naturally result from that force, but also that they are moved by certain active Principles, such as is that of Gravity, and that of which causes Fermentation, and the Cohesion of Bodies.(Newton, 1979: 401).

And somewhat earlier he wrote:

> For we meet with very little Motion in the World, besides what is owing to these active Principles. And if it were not for these Principles, the Bodies of the Earth, Planets, Comets, Sun, and all things in them, would go cold and freeze, and become inactive Masses; and all of Putrefaction, Generation, Vegetation and Life would cease, and the Planets and Comets would not remain in their Orbs. (Ibid.: 399-400)

One notices that Newton mentions *micro-level* (*'Putrefaction, Generation, Vegetation'*), *meso-level* (*'Bodies of the Earth'*), and *macro-level* (*'Planets, Comets, Sun'*). On all levels active principles hold matter together. Newton has associated various different processes in nature with these principles. Henry More taught Newton the theological implications of Cartesianism (Koyré, 1968: 110-124; Westfall, 1998: 304; Gjertsen, 1986: 369-370; Dobbs, 1991: 33). As mentioned above More was an exponent of Renaissance neo-Platonism, which is typified by a hylozoistic, vitalistic conception of nature opposite to that of mechanicism.[21] Mechanicism could not offer place for the divine *in*

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[21] McMullin makes an interesting reconstruction of Newton's train of thought. Two premises are of importance – I also give the consequences: '(P1) Bodies cannot act at a distance upon one another without the aid of an intermediary. (P2) Matter cannot of itself be the source of new motion. It follows that on the basis of either P1 or P2 that apparent motions at a distance can be explained only by postulating the agency of non-material entities (e.g. direct divine action, non-material entities acting at a distance, a non-material medium) to transmit action.' (McMullin, 1978: 101).

rerum natura, because of the equation of extension with matter. God is '*nullibi*': 'nowhere'. More therefore called Réné Descartes a '*nullibist*' (Cassirer, 1970: 149; Koyré, 1968: 138). In the final paragraph of the *Scholium Generale* Newton linked these principles with electricity and light:

> A few things could now be added concerning a certain very subtle spirit pervading gross bodies and lying hidden in them; by its force and actions, the particles of bodies attract one another at very small distances and cohere when they become contiguous; and electrical bodies act at greater distances, repelling as well as attracting neighbouring corpuscles; and light is emitted, reflected, refracted, inflected, and heats bodies; and all sensation is excited, and the limbs of animals move at command of the will, namely, by the vibration of this spirit being propagated through the solid fibers of the nerves from the external organs of the senses to the brain and from the brain into the muscles. But these things cannot be explained in a few words; furthermore, there is not a sufficient number of experiments to determine and demonstrate accurately the laws governing the actions of this spirit. (Newton, 1999: 944).

On a another place he wrote:

> For, from the forces of gravity, of magnetism, and of electricity, it is manifest that there are various kinds of natural forces, and that there are still more kinds not to be rashly denied. It is very well known that greater bodies act mutually upon each other by those forces, and I do not clearly see why lesser ones should not act on one another by similar forces. (Quoted in McMullin, 1978: 51).

One sees how Newton linked *active principles* with processes like electricity, magnetism[22], gravitation, cohesion, chemical processes, processes in the brain, free will, and light. Their activity is of the same

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[22] Very well known in this area is *De Magnete* (1600) of William Gilbert (1544-1603). Gilbert saw magnetism not just as some process of nature, he saw it as the key to unravel the mysteries of nature. This book is a clear expression of Renaissance-vitalism and it can be considered the complete antipode of mechanicism. Descartes, later, tried to provide a mechanical explanation for magnetism (Westfall, 1984: 25, 28, 37; Koyré, 1968: 131).

order.[23] Finally, these principles are connected with the activity of god (McGuire, 1995: 226-227). It was theologically unacceptable for Newton that these principles were internal or essential features of matter. Activity is a divine prerogative (Dobbs, 1982: 524). I will now elaborate on this by means of Newton's reflections on gravitation. We shall see that what counts for gravitation also counts for other analogue processes *salva veritate*. An important question for Newton and his contemporaries was whether gravitation is an essential property of matter. In a famous passage he declared[24]:

> You sometimes speak of Gravity as essential and inherent to Matter. Pray do not ascribe that Notion to me; for the Cause of Gravity is what I do not pretend to know, and therefore would take more time to consider it. (Cohen, 1978: 258).

The reason is evident: if gravitation is an essential feature of matter then matter is self-acting (McMullin, 1978: 104; McGuire, 1995: 239) – but also more chaotic:

> It is inconceivable that inanimate brute matter should, without the mediation of something else which is not material, operate upon and affect other matter without contact, as it must be, if gravitation (...) be essential and inherent in it. And this is the reason why I desired you not ascribe innate gravity to me. (Cohen, 1978: 302-303).

As a consequence of this, god (or other immaterial things) would be superfluous to explain the behaviour of matter. Put differently: if gravitation were essential to matter then no (immaterial) intermediary or agent is needed in order that two bodies attract each other 'at a distance' (McMullin, 1978: 59).[25] On July 16th, 1717, Newton declared in the *caveat* of the second edition of the *Opticks*:

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[23] Home however states that Newton defended a mechanical approach to electricity. (Home, 1985: 108).

[24] Newton also expresses this point of view in the *Principia* (Newton, 1999: 796). For a recent analysis see Henry, 1994.

[25] Koyré, however, always maintained that Newton could not agree with the idea of '*action at a distance*' (Koyré, 1970: 16).

> And to shew that I do not take Gravity for an essential Property of Bodies, I have added one Question concerning its cause, chusing to propose it by way of a Question, because I am not satisfied about it for want of Experiments. (Newton, 1979: cxxiii).

How does gravitation hold matter together so that nature does not turn into pure chaos? Newton pondered on different possibilities. None of them seemed to have fully satisfied him. In the period before the *Principia* Newton proposed two solutions. The first was god himself (McMullin, 1978: 76; Dobbs, 1988: 59). In *De gravitatione* Newton indeed declared:

> they [bodies] are moved by Him much as our minds move our bodies. (Hall & Hall, 1978: 141).

The second solution was a kind of mechanical ether.[26] In *The Hypothesis of Light* of 1675 his conception of the ether seems to be more spiritualized (Dobbs, 1991: 103; Rossi, 2001: 220). He spoke of an 'aethereal spirit' (McMullin, 1978: 77). In 1678-9 we can again find a more mechanical approach to the ether (Dobbs, 1991: 118). During the period of the *Principia* Newton saw four solutions – McMullin speaks of '*an ontology for the Principia*' (McMullin, 1978: 79). First in line is again the ether – this time no longer mechanical. Second is light – this is, of course, again linked up with neo-Platonism – which served as a kind of *fons vitae* (Ibid.: 94). Third is an 'active spirit'. Last in line is god himself. After the *Principia* we can trace two solutions: *primo* an omnipresent 'penetrating force of spirit' and *secundo* an 'electrical spirit'. From 1707 on Newton was enormously fascinated by electricity. This was a direct consequence of a series of electrostatic experiments which were performed by Francis Hauksbee (1670-1713) in that year at

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[26] Newton's conception of the ether in his early years is probably influenced by Descartes (Dobbs, 1991: 92). In 1669 the first active principle emerges: '*the mercurial spirit*'. This is probably a consequence of Newton's reading of Henry More – mainly *The Immortality of the Soul* (1659) – and Ralph Cudworth – author of *The True Intellectual System of the World* (1678) (Dobbs, 1991: 93-94).

The Royal Society.[27] The influence can be traced in the *Scholium Generale* of 1713 and the *Queries* of the *Opticks*. The active ether is:

> a substance in which bodies move and float without resistance[28], and which has therefore no *vis inertiae* but acts by other laws than those that are mechanical. (McMullin, 1978: 96).

Newton often associated electricity with light (Dobbs, 1991: 220).

3.2. God, Matter and Space

In the previous part I discussed the relation Newton saw between matter and god. But how did matter come into being? In the article *Space, Infinity, and indivisibility: Newton on the Creation of Matter* McGuire describes Newton's view on this subject (McGuire, 1982: 145-190). We shall see that space is the *container* in which all things come into being. I will make a distinction between the moment during the genesis and the moment after the genesis.
(1) God created matter *ex nihilo* (McGuire, 1995: 216). Newton begins with the statement that space is infinite, perennial, and immovable. As we have seen above space is 'co-eternal' with god and it contains 'an infinitude of different kind of volumetric figures' (McGuire, 1982: 172). These figures structure space:

> if space were totally unstructured, ultimately it would be unintelligible to the human mind, since it would lack the geometrical determinateness

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[27] Hauksbee was a student of Robert Boyle. Although he never achieved Fellowship, he acquired an official position at the *Royal Society:* he was demonstrator from 1703 until his death in 1713. One of these experiments consisted in rubbing a glass jar, out of which all air was removed with a *vacuum* pump, until sparks appeared. (Gjertsen, 1986: 252-253). On the impact of these experiments on Newton there is consensus between Newton scholars (McMullin, 1978: 94-97; Westfall, 1998: 684-686; Dobbs, 1991: 222; Cohen, 1999: 281). Cohen added in his introduction to his recent critical edition of the *Principia* an unpublished manuscript in which Newton expresses his enthusiasm for electrical phenomena (Newton, 1999: 287-292). Hauksbee was replaced in 1714 by J.T. Desaguliers (Westfall, 1998: 685).

[28] In the second edition of the *Principia* (1713) Newton mentions '*a non resisting aether*' (Newton, 1999: 446).

> appropriate to the form of being that it is. (Ibid.)

God is the *'spiritual tonic'* who injects life into these spatial figures (McGuire, 2000: 291). This happens *voluntate Dei:*

> Divine power conditions omnipresent figures in the uncreated extension of space, so that each is a causal ground necessary and sufficient to produce those perceptions of properties which the mind contributes to the nature of corporeal phenomena. (McGuire, 1982: 147).

God stimulates directly our sensory perception.[29] Newton has a – from our modern point of view – naive view on visual perception: external objects cause movement in our eyes, which are in their turn passed on to the nerves in our brains and finally result in images in our head (Tammy, 1979: 54.) Matter ('corporeal extension') is contingent; it exits *gratia Dei*.[30] God can influence certain regions in infinite (absolute) space in such a way that the figures (also see section 5) inherent to space cause sensory perception. What was invisible is made visible by god. God activates matter. We can however not grasp the true nature of matter (Westfall, 1998: 303). As we have seen, matter is not identical to space:

> spaces are not very bodies themselves but are only the places in which bodies exist and move. (Hall & Hall, 1978: 148).

Regions in (absolute) space can never be numerically identical. In other words:

> God's informing region x with b at t, and region y with b at t_1, does not entail the identity of x with y. (McGuire, 1982: 179).

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[29] Compare with: 'For it is certain that God can stimulate our perception by his own will, and thence apply such power to the effects of his will.' (Hall &Hall, 1978: 139).

[30] Compare with: 'Now that extension has been described, it remains to give an explanation of the nature of body. Of this, however, the explanation must be more uncertain, for it does not exist necessarily but by divine will, because it is hardly given to us to know the limits of the divine power, that is to say whether matter could be created in one way only, or whether there are several ways by which different beings similar to bodies could be produced.' (Ibid.: 138).

How does the materialisation of these figures take place? What is the relation between these figures and sensory perception? These are two questions which emerge in Newton's *onto-theological scheme*. I begin with the first question. We can never fully understand how god does this materialisation. There is however one similar process: the way our mind moves our body. We do not know how we do this, we just know we do. Now for the second question. Uncreated and infinite space can be considered as the *'receptacle'* where god creates all things (Ibid.: 177; McGuire, 1998: 279). Newton's vision is therefore rather Platonic:

> Thus in the spirit of Plato's Timaeus Newton conceives the reality of structured space as an eternal and unchanging matrix into which Divine will impresses the form of matter. And consequently he rejects what is the scholastic version of Aristotle's doctrine of first matter as that undifferentiated thing out of which informed individuals are said to come to be. (McGuire, 1982: 177; also see McGuire, 1998: 280).

To conclude: infinite space is the ontological ground where the genesis of matter takes place.[31] Thus:

> instead of thinking in terms of "bodies", Newton thinks of space as a system of regions into which material features are ascribed by the divine will. Consequently, space's invisible figures are made manifest and become impenetrable physical realities. Newton conceives these "material features" as active powers able to bring about representations of bodies in the mind of the external presence of bodies. (Ibid.)

We can also conceive *De gravitatione* as a kind of cosmogony. Space is thus an independent entity.

(2) God not only created matter, he constantly vitalises it after the creation. In 3.1. I already referred to processes as gravitation, electricity, magnetism, etc. The precise way this takes place Newton never explained to his full satisfaction. Newton's ontology can be summarised as follows:

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[31] McGuire points out the following influence: 'Newton is also in the company of writers like Pierre Gassendi, Walter Charleton, Ralph Cudworth, and Blaise Pascal. These seventeenth-century writers, like the Stoics, the middle Platonists, Philoponus, and the sixteenthcentury writer Patrizi, hold that space and time are prior ontologically to the way of being of other created things.' (McGuire, 2000: 280).

> there exists God's active will along with created finite wills; and coexistent with Divine presence, as a co-principle of material creation, is uncreated extension whose inherent parts are endowable by God with active powers. Thus God, created wills and matter, qua powers, are active entities, all of which are distinguished from infinite extension. But it is extension, conjoined with active powers, that provides the causal basis for the mind's representation of both the primary qualities of matter, such as impenetrability, and sensations of colors, sound and touch. (McGuire, 1982: 177).

One notices Newton's voluntaristic conception of god.[32] Newton endorses the idea that the world could have been created differently.[33] *A priori* knowledge of nature is impossible. There even might be other worlds 'in other parts of space' (Funkenstein, 1986: 194).[34] For Spinoza, for example, knowledge of god was an *a priori* matter; for

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[32] For a general view: see Force, 1990. James E. Force has recently argued that one can not stress Newton's voluntaristic conception of god enough (Force, 2000: 257.) Westfall however denies a theological influence - he does not deny a 'religious' influence - on Newton's scientific work (Westfall, 1982: 139). According to Force both Newton's inductivism and his belief in miracles - two contradictory attitudes to our modern mind - can be explained by Newton's conception of god. If the world is created by a voluntaristic god, this world can only be know *a posteriori*. Hence the importance of induction. Because god maintains the laws of nature, he can also cause deviations of these laws. Miracles, however, do not occur as frequently as normal phenomena (Westfall, 1973: 203; Harrison, 1995: 544). Newton wrote: 'For miracles are so called not because they are the works of god but because they happen seldom and for that reason create wonder. If they should happen constantly according to certain laws (...) they would no longer be wonders or miracles.' (Quoted from Westfall, 1973: 203-204). In a letter to Thomas Burnet (1635-1715) in 1680 he wrote: 'Where natural causes are at hand God uses them as instruments in his works, but I doe no think them alone sufficient for ye creation & therefore may be allowed to suppose amongst other things God gave the earth it's motion by (...) degrees.' (Quoted from Ibid.: 43). Belief in miracles was not unusual for the *virtuosi*. Robert Boyle, e.g., also was a strong believer of miracles (Ibid.: 89). To put all this in other words: Newton's theology fits hand in glove with his epistemology.

[33] Compare with: '(...) and that if this world were not constituted from that creation, at least another very like it would be constituted.' (Hall & Hall, 1978: 145).

[34] Leibniz must have been horrified by this thought.

Newton such knowledge only can be founded *a posteriori.*[35] God is to a certain amount anthropomorphic – just think of the analogy between human and divine will.[36] Newton's notion of causality is influenced by this:

> efficient causality is inseparably connected with intentional action that leads to the realisation of conscious ends. (McGuire, 1982: 175).

He is 'a conscious agent, and infinitely capable of purposive action in the realisation of his intentions' (McGuire, 1982: 175). The difference between god and humans becomes merely quantitative (Funkenstein, 1986: 291): our will can do infinitely less than the infinite will of god. Compare this with:

> Since each man is conscious that he can move his body at will, and he believes further that all men enjoy the same power of similar moving their bodies by thought alone; the free power of moving bodies at will can by no means be denied to God, whose faculty of thought is infinitely greater more swift. (Hall & Hall, 1978: 139).

Also recall the term 'quantity of existence' which can be measured by the amount of space and time an entity respectively encloses or lasts.

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[35] Compare with: 'If God moves all things after the fashion in which the human body moves the parts of the human body, the "causes" of motion would seem to be permanently, out of the reach of the inductive method, which provisional "positivism" of the *Principia* in regard to causes would turn out to be the best that the "experimental philosophy" could do.' (McMullin, 1978: 84). And further: 'Newton accepted the necessity of going beyond the mathematical formalism of the *Principia* to give a causal account of gravitational and other motions. A straightforward positivist acsesis might suffice as a short term device, but it was certainly inadequate as a definitive position for someone who regarded himself as a natural philosopher.' (Ibid., p. 101).

[36] Compare with: 'Since each man is conscious that he can move his body at will, and believes that all men enjoy the same power of similarly moving their bodies by thought alone; the free power of moving bodies at will can by no means be denied to God, whose faculty of thought is infinitely greater and more swift.' (Hall & Hall, 1978: 138-139). And with: '(...) God may appear (to our innermost consciousness) to have created the world solely by the act of will, just as we move our own bodies by an act of will alone; and, besides, so that I might show that the analogy between the Divine faculties and our is greater than has formerly been perceived by Philosophers.' (Ibid.: 141).

3.3. God, Time and Space

In this subsection I wish to focus on the ontological and logical relationship between god and the existence of space and time. Recall the already quoted fragment from the *Scholium Generale*:

> He is not eternity and infinity, but eternal and infinite; he is not duration and space, but he endures and is present. He endures forever, and is present everywhere, and by existing always and everywhere, he constitutes duration and space. Since every part of space is always, and every indivisible moment of time is everywhere, certainly the Maker and Lord of all thing will not be never and nowhere. (Newton, 1999: 941).

He constitutes space and time. Time and space are not attributes of the essence of god (McGuire, 1990: 102). Newton wrote:

> when the Hebrews called God *MAKOM*, place, the place in which we live & move & have our being & yet did not mean that space is God in the literal sense. For they used to speak of God by figures and allusions & put space for his omnipresence by a figure. And so space & duration are by the writers of Logick and Metaphysics called quantities & with respect to God's ubiquity & omnipresence they have a nearer relation to the Predicaments of *Ubi* & *Quando* then to that of Quality & therefore where they are called Qualities the Reader is to understand it with a figure. (Quoted from McGuire, 1995: 13).

Space and time are *'modi'* of the way god exists.[37] However, this is no pantheism: god is not literally identical with infinite space nor time

[37] E.J. Dijksterhuis fits this position: 'The strong influence which Newton's religious ideas exercised on his scientific thoughts is revealed, among other things, in his belief in the existence of absolute space and absolute time. The former to him symbolizes God's omnipresence, the latter his eternity. By existing everywhere and always, He constitutes space and time. He is omnipresent not only virtually, i.e. through His influence, but also substantially.' (Dijksterhuis, 1969: 487).

(McGuire, 1990: 97).[38] Newton wanted to insert a god-pantokrator in the frame of nature. In order to be that he has to be able to be everywhere and always. In order to distinguish god from space he uses the Hebrew word '*MAKOM*'. Newton does not consider space and time as attributes nor substances.[39] Let us focus, for an instance, on the traditional dichotomy substance-attribute.[40] A substance is then considered as an independent entity, while the attributes are considered as dependent of the substance. So the substance, in this view, is ontologically prior to the attribute.[41] If all substances would be destroyed, then all attributes would cease to exits. Space and time would not cease to exit in Newton's view. They are thus ontologically prior. The ontology of substance and attribute is no full explanation of the cosmos. Time and space are independent of all phenomenal things:

> they simply characterize all being, whether it is substance, attribute or accident and are really distinct from existing things and independent of their natures. Their mode of predication is therefore external, as they are not properties which attach to the nature of things in virtue of inherence. Space and time are neither in a substance in the manner of its extension and shape, nor are they in things as parts are wholes and

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[38] Newton denies such explicitly: 'By reason of its eternity and infinity space will neither be God nor powerful nor alive, but will merely be increased duration and magnitude.' (McGuire, 1978: 119).

[39] This does not conflict with the fact that I earlier wrote that time and space are '*a kind of*' predicate and '*a kind of*' substance.

[40] Compare with: 'Perhaps it may be expected that I should define extension as substance or accident or else nothing at all. But by no means, for it has its own manner of existence which fits neither substances nor accidents.' (Hall & Hall, 1978: 131-132)

[41] Their is one difficulty here, however. For a defender of this vision a legitimate question is what we ought to understand under 'substance'. When one asserts that the substance is ontologically prior to the attributes, then the problem arises that it is epistemologically indeterminate. It speaks for itself that if there was no tree – our substance – there could be ascribed no predicates to it. The question is however was remains of our substance 'tree' if we strip him of all relations and attributes. It seems to be the case that we can not say anything about it. We can not give any content to our tree. The substance is supposed to be different from the properties which are ascribed to it, but that difference can not be characterised. So the 'bearer' of properties seems ontologically inescapable, but is epistemologically indeterminate.

> as a whole contains parts. Furthermore, they are not accidents or modes of existing things; for this allows that they exist only when finite things exist. (McGuire, 1978: 8).

They are not from the same order as 'apple' or 'prism'. They are the container in which all things exist. From that point of view they are 'a kind of' substance. Because they are the container in which all things exist, all phenomenal entities have to have the property – or put more precisely their 'being' has the property – of 'being in space and time'. This is a transcendental property. 'Being' is identical with 'being in space and time'. Hence they are 'a kind of predicate'. A predicate of higher order however.
McGuire writes:

> God's eternal existence is coeval with the existence of infinite space and time. They exist because God exists. In other words, built into Newton's conception of the actuality of existence is the claim that God necessarily possesses a nature that exists omnitemporally and omnipresently with respect to infinite space. (...) If Gods existence is therefore eternal and uncreated, and if all things including God must exist with respect to space and time to be actual existents, the fact of God's sheer existence 'constitutes' the existence of infinite space and time. They are the consequences of God's eternal existence. For if God did not exist, there would be no sufficient reason for their existence. (McGuire, 1995: 16)

Time and space are not intrinsic properties of god, but consequences of his existence (Koyré, 1970: 113; Tamny, 1979: 50). The existence of god and the existence of space and time imply one another. They are logically speaking equivalent: 'A' (=god) implies 'B' (=space and time) and *vice versa*. Newton wrote:

> If ever space had not existed, God at that time would have been nowhere; and hence he either created space later (in which he was not himself), or else, which is no less repugnant to reason, he created his own ubiquity. (Hall & Hall, 1978: 137).

Space, time and god are all infinite. Space and time are an infinite consequence of an infinite effect. God is everywhere and always. His

essence remains the same. If one accepts both premises it is not difficult to conclude that god is uncaused. As McGuire puts it:

> Divine existence is explained solely by reference to God's previous existence, since existing omnitemporally is an essential fact pertaining to God's unending and permanent duration. (McGuire, 1990: 99).

An entity which is always and everywhere and which is uncaused is finally necessary.[42] To conclude:

> But there is no contradiction in holding that an essential non-extended being is capable of so existing. On the contrary, to deny that it can is to think of God as an extended spirit. God is omnipresent in the sense that he remains numerically and unalterably the same individual at all places whatsoever. (McGuire, 1995: 38).

4. Newton's network versus Leibniz' and Descartes'

Newton's god is the biblical god who is directly present in his creation (Goldish, 1998: 92). He is therefore not a philosophical, impersonal or abstract god, nor an uninterested *prima causa* (Koyré, 1968: 229, 255). His essence stays the same in space and time:

> Thus on Newton's view, to specify God's permanent duration requires that he is [the] same individual at all times whatsoever. (McGuire, 1995: 29).

God literally exists in infinite space and time (Koyré, 1968: 226). This entails two things. First of all god necessarily exists on all places and at all times. Secondly, not only does he exist on all times and at all places, but he is also active everywhere and always. He can interfere always and everywhere. The power of god is thus not limited to the moment of creation - *potentia ordinata;* he is active in the created world after creation - *potentia absoluta*. He is really substantially present. Just

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[42] Compare with: 'Whatsoever necessarily exits, exists always and everywhere, since the law of necessity is the same in all places and all times.' (McGuire, 1978: 123).

consider this famous fragment of the *Scholium Generale*:

> He rules all things, not as the world soul but as the lord of all. And because of his dominion he is called Lord God Pantokrator [παντοκρατωρ]. For "god" is a relative word and has reference to servants, and godhood is the lordship of God, not over his own body as is supposed by those for whom God is the world soul, but over servants. The supreme God is an eternal, infinite, and absolutely perfect being; but a being, however perfect, without dominion is not the Lord God. (...) He is eternal and infinite, omnipotent and omniscient, that is, he endures from eternity to eternity, and he is present from infinity to infinity; he rules all things, and he knows all things that happen or can happen. (Newton, 1999: 941).

Descartes' god, who was not substantially present in his creation, is not the biblical one as Newton understood it. Leibniz' god is also an *intelligentia supra-mundana*, in stead of an *intelligentia mundana* (Koyré, 1968: 242). What should be noticed however is that for both Descartes, Leibniz and Newton god is the guarantee of the intelligibility en rationality of the world (Funkenstein, 1986: 193). Let me illustrate one more point for space. Newton wrote:

> What is here laid down seems to put an end to all those disputes and difficulties which have sprung up amongst the learned concerning the nature of pure space. But the chief advantage arising from this is , that we are freed from that dangerous dilemma, to which several who have employed their thought on the subject imagine themselves reduced, to wit, of thinking either that real space is God, or else that there is something beside God which is eternal, uncreated, infinite, indivisible, immutable. Both of which may be thought pernicious and absurd notions. It is certain that not a few divines, as well as philosophers of great note, have, from the difficulty they found in conceiving either limit or annihilation of space, concluded it must be divine. And some of late have set themselves particularly to show, that the incommunicable attributes of God agree to it. Which doctrines, how unworthy so ever it may now seem of the divine nature, yet I do not see how we can get clear of it, so long as we adhere to the received opinions. (Quoted from Koyré, 1968: 222).

If space is an '*affection of being*', than we escape the false dilemma

between pantheism (cf. Spinoza) and the statement that space is superior to god (cf. Leibniz' criticism). God and all entities are located in the same container of space and time. There are also formally – not just ontologically – on the same level. There exits a strong link between 'being omnipresent' and 'being necessary':

> That God cannot but exist at all possible times is a claim about his nature, not a claim about sheer existence omnitemporally. The latter claim is consistent with merely contingent existence. It is in virtue of its nature, then, that God is conceived as a necessary being, and that infinite time is a consequence of its existence. Now according to Newton's conception, God is a being who always has and always will exist. So it is natural enough that he should think of God's existence as not being caused. As there was never a time at which God's existence was preceded by anything else, he can be said to be an uncaused being. This means that he is causally independent of conditions, state-of-affairs, and circumstances external or other than his nature. Thus Divine existence at any given time is solely explained by reference to God's existence at an earlier time. So that God exists omnitemporally is a fact about his unending and permanent duration. (Quoted from Koyré, 1968: 222).

Because god has no beginning, he is causally independent, thus uncaused and thus necessary. Newton's conception of god – the Παντοκρατωρ – and his rejection of Descartes' *systema mundi* fit hand in glove. In order that god is able to act directly in his creation, he has to be able to act in space and time. In this way, Newton put god and all other entities in the same logical and physical field. Newton's god is to a higher extent secularised than a supra-temporal and supra-spatial god. Space is the meeting place between material and spiritual things, between the human and the divine (Cassirer, 1970: 149). Amos Funkenstein considers Newton's philosophy of nature as 'a secular theology in the sense that it was oriented ad seculum' (Funkenstein, 1986: 5). Problems in natural philosophy were also religious problems.[43] Besides their obvious

[43] Westfall notes on Newton's interest for theology: 'Newton's interest in theology was not a private idiosyncrasy but a reflection of a general problem that occupied nearly every scientist of the late seventeenth century and every thinking person beyond the scientific community.' (Westfall, 1987: 565).

physical meaning space and time – space e.g. has to be infinite in order to render Newton's first law valid – have theological meaning.[44] It appears to me that the direct introduction of god in the realm of nature was a clear step towards the *'Death of God'*. Or to state it more paradoxically: Newton's attempt to render god more close, brought god nearer to his end.[45] However, Newtonian metaphysics was, as I said, in origin religious. His conception of god is highly secularised. His conception is for example more secularised than Descartes' conception. As is well known, Descartes needs three different ontological levels to explain reality: *res cogitans*, *res extensa* and *deus*. In Newtonian metaphysics all of these exist *on the same level*. As we have seen space and time exist as real entities: so there is a strong dualism – in matter of fact a kind of Platonism – is Newton's thinking. The gulf between absolute space and time on the one hand and humans on the other seems to be greater, than the one between god and humans. Newtonian metaphysics can thus be seen as the expression of how religious attitudes adapted themselves, i.e. secularised themselves, to a world of growing complexity.[46] The goal of Newtonian science was not to dispose of

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[44] The general thesis of Funkenstein's book is indeed that the 'scientists' of the 17th century often defended scientific ideas by means of theological arguments and, *vice versa*, that their statements on the divine often had physical consequences. Both were intertwined. Funkenstein stresses that the Newtonian space and time is homogenous, absolute and infinite because of three important theological reasons. (This converges with the findings of McGuire.) Space and time are *homogenous* because *'the same forces can act everywhere in the same manner'*. In other words: in order that the laws of nature are valid everywhere. God is active always and in the same fashion. They are also *absolute* in order to suppose *'unequivocal causality'*: god's activity is then unequivocal. If temporal relationships were relative, then cause-effect relationships would also be. *Idem* for spatial relationships. They are *infinite* in order to be ascribed as predicates to god. God is no longer supratemporal, but omnitemporal. *Idem* for space. (Funkenstein, 1986: 90-96).

[45] Compare with: 'Secular Newtonianism was in fact destroying the religious-scientific world-view that Newton had created.' (Manuel, 1974: 49). (Also see Burtt, 1967: 261).

[46] Matt Goldish correctly stresses the religious crisis at the end of the 17th century. In that period the idea was abandoned that there could be no conflict between *'the Book of Nature'* and *'the Book of Scripture'*. This crisis expressed itself at three levels: a crisis (1) within the study of *'the Book of Nature'* (the traditional worldview was being replaced by a more 'scientific' worldview), a crisis (2) within the *'the Book of Scripture'* and,

religious beliefs; its aim was – in origin – to maintain and reinforce these religious beliefs by changing the conception of god. Hence Newton's tinkering with notions as 'space', 'time', 'being', 'infinity', etc. He was constructing a different, in my opinion more secularised, *onto-theological network*.

5. Afterthought

As we have seen Newton was not only a physicist, but also a metaphysician. When one puts together the scattered pieces it is fairly easy to reconstruct Newton's general view on space and time. One important evolution in Newton's train of thought is the 'secularisation of god'. Newton, then, was not only was a reformer in science, he also was a defender of a more 'rationalised', i.e. secularised, conception of god. As we have seen god and all other existing entities are on the same formal *and* physical level. God, space and time form the *onto-theological scheme* of reality. It is this metaphysical scheme that also underlies the *Principia*. Space certainly was conceived by Newton as an entity as such. Time is more like an objective process in reality extending from past, over the present, to the future. I hope that the reader by now realises that scientific problems were for Newton inseparable from *'onto-theological'* ones. Ultimately, Newton had only his god to blame for his troubles. To conclude on space and time:

> Hence to claim that space and time are reifications of Newton's quantities, or that absolute motion requires postulation of these entities, is to miss the fundamentally theological significance of Newton's reasoning. (McGuire, 1995: 39).

I could not agree more.

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finally, a crisis (3) concerning the relationship between both (e.g. *'What are the religious consequences of science?', 'Which has the greatest authority?'*) (Goldish, 1998: 2).

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