which is what is meant by "place". But that to which and from which we commonly observe things to move is itself mobile, whereas Aristotle has defined it as something immobile. That that to which and from which we commonly observe things to move is mobile can be seen in the light of ancient and modern science. We talk about the place of a man on a ship, perhaps of his cabin or of his chair as his place. When we think of him as going to or from a place we mean something like this. We consider him to remain in the same place while sitting in his chair even after the ship as a whole has sailed some distance over the earth (according to ancient science it has then moved relative to the universe as a whole). And in the course of the voyage when the man goes to and from each of these places we think of him as going to and from the same place in number throughout the voyage. Yet, as the ship is moved, the surface bounding the man while he is in his chair has been moved also. Now, according to Aristotle and St. Thomas, the place of the man before and after the ship has been moved must be different, for his position before and after the ship has been moved are different relative to the universe as a whole. Thus, what is commonly regarded as one and the same place in number (the same place in number to and from which a thing is moved) is to be regarded, according to the definition Aristotle has given us, not as one place but as different places as the voyage progresses. Certainly, those "places" to which and from which we observe bodies to move are commonly at rest relative to the earth. Yet, we now say that the earth is mobile. This makes those "places" mobile too. From these facts it seems plain that what we commonly mean by "place" is something mobile, contrary to the definition of Aristotle. In other words, he has not defined place but rather something else.

313. We cannot give a complete answer to this objection here. It will be taken up again more completely toward the end of the present work. But even here we can indicate certain aspects of the answer. When a container is moved, the contained body actually divided from it is moved _per accidens_, it is moved only from the fact that the container is moved. When the container has been moved, it has changed its place. The same thing is true of the body contained by it, only the contained body is moved _per accidens_. When the container is moved, the place of the contained body does not remain the same in number. The fact that it was the same body containing the one contained throughout the motion does not make the place of the contained body the same throughout the motion except materially. The proper place of the contained body remains the same in subject only, i. e. the surface which contained the contained body and is its place is the surface of the same containing body before and after the contained body is moved. But what is essential (i. e. what is true by virtue of the definition of place) is that, taken

as the place of the contained body, the surface containing this body is a different surface before and after the contained body is moved, whether or not the subject of the surface (i. e. the containing body) remains the same in number. Of course, the converse is also true, as we have already indicated.[1] It is entirely possible for the proper place of a thing to remain one in number though the container of the body be constantly moving past it.

314. Now, perhaps the answer to the objection can be understood. True, we think that the place of a thing remains one and the same in number when it remains in the same position relative to the ship, even though the ship is moving relative to the universe as a whole. We can now see three reasons for this. First, the place of the thing at rest with respect to the ship does remain one and the same in some respect even though the ship is in motion, i. e. it remains one and the same in number per accidens, i. e., in subject or materially. It is the same part of the ship which contains it during the entire voyage.

315. Second, as we have already hinted,[2] in order to distinguish one place from another, we must make reference to bodies. In the case of the man on the ship, the ship itself is the most convenient body of reference. Therefore,

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[1]Par. 247-251.
[2]Par. 238.

it is natural that while we are on the ship we should determine the unity or diversity of places by positions relative to the ship as a whole. The same thing is true of a thing on the earth. It is natural for us to determine the place of a thing on the earth by its position relative to the earth as a whole. But this does not mean that we conceive of place as being mobile, as a ship or the earth (being bodies) may be. Rather, we suppose place to be immobile, and we say that a place is one in number when it has a fixed position relative to these (the ship or the earth) because they seem to us to be immobile.

316. Third, from the fact that the proper place of a thing is changed only per accidens when its container is moved, the position of the proper place relative to the rest of the universe as a whole being changed only because its common place (the place of its container) is changed, it seems that the proper place is not changed at all. But this is false. The fact that the proper place of the man on the ship is changed only per accidens when the ship is moved does not mean that his proper place is not really changed. He has really changed his proper place but per accidens, i. e., because of the motion which is proper to the whole or container. His proper place is immobile relative to the universe as a whole.

317. In general, it must be remembered that our

original conception of place is very confused. The point is that we do not know exactly what place is by common knowledge. It is therefore not surprising that our original conception of place is such that from it one can be led to suppose all sorts of strange things. This is amply shown by the dialectical analysis preceding Aristotle's determination of the question. And this is the case with the belief that the place of a thing which remains at rest relative to a ship remains the same in number even though the ship itself is moved relative to the universe.

318. Our present analysis of Aristotle's treatment of place may be concluded by affirming that his definition has been shown to be the correct one, for he has shown that it is the only possible one. He has answered certain objections against it and we have attempted to answer others in the light of what he and St. Thomas have said. Though we must take exception to certain of the things Aristotle says in his treatise on place due to his ancient cosmology, it may be asserted that at least thus far no serious objections have been found to what is crucial to this section of his work, the definition of place. However, we will see below that there remain some very serious difficulties. These difficulties arise from the advance of modern science. Therefore, when we have concluded our analysis of Newtonian space we will reconsider the immobility of Aristotelean place.

NEWTONIAN SPACE

319. That Newton's conception of space is related in some way to Aristotle's treatise on place can easily be seen from the following remarks of Newton.

> Place is a part of space which a body takes up, and is according to the space, either absolute or relative. I say a part of space; not the situation, nor the external surface of the body. For the places of equal solids are always equal; but their surfaces, by reason of their dissimilar figures, are often unequal. Positions properly have no quantity, nor are they so much the places themselves, as the properties of places. The motion of the whole is the same with the sum of the motions of the parts; that is, the translation of the whole, out of its place, is the same thing with the sum of the translations of the parts out of their places; and therefore the place of the whole is the same as the sum of the places of the parts, and for that reason, it is internal, and in the whole body.[1]

We will not analyse these remarks immediately. We have presented them here only to indicate that Newton regards place as a kind of space. Having seen this in a general way, we will now consider Newton's conception of space. First we will consider certain distinctions Newton makes. Then we will consider in a general way how Newton attemps to establish the existence of a certain kind of space. In this way we

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[1] Newton, Mathematical Principles of Natural Philosophy, Scolium following definition 8 in book I, p. 6.

will both become familiar with what Newton means by space and also acquire a confused insight into the problem he is trying to solve. We can only proceed in this way because Newton does not define space. "I do not define time, space, place and motion, as being well known to all."[1] Thus, the only way we can manifest his conception of space while remaining close to his very words is by following the distinctions he makes and considering the justification he gives for them. Having acquired a knowledge of what Newton considers space to be, we will attempt to judge his opinion that place is a space by comparing his view with what we have previously discovered in considering Aristotle's treatise. Then, in the light of the additional knowledge we have acquired we will reconsider the immobility of Aristotelean place.

320. We will begin, as we have said, by considering certain distinctions which Newton makes. In describing space, he divides it into two kinds, absolute and relative.

> Absolute space, in its own nature, without relation to anything external, remains always similar and immovable. Relative space is some movable dimension or measure of the absolute spaces; which our senses determine by its position to bodies; and which is commonly taken for immovable space; such is the dimension of a subterraneous, an aerial, or celestial space, determined by its position in respect of the earth. Absolute and relative space are the same in figure and magnitude; but they do not remain always numerically the same. For if the earth, for instance, moves, a space of our air, which relatively and in respect of the earth remains always the same, will at one time be one part of the absolute space into which the

[1] Newton, <u>Mathematical Principles</u>, p. 6.

> air passes; at another time it will be another part of the same, and so absolutely understood, it will be continuously changed.[1]

They are distinguished in that absolute space is entirely immobile, whereas relative space is mobile. If we consider some dimension or set of dimensions as being one in number because it remains always the same relative to some given mobile body, what we are considering is a relative space. Such a space is mobile because it moves when the body to which it is relative moves. Thus, the distance from London to Paris remains the same distance (or the space which separates them remains the same) though the earth has travelled half way around the sun. In the same way we might say that a jar shipped across the ocean contains the same space when it arrives in New York that it did when it left Paris. Thus, as a body moves, the spaces relative to it move with it. Absolute space interpenetrates with relative space but never moves, no matter how the bodies move.

321. Now, as we saw previously, according to Newton place is a part of space occupied by a body. From this, then, another distinction follows.

> Absolute motion is the translation of a body from one absolute place into another; and relative motion, the translation from one relative place into another. Thus in a ship under sail, the relative place of a body is that part of the ship which the body possesses; or that part of the cavity which the body fills, and which therefore moves together with the ship: and relative

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[1]Newton, Mathematical Principles, p. 6.

> rest is the continuance of the body in the same part of the ship, or of its cavity. But real, absolute rest, is the continuance of the body in the same part of that immovable space, in which the ship itself, its cavity, and all that it contains, is moved. Wherefore, if the earth is really at rest, the body, which relatively rests in the ship, will really and absolutely move with the same velocity which the ship has on the earth. But if the earth also moves, the true and absolute motion of the body will arise, partly from the true motion of the earth, in immovable space, partly from the relative motion of the ship on the earth; and if the body moves also relatively in the ship, its true motion will arise, partly from the true motion of the earth, in immovable space, and partly from the relative motions as well of the ship on the earth, as of the body in the ship; and from these relative motions will arise the relative motion of the body on the earth. As if that part of the earth, where the ship is, was truly moved towards the east, with a velocity of 10010 parts; while the ship itself, with a fresh gale, and full sails, is carried towards the west, with a velocity expressed by 10 of those parts; but a sailor walks in the ship towards the east, with 1 part of the said velocity; then the sailor will be moved truly in immovable space towards the east, with a velocity of 10001 parts, and relatively on the earth towards the west, with a velocity of 9 of these parts.[1]

There is a distinction between absolute and relative motion corresponding to the distinction between absolute and relative space. When a body moves from one part of absolute space to another (from one absolute place to another) it possesses absolute motion. When a body moves from one part of a relative space to another (from one relative place to another) it possesses relative motion. It is quite plain from this passage how, considering it in the abstract, one can calculate the amount of absolute motion from the relative motion of a body and vice versa. We say "in the abstract"

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[1]Newton, <u>Mathematical Principles</u>, p. 7.

because such a calculation obviously depends upon the ability to detect the absolute motion of some body. Indeed, this is the problem, for it is usually not too difficult to discover the motion of a body in relative space. This consists simply in detecting the motion of a body relative to some other body, as is plain from Newton's own remarks cited above. We do this every day, e. g. by the speedometer of a car.

322. But the detection of absolute motion is quite another thing. Newton frankly admits that absolute motion, i. e. motion from one part of absolute space to another, cannot be directly detected. All that we can directly observe is the motion of one body relative to another. Whether either of them is at rest absolutely or both are absolutely in motion and the amount of absolute motion cannot be directly known by sensible observation.

> But because the parts of space cannot be seen, or distinguished from one another by our senses, therefore in their stead we use sensible measures of them. For from the positions and distances of things from any body considered as immovable, we define all places; and then with respect to such places, we estimate all motions, considering bodies as transferred from some of those places into others. And so, instead of absolute places and motions, we use relative ones; and that without any inconvenience in common affairs...[1]

But such a knowledge of the motions of bodies relative to other bodies (i. e. to relative space) does not satisfy Newton, even though it is the only motion which we can know

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[1] Newton, Mathematical Principles, p. 8.

directly by sensible observation. Thus, he continues as follows:

> ...but in philosophical disquisitions, we ought to abstract from our senses, and consider things themselves, distinct from what are only sensible measures of them.[1]

However, if Newton recognizes that we can only observe motion itself insofar as it is relative, i. e. insofar as it is relative to some other body, why does he think there is absolute motion and therefore absolute space? This is Newton's answer.

> But we may distinguish rest and motion, absolute and relative, one from the other by their properties, causes and effects.[2]

323. First we will consider the properties of motion to which Newton refers. I. All bodies which are at rest in absolute space are at rest relative to each other.

> It is a property of rest that bodies really at rest do rest in respect to one another.[3]

This is evidently true. All things at rest with respect to the same thing (in this case absolute space) are at rest with respect to each other. But this does not help us determine which bodies, if any, are at rest with respect to absolute space because of the following property.

324. II. The parts of a body or the bodies in a system which maintain the same position relative to the whole

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[1] Newton, <u>Mathematical Principles</u>, p. 8.
[2] <u>Ibid</u>.
[3] <u>Ibid</u>.

possess the same motion as the whole.

> It is a property of motion, that the parts, which retain given positions to their wholes, do partake of the motions of those wholes. For all the parts of revolving bodies endeavor to recede from the axis of motion; and the impetus of bodies moving forwards arises from the joint impetus of all the parts. Therefore, if surrounding bodies are moved, those that are relatively at rest within them will partake of their motion. Upon which account, the true and absolute motion of a body cannot be detected by the translation of it from those which only seem to rest...[1]

Absolute motion, and hence absolute space cannot be detected in a body or system of bodies the parts of which are at rest each to each, for the whole may or may not have some absolute motion. The fact that the bodies considered do not move relative to others in the same system does not show that the entire system under consideration has no absolute motion.

325. III. A body at rest with respect to some relative space, being contained by a part of that relative space as by a plane, possesses the absolute motion of that relative space. When the body is then moved with respect to that relative space, the absolute motion of the body must be calculated by combining the relative motion of the body with respect to that relative space with the absolute motion of the relative space. Since such a calculation depends upon a previous knowledge of the absolute motion of the relative space, one cannot determine the absolute motion of

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[1] Newton, Mathematical Principles, p. 9.

a body merely by considering the motion of a body with respect to some relative space. In other words, we cannot determine absolute space in this way.

> A property, near akin to the preceding, is this, that if a place is moved, whatever is placed therein moves along with it; and therefore a body, which is moved from a place in motion, partakes also of the motion of its place. Upon which account, all motions, from places in motion, are no other than parts of entire and absolute motions; and every entire motion is composed of the motion of the body out of its first place, and the motion of this place out of its place; and so on, until we come to some immovable place, as in the before-mentioned example of the sailor. Wherefore, entire and absolute motion can be no otherwise determined than by immovable places...[1]

326. These are the properties of absolute and relative motion which Newton gives. But it must be admitted that thus far he has given neither a method by which motion relative to absolute space can be calculated from motion with respect to relative space, nor any proof that absolute space itself even exists.

327. Having given the properties of absolute and relative motion, Newton compares the causes of the two supposed kinds of motion.

> The causes by which true and relative motions are distinguished, one from the other, are the forces impressed upon bodies to generate motion. True motion is neither generated nor altered, but by some force impressed upon the body moved; but relative motion may be generated or altered without any force impressed upon the body. For it is sufficient only to impress some force on other bodies with which the former is compared, that by their giving way, that relation may be changed,

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[1] Newton, <u>Mathematical Principles</u>, p. 9.

> in which the relative rest or motion of this other body did consist. Again, true motion suffers always some change from any force impressed upon the moving body; but relative motion does not necessarily undergo any change by such forces. For if the same forces are likewise impressed on those other bodies; with which the comparison is made, that the relative position may be preserved, then that condition will be preserved in which the relative motion consists. And therefore any relative motion may be changed when the true motion remains unaltered, and the relative may be preserved when the true suffers some change. Thus, true motion by no means consists in such relations.[1]

Absolute motion is only and always altered by the application of a force to the body concerned, whereas the application of a force to a body is not the only way to alter the relative motion of that body, nor does the application of a force to a body always alter the relative motion of that body.

328. Because it seems to Newton that we have a direct experience of relative motion alone, it might appear that he ought to begin by considering the cause of relative motion. Then, he ought to compare absolute motion to relative motion, going from the more known to the less known. However, instead of doing this, he begins with absolute motion, making relative motion known by comparing it with absolute motion. A very good reason can be given for doing this. For whereas what Newton would call relative motion is itself more known to us than absolute motion, relative motion is not more known to us as such, i. e., as relative

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[1] Newton, Mathematical Principles, p. 10.

motion. Rather, the first motion we know is relative motion, but we think of it as absolute motion. It is only later that we come to know relative motion as such. Hence, in comparing absolute and relative motion it is best to begin by considering absolute motion, for motion is first known to us as absolute. Then relative motion ought to be explained by comparing it with absolute motion. This, then, is the procedure Newton uses and it is also the one we will use.

329. According to Newton's analysis, whenever we apply a force to some body, the absolute motion of that body is altered. It is impossible for a force to be applied to a body without the absolute motion of the body being altered in some way. Whether the applied force makes the body begin or cease to move absolutely, increase or decrease its absolute speed, or alters the direction of the absolute motion depends upon the direction of the force compared to the previous absolute motion of the body. But whatever the effect, the absolute motion of the body will be altered in some way if a force is applied to the body. This result is utterly independent of any forces applied to other bodies.

330. Further, an alteration in the absolute motion of a body can be affected only by the application of a force to the body. No force applied to other bodies can alter the absolute motion of a body unless that force is in some way communicated to the body in question, i. e., unless that

force is ultimately applied to that body also.

331. But these conditions do not apply to relative motion. A force may be applied to a body without its acquiring a relative motion, i. e., a motion with respect to some space, which space is defined as being at rest with respect to some other body. Thus, if some force were applied to a planet its absolute motion would indeed be altered. But if another force were applied to the sun at the same time in such a way that the absolute motion of the sun were altered in the same way, the motion of the planet relative to the sun (and hence to the relative space defined as being at rest with respect to the sun) would in no ways be altered. The motion of the planet relative to the sun would remain the same. Thus, the application of a force to a body does not necessarily entail an alteration in its relative motion.

332. Further, the relative motion of a body may be altered without any force being applied to it at all. For instance, if a force were applied to the sun alone, the absolute motion of the sun would be altered while the absolute motion of a planet circling the sun would not be affected since no force was applied to it.[1] Yet the motion

[1] Plainly we are omitting the consideration of certain factors. For instance an alteration in the relative position of the sun would certainly affect the absolute motion of the planet, since such an alteration would involve a change in the gravitational force acting upon the planet. But a consideration of such factors would complicate the present explanation without clarifying the doctrine being considered.

of the planet relative to the space defined as being at rest with respect to the sun would certainly be altered.

333. In presenting these distinctions Newton seems to be getting at something commonly observed. No doubt there are motions produced by the application to a body of a force (in some sense of the word). Sometimes we are aware of applying "force" to bodies (as when we throw a ball). There are other "motions" which seem to be opposed to true motions. These relative motions belong to things not because of something done to them but because of something else. Thus we talk about the scenery passing by when we look out of the window of a moving train. The scenery moves not because of something done to it, but because of something done to the train. We also think of the water in a river as moving because it moves with respect to the earth, whereas we think of the river bank as at rest because it is at rest with respect to the earth. Yet at other times we think of the earth as moving about the sun, the river bank, of course, moving with it. Understood in this way, perhaps one might call the distinction between absolute and relative motion the distinction between true and apparent motion,[1] because we ascribe relative motion to bodies because they move relative to what appears or what we consider to be motionless.

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[1]Newton, Mathematical Principles, p. 12.

334. But, if relative motion is motion relative to something mobile, should not absolute motion be motion with respect to what is immobile? Thus, it seems that there must be something immobile if there is to be an absolute motion. But what could this immobile thing be? All bodies are mobile, or at least we can see no reason for supposing there to be any bodies which are absolutely immobile.[1] Therefore, it seems there must be some absolutely immobile thing which is not a body and yet relative to which bodies can move (i. e., by an absolute motion). But what could this immobile thing be except an absolutely immobile space? Thus, it may have seemed to Newton, the existence of absolute motion as opposed to relative motion (as indicated by the above distinctions) requires the existence of an absolute space.

335. We will take up these distinctions between absolute and relative motion again when we consider Newton's views in the light of Aristotle's doctrine. But for the present we may note that the argument for the existence of absolute space depends upon the supposition that there is nothing else absolutely immobile to which "absolute" motion could be compared. We may also note that even if one supposes absolute space to exist and Newton to be correct in his

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[1]Newton himself recognized the possibility of a body absolutely at rest (Mathematical Principles, p. 9) but saw no reason for supposing its existence.

distinctions between absolute and relative motion, he has still not shown any method of calculating the actual absolute motion of a body and hence has not shown any method of determining the relative motion of absolute space to any body,[1] since the application of a force to a body (for Newton) merely alters the absolute motion of a body, adding to, subtracting from or changing the direction of its absolute motion, but leaving the original absolute motion quite unknown.

336. Having compared the causes and the properties of absolute and relative motion, Newton considers their effects.

> The effects which distinguish absolute from relative motion are, the forces of receding from the axis of circular motion. For there are no such forces in a circular motion purely relative, but in a true and absolute circular motion, they are greater or less, according to the quantity of the motion.[2]

According to Newton there is one effect of absolute rotation by which we can distinguish it from purely relative rotation. In this way, according to Newton, not only can we see that there is a rotation which is not purely relative, but we can even calculate the amount of absolute rotation a body possesses. This is how Newton shows this distinction.

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[1] The fact that absolute space is absolutely immobile does not prohibet it from having a motion relative to some body any more than the fact that the absolute motion of a body is not altered prevents it from having its relative motion altered.

[2] Newton, Mathematical Principles, p. 10.

> If a vessel, hung by a long cord, is so often turned about that the cord is strongly twisted, then filled with water, and held at rest together with the water; thereupon, by the sudden action of another force, it is whirled about the contrary way, and while the cord is untwisting itself, the vessel continues for some time in this motion; the surface of the water will at first be plain, as before the vessel began to move; but after that, the vessel, by gradually communicating its motion to the water, will make it begin sensibly to revolve, and recede by little and little from the middle, and ascend to the sides of the vessel, forming itself into a concave figure (as I have experienced), and the swifter the motion becomes, the higher will the water rise till at last, performing its revolutions in the same times with the vessel, it becomes relatively at rest in it. This ascent of the water shows its endeavor to recede from the axis of its motion; and the true and absolute circular motion of the water, which is here directly contrary to the relative, becomes known, and may be measured by this endeavor. At first, when the relative motion of the water in the vessel was greatest, it produced no endeavor to recede from the axis; the water showed no tendency to the circumference, nor any ascent towards the sides of the vessel, but remained of a plain surface, and therefore its true circular motion had not yet begun. But afterwards, when the relative motion of the water had decreased, the ascent thereof towards the sides of the vessel proved its endeavor to recede from the axis; and this endeavor showed the real circular motion of the water continually increasing, till it had acquired its greatest quantity, when the water rested relatively in the vessel. And therefore this endeavor does not depend upon any translation of the water in respect of the ambient bodies, nor can truly circular motion be defined by such translation. There is only one real circular motion of any one revolving body, corresponding to only one power of endeavoring to recede from the axis of motion, as its proper and adequate effect; but relative motions, in one and the same body, are innumerable, according to the various relations it bears to external bodies, and, like other relations, are altogether destitute of any real effect, any otherwise than they may perhaps partake of that one only true motion.[1]

From this passage it should be quite clear how Newton

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[1] Newton, <u>Mathematical Principles</u>, p. 10-11.

opposes absolute and relative rotation. All the parts of a body rotating absolutely tend to recede from the axis of rotation, the more rapid the rotation, the greater the tendency of the parts to recede from the axis. Thus, if the fly-wheel of a motor rotates too rapidly, it will break into pieces. Measuring this tendency of the parts to recede, we can determine the amount of absolute rotation. An instance of this tendency, according to Newton, is what is observed when a bucket of water is made to rotate rapidly. As the water in the bucket acquires the rotation it tends to recede from the center of the bucket (the axis of rotation), gradually climbing the sides of the bucket. Thus, while the water continues to rotate, the surface of the water is concave. If we stop the bucket from rotating, as the water ceases to rotate it ceases to be repelled by the axis of rotation and hence the surface of the water becomes flat again. Thus by measuring the force by which a body or the parts of a body tend to move away from its axis of rotation, we can determine the speed of rotation of the body.

337. According to Newton, that such a rotation is not a purely relative one can be seen from the fact that rotation which is plainly relative produces no such effect. So, in the instance given above, when the bucket itself is first rotated, before the rotation of the bucket has been communicated to the water it contains, the water may be said to rotate relative to the bucket or to the space defined as

being at rest with respect to the bucket. Yet the surface of the water is flat; there is no tendency of the water to recede from the axis of its rotation relative to the bucket. Hence, this obviously relative rotation is something quite different from the first kind of rotation, that in which there is this tendency to recede from the axis of rotation. Now, one would not expect real internal effects to be found in a body as a result of its purely relative motion since the existence of this motion depends upon the frame of reference chosen alone, i. e., its existence does not depend upon anything done to the body in question. Thus, because rotation sometimes produces real internal effects within the rotating body (a tendency to recede from the axis of rotation), in some cases the rotation is not purely relative. The internal effects in these cases can only be the result of a true, absolute motion according to Newton. Hence, it would seem Newton might argue, there is such a thing as absolute rotation.

338. Two things seem to follow from what has been determined thus far. I. Since, as we have seen,[1] an absolute motion appears to require something absolutely at rest relative to which a thing can be in absolute motion, the absolute rotation apparently established here requires an absolute, immobile space, for what else can we suppose to be

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[1] Par. 334.

absolutely immobile.[1] II. Since absolute rotation can be determined by a measurable quantity, centrifugal force, the relative rotation of absolute space can be determined also, so that we can, as it were, fix absolute space in the relative spaces of which we are more directly aware.[2]

339. Newton's position here is certainly a sound one in the sense that the distinction which he makes between absolute and relative rotation is one based upon an empirically observed difference which demands an explanation. And Newton proposes one which appears to account for the facts. One might question whether what Newton calls "absolute circular motion" must, in fact, be relative to something absolutely at rest or immobile. For who knows what forces (to speak in Newtonian terms) the huge mass of the system of the observed "fixed" stars exerts upon terrestrial bodies? Thus, perhaps the observed centrifugal force results not from truly absolute motion in Newton's sense, but simply from some force applied by the "fixed" stars to any small body rotating with respect to them, even though the "fixed" stars themselves may be rotating as a system.[3] However, one cannot reject the Newtonian position simply because of a possible alternative hypothesis. The Newtonian position is much simpler and is, therefore, in

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[1]Note de similarity of this argument to the one given above, par. 206.

[2]Newton, Mathematical Principles, p. 12

[3]In practice, Newtonian physics uses the "fixed stars" as a system of reference. See Philipp Frank, Modern Science and Its Philosophy, pp. 235-238.

view of the information available in his day, a good one. But is must be kept in mind that it is only an hypothesis.

340. There is one more aspect of Newtonian space which we must mention before attempting to judge his position. For Newton supposes space to be as if the divine sensorium or sensory. Newton presents this doctrine as follows.

> Is not the sensory of animals that place to which the sensitive substance is present, and into which the sensible species of things are carried through the nerves and brain that there they may be perceived by their immediate presence to that substance? And these things being rightly dispatched, does it not appear from phenomena 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 thoroughly 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 little sensoriums, are there seen and beheld by that which in us perceives and thinks.[1]

Exactly what is meant by this passage is not very clear. However, elsewhere he says:

> He (God) is not eternity and infinity, but eternal and infinite; he is not duration or space, but he endures and is present. He endures forever, and is everywhere present; and by existing always and everywhere, he constitutes duration and space.[2]

Further, Alexandre Koyré says:

> Moreover, Newton does not say that place <u>is a sensorium</u>, but calls it thus only by way of comparison, in order to indicate that God really and effectively perceives things in themselves, where they are, being present to them, and not purely transcendent - present, acting, forming and reforming...[3]

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[1]Newton, <u>Optics</u>, Bk, III, pt. I, p. 543 of vol. 34, <u>Great Books</u>.

[2]Newton, <u>Mathematical Principles</u>, General Scolium, p. 545.

[3]Alexandre Koyré, <u>From the Closed World to the Infinite Universe</u>, p. 242.

And elsewhere Koyré says:

> As for Sir Isaac Newton, he does not say that space is an organ which God uses in order to perceive things, nor that God needs any means for perceiving them. Quite the contrary, he says that God, being everywhere, perceives them by his immediate presence in the very space where they are. And it is just in order to explain the immediacy of this perception that Sir Isaac Newton - comparing God's perception of _things_ with the mind's perception of _ideas_ - said that infinite space is, so to speak, as the _sensorium_ of the Omnipotent God.[1]

Thus, though it would not be correct to say that space is the divine sensory, God by its universal presence establishes space, evidently absolute space since this is "true" space. In amplification of Newton's words, Dr. Samuel Clarke, who would seem to be presenting Newton's own views,[2] makes the following statement:

> ...If no Creatures existed, yet the Ubiquity of God, and Continuance of his Existence, would make Space and Duration to be exactly the same as they are Now.[3]

341. In passing, it might be noted that these remarks suggest a certain way of interpreting Newtonian space. It exists independently of other physical things, not being an accident of them or depending upon them.[4] It is an extended magnitude or continuous quantity in some sense, as should be plain from the preceding remarks. But it does not have sensible qualities, nor does it have motion. It sounds

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[1] Alexandre Koyré, _From the Closed World to the Infinite Universe_, p.237.

[2] On this question see Koyré, _Ibid_., p. 300, note 3.

[3] Cited by Koyré, _Ibid_., p. 257.

[4] Compare this with par. 151 above.

remarkably like the intelligible matter with which the science of geometry deals[1] (which matter is also in a way prior to sensible matter), but with this difference: Newton apparently thinks that his space exists physically, separated from other things, whereas, of course, the matter of geometry is only an abstraction, not existing separated from sensible matter. Of course, having pointed out this similarity between Newtonian space and the intelligible matter which concerns the geometrician,[2] it remains to be seen whether Newtonian space really exists separated from other physical things. In a limited way, this question will be considered below. We have shown the similarity between the two here only as an aid to understanding what Newton means by absolute space.

342. Now, whatever Newtonian space is essentially,[3] it may well be that we have the ultimate justification for absolute space in Newton's mind in his remarks about the divine sensorium. Thus, speaking of Newton's absolute space, Burtt says:

> Everything that happens in it, being present to the divine knowledge, must be immediately perceived and intimately understood. Certainly, at least, God must know

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[1]See St. Thomas, II Physicorum, Lect. V; In Boetii De Trinitate, q. 5, a. 3; I[a], q. 85, a. 1, ad2.

[2]The similarity between the two (Newtonian space and the extension with which geometry deals) is great enough to lead Burtt to say that for Newton "Space was identified with the realm of geometry." (The Metaphysical Foundations of Modern Science, p. 238.

[3]For Koyré, following Clark, space is a property of God. (From the Closed World to the Infinite Universe, pp. 247, 271.

> whether any given motion is absolute or relative. The divine consciousness furnishes the ultimate centre of reference for absolute motion. Moreover, the animism in Newton's conception of force perhaps plays a part in the premises of the position. God is not only infinite knowledge, but also Almighty Will. He is the ultimate originator of motion, and is able at any time now to add motion to bodies within his boundless sensorium. Thus all real or absolute motion in the last analysis is the result of an expenditure of the divine energy, and whenever the divine intelligence is cognizant of such an expenditure, the motion so added to the system of the world must be absolute.[1]

In the last analysis God can surely distinguish true from apparent motion since he moves all things and therefore by his divine knowledge knows which things he has moved and which he has not moved. Further, since he knows which things are truly moved and the degree to which they are moved, he must know the extension over which they are moved. Since the distance which they are moved is determined not by comparing them to some body arbitrarily supposed to be at rest, but rather by the degree God has moved them, the extension over which they move must be a real extension. It must be absolute space, not some relative space. Therefore, Newton thinks, absolute space exists.

343. Now, we do not intend to analyse Newton's space insofar as it it considered as if the divine sensorium. Plainly, such a treatment goes beyond the realm of natural science, to which we are restricting ourselves. Actually, it would seem that to explain Newtonian space in terms of God's

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[1]Burtt, <u>Ibid</u>., p. 261.

presence according to his knowledge and power would be to explain the more known by the less known. At any rate, we mention this aspect of Newtonian space only to exclude it from our present analysis.

NEWTONIAN PLACE SEEN IN THE LIGHT OF ARISTOTELEAN DOCTRINE.

344. Now that we have attained a certain familiarity with the Newtonian conception of space we may compare his views with those of Aristotle. Perhaps it would be well to begin by repeating a previously cited passage from the Mathematical Principles of Natural Philosophy, one in which Newton attempts to show that place is a space.

> Place is a part of space which a body takes up, and is according to the space, either absolute or relative. I say, a part of space; not the situation, nor the external surface of the body. For the places of equal solids are always equal; but their surfaces, by reason of their dissimilar figures, are often unequal. Positions properly have no quantity, nor are they so much the places themselves, as the properties of places.[1]

From this passage it is plain that Newton desires to substitute another conception of place for that of Aristotle. Thus he expressly denies that place is "the external surface of a body." But note that he says "external surface." What Newton means by "external surface" is not altogether clear. He may mean the outside surface of the body in place. His very words seem to indicate he is referring to the surface of the contained body, but if this is indeed the view he wishes to

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[1] Mathematical Principles, p. 6.

refute, he might merely have pointed out that the place of a body is separable from the body whereas its surface is not.[1] But surely it is Aristotle's definition of place that Newton wishes to refute, and as we have seen, this definition makes place the surface of the containing body. This suggests that perhaps, in spite of his words, he is referring to the surface of the containing body. Yet, it is possible that Newton so grossly misunderstands Aristotle's definition as to think it refers to the surface of the contained body. At any rate, it makes no difference to the understanding of his argument whether the "external surface" is taken to be the surface of the contained body or that of the containing body, for Newton rejects the idea that place is a surrounding surface because the places of equal bodies are equal, whereas their surfaces are not necessarily equal. Newton's point is that the surfaces surrounding bodies of equal volume are not necessarily of equal area. Therefore, if place is a surrounding surface, the places themselves of bodies equal in volume are not necessarily equal, i. e. of equal area. Since, Newton supposes, the places of equal bodies must be equal, place cannot be a surrounding surface.

345. But we have already considered this objection in principle. For basically it is the same as that presented by Joseph Albo. In summary, our answer to this objection

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[1] See par. 202-204.

was that the proper place of a thing is equal to the thing in the sense that its capacity is wholly and perfectly exhausted by the body it contains. Thus the capacity of a proper place and the extension of the contained body are perfectly equal.[1] Hence, the fact that the surfaces containing bodies of equal volume are not necessarily the same in area does not exclude the containing surfaces of equal bodies from being said to be always equal in capacity. This is sufficient. Newton's objection, then, is easily rejected.

346. But his objection to place being a position is more acceptable. It would be difficult to suppose that the positions of equal bodies are equal, for we do not think equality or inequality belongs to position. Because the places of equal bodies are equal (since a place is equal to the body it contains), plainly place cannot be position. Yet, as Newton himself notes, "position" is somehow associated with place. He understands it to be a property of place. We will return to this aspect of place again.

347. Having attempted to show that place is neither a surface nor a position, Newton gives an argument to show what place truly is.

> The motion of the whole is the same with the sum of the motions of the parts; that is, the translation of the whole, out of its place, is the same thing with the sum of the translations of the parts out of their places;

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[1]See the analysis beginning at par. 257.

> and therefore the place of the thing is the same as the sum of the places of the parts, and for that reason, it is internal, and in the whole body.[1]

The place of a whole is the same thing as the sum of the places of its parts. But this can be the case only if place is some sort of interval or extension. Therefore, place is an interval or space.

348. Newton argues to the first proposition from the motion of a whole. Apparently he begins from the fact that some bodies are composed of actual parts. This being the case, Newton holds, when the body as a whole is moved, the motion of the whole must be the same thing as the collective motion of its parts from one set of places to another set of places. Thus in at least some cases, the place of a whole is precisely the same thing as the sum of the places of its parts.

349. One must note that this argument does not suppose all bodies to be composed of actual parts (thus supposing actual parts of parts to infinity). It only supposes some bodies to have some actual parts. For it follows from this, according to the argument, that the places of those bodies which do have actual parts are composed of the places of those parts in some way. Therefore, place must be such that the places of a whole may be composed of the places of its parts. For Newton's argument this is sufficient.

350. However, if it is in this way that Newton arrives

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[1]Newton, Mathematical Principles, p. 6.

at the first proposition (that the place of a whole is the same thing as the sum of its parts), one might ask why he proceeds by an argument from the motion of a whole. For having supposed a whole to be composed of actual parts, is it not obvious that the place of the whole is in some way the same thing as the sum of the places of the parts? Why talk about motion at all? Perhaps, having supposed a whole to be composed of actual parts, he uses the motion of these parts to manifest the places of the parts and hence the composite nature of the place of the whole because the apprehension of place itself, as something distinct from the body in it, arises only from the motion of the bodies.[1] Let us suppose, then, as seems likely, that this is the way Newton attemps to establish the place of a whole to be the same as the sum of the places of its parts.

351. Taking this to be established, Newton argues that a place must be a magnitude or extension penetrating the body in it for how else could the places of the parts be added together to make the place of the whole? Yet when a body moves, its place does not move with it. Therefore, place must be an extension penetrating the whole body it contains, and yet separated or distinct from it. Place must be a space.

352. From what has already been said,[2] it is plain

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[1] See par. 139.

[2] See analysis beginning at par. 257.

that we cannot accept this reasoning. A place is said to be equal to the body it contains by virtue of the capacity of the place, the place containing neither more nor less than the body. This being the case, equality in places refers to equality in their capacities. Therefore, it is certainly true that the place of a whole is equal to the sum of the places of the parts of that whole in that the capacity of the place of the whole is equal to the capacity of the places of all the parts, the place of the whole containing neither more nor less than the places of the parts taken together. But to go beyond this statement of the situation, to say that the place itself of the whole is the "same" as the sum of the places of the parts in the sense that a line is the "same" as the sum of its parts is to go beyond that common knowledge of place from which we must determine what it is. To do so is, in fact, to imagine place to be a kind of space. Understanding the addition of places in this way can be justified only if place is a space. In other words, Newton's argument begs the question.

353. Yet, we can easily see why Newton argues as he does. We are certain that the (proper) place of a thing contains neither more nor less than the thing.[1] A man with a highly developed imagination will be strongly inclined to think that equality in this sense implies that the two (the

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[1] See par. 192.

place and the body) are themselves equal magnitudes. Having conceived place in this way, the rest of the argument follows.

354. However, the fact that Newton's argument does not prove place to be a space does not, in itself, prove that place cannot be a space. One can argue to a true conclusion from questionable or even false premises. Therefore, we ought to consider whether or not place can be a Newtonian space. We have already seen at considerable length that Aristotle argues against the possibility of place being a space. Therefore, we will begin by determining whether Newton's opinion can be maintained in the face of Aristotle's objections to place being a space.

355. It will be recalled that Aristotle, at least implicitly, argues against place being either of two conceptions of space, one utterly immobile, the other in some way mobile.[1] As we have seen, Newton also speaks of two kinds of space, absolute space and relative space. For Newton absolute place is a part of absolute space, relative place is a part of relative space.

> Place is a part of space which a body takes up, and is according to the space, either absolute or relative.[2]

And Newton's absolute space is immobile, whereas his relative space is mobile.

Absolute space, in its own nature, without relation

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[1] See par. 210-211

[2] Cited in par. 319.

> to anything external, remains always similar and immovable. Relative space is some movable dimension or measure of the absolute spaces...[1]

Thus, both Aristotle and Newton consider two spaces, each of them distinguishing between a movable and an immobile one. To this extent, at any rate, their analyse correspond.

356. Now, we will treat Newton's relative space first. Many times Newton calls absolute space true space or real space, as opposed to relative space.[2] Relative space, for Newton, then, is not true space in some sense. From what we have already said, it is easy to see why. Since the same body at the same time may be considered to be at rest or in motion to a greater or lesser degree, depending upon the reference body we have chosen to consider at rest, the distance in relative space over which this body moves varies according to this choice. Thus, this distance or space is not something really independent of our choice of a reference body. Hence, for Newton, relative space is not, in itself, something real in things, but is imposed on them from without by reason.

357. We can come to a more satisfactory understanding of how Newton must understand relative space if we consider how it is related to absolute space. Absolute space is truly real. In the Newtonian view, whenever we see the physical dimensions of that body, we know there is a real space penetrating the dimensions of that body but distinct from it. Of course, we

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[1]Cited in par. 320.

[2]See par. 320, 324, 327, 336.

do not see the dimensions of the space as distinct from those of the body, but they are there nevertheless. Now, at any given instant, the extension of each body is coextensive with some definite part of absolute space. But if the body is moving absolutely, this coextension of the magnitude of the body with a definite part of space does not exist for any period of time, but only in the instant, the indivisible of time. While the body is moving, the extension of the body is coextensive with constantly different parts of absolute space. Yet, the body is constantly penetrated by absolute space. Of course, as a body moves with respect to absolute space, it brings with it its own relative space (the one defined as being at rest relative to it). Thus, we have a body and the space attached to it moving in absolute space, both being interpenetrated by absolute space.

358. But for Newton does relative space have any physical existence distinct from the absolute space in which it moves? We hinted above that the answer to this question was no.[1] We can understand this answer more distinctly by reconsidering the kind of existence mobile or logical place (space) has for Aristotle. We saw above that logical place is a magnitude coextensive with the body in it but taken as distinct from the body because we conceive its measurement as different from that of the body.[2] When measuring a body, we

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[1] Par. 356.
[2] See par. 22-27.

think we are measuring from one term of the body to its opposite term; when measuring the space which a body occupies, we think we are measuring, not from one side of the body to the other, but from one containing surface of the surrounding or containing body to its opposite containing surface. Though the result of measuring the two will be the same measure-number because the containing and contained body are in contact, still we consider ourselves to have measured two distinct things, in the one case the size of the contained body, in the other the room within the container. Yet, it is physically the same magnitude we measure in the two cases, that of the contained body.[1] Thus, the physical foundation of this place or space is the very magnitude from which the place is considered distinct, the magnitude of the measured body. The distinction betweem them is a distinction in reason.[2]

359. Perhaps a concrete case will help to clarify the matter. When an engineer wishes to build a bridge across a river, he measures the distance through the air that the bridge must span. Yet he thinks he is measuring, not the air, but rather the distance between the banks of the river. While the length he arrives at exists only in the air, or at least need not be thought to exist except in the air, the part of

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[1] That this is Aristotle's view is plain from his treatise on the void.

[2] See par. 27.

the air in which this extension physically exists is constantly changing because of the wind. Nevertheless, the extension expressed in measure-numbers remains always the same.

360. Newton must regard the distinction between relative and absolute space in a similar way. A relative space is some distance or set of distances measured from a reference body. For Newton, the true foundation of these relative extensions is absolute space. This is why absolute space alone is called true space. Because the reference body may be moving in absolute space, the foundation for a given relative space may not remain the same, while as a measured quantity the space may remain the same (as does the distance between the reference body and some body at rest relative to it). This, then, must be the way in which Newton understands the existence of relative space.

361. From this analysis, we can now see an additional parallel between the two kinds of space treated by Aristotle and Newton. Not only do both of them consider a mobile and an immobile space, but both men hold that mobile space has its foundation in something else, for Aristotle the dimensions of bodies, for Newton absolute space.

362. It might also be noted that Aristotle's argument against place being a mobile space[1] would apply to Newton's

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[1]See par. 238-241.

relative space also, if this relative space were thought to exist independently of absolute space, an application which Newton himself would seem to admit.[1] For Newton's relative spaces move with respect to each other. Their parts must, then, move from place to place, being penetrated by their own proper places, new being in this space (place), now in that. Thus, if place is a part of relative space, place moves from place to place. But note that in the Newtonian view, this process does not go on to infinity, for the places to and from which the parts of relative spaces are moved are themselves absolutely immobile, being parts of absolute, immobile space. This being the case, there is no satisfactory reason for proposing that the parts of relative space are really places. If place is a space, why not simply say that things moving from place to place move from one part of absolute space to another?

363. Now, we turn out attention to absolute space. From what has been said already, we can see why Newton is so anxious to establish both the existence of absolute space and

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[1]"As the order of the parts of time is immutable, so also is the order of the parts of space. Suppose those parts to be moved out of their places, and they will be moved (if the expression may be allowed) out of themselves. For times and spaces are, as it were, the places as well of themselves as of all other things. All things are placed in time as to order of succession; in space as to order of situation. It is from their essence or nature that they are places; and that the primary places of things should be movable, is absurd. These are therefore the absolute places; and translations out of those places, are the only absolute motions." (Newton, Mathematical Principles, p. 8.

a method of calculating motion relative to it. Since true motion is motion with respect to absolute space, a knowledge of absolute space is presupposed to a perfect quantitative knowledge of true motion. For instance, the true distance which a body moves is the distance it moves in absolute space. Since we cannot be satisfied with an analysis of relative motion, but must seek a knowledge of true motion[1] he attempts to show the existence of absolute motion and to give a method for calculating it, or at least changes in it. If a thing did not move to or from a part of absolute space as to or from a place, Newton's analysis of absolute space would seem to be substantially beside the point. At the very least, the distinction between absolute and relative motion would have to be interpreted in a very different fashion.

364. Having seen the importance of the question, we will now attempt to determine whether place can be a part of absolute space. Because we have already treated in some detail Aristotle's objection to the opinion that place is an immobile space, it is natural for us to begin by determining whether Aristotle's objection is applicable to Newton's position. It would be unnecessary duplication to repeat the objection in full detail here. Therefore, we will present only a short summary of Aristotle's argument. As we have seen,[2] he argues that because a body may be divided infinitely

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[1]See par. 322.

[2]It was given above, par. 212-236.

in potency and because each of these parts divided from the whole must have distinct place, in the space occupied by any body there must be an infinity of spaces if a place is a space. Because the gradual division of the body into more and more parts cannot produce the additional spaces necessary so that each part might have a space (place), each of the additional needed spaces must have been there from the beginning. Since a body is potentially divisible infinitely, there must be an actual infinity of spaces in any space. Because we cannot propose the existence of an actual infinity if there is any other alternative, and because place can be defined in such a way as to avoid proposing the existence of an actual infinity (i. e., the way Aristotle does it), the opinion that place is a space must be rejected.

365. Evidently, Aristotle's argument does apply to Newton's absolute space. If place were a part of such a space, there would have to be an actual infinity of places for the reason indicated by the argument.

366. However, against the application of this argument to Newtonian space it may be objected that Newton was an atomist.

> All these things being considered, it seems probable to me that God in the beginning formed matter in solid, massy, hard, impenetrable, moveable particles, of such sizes and figures, and with such other properties, and in such proportion to space, as most conducted to the end for which he formed them; and that these primitive particles being solids, are incomparably harder than any porous bodies compounded of them; even so very hard as

> never to wear or break in pieces; no ordinary power being able to divide what God himself made one in the first creation. While the particles continue entire, they may compose bodies of one and the same nature and texture in all ages; but should they wear away, or break in pieces, the nature of things depending on them would be changed. Water and earth, composed of old worn particles and fragments of particles, would not be of the same nature and texture now, with water and earth composed of entire particles in the beginning. And, therefore, that Nature may be lasting, the changes of corporeal things are to be placed only in the various separations and new associations and motions of these permanent particles; compound bodies being apt to break, not in the midst of said particles, but where those particles are laid together, and only touch in a few points.[1]

If bodies cannot be divided infinitely (which they cannot be if they are composed of indestructible particles), then an actual infinity of absolute spaces in not needed in order that place be a space. If the division of bodies is not infinite, the spaces required for them are not infinite.

367. There are several things which might be said in answer to this objection. First, we saw above[2] that Aristotle (at least as understood by St. Thomas) did not hold bodies existing concretely to be infinitely divisible. Yet, as we also saw,[3] the argument need not be rejected by an Aristotelean for this reason. To reproduce this reasoning here would be an unnecessary duplication. Therefore, we will simply point out how doubtful it is that what is permitted by

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[1] Newton, Optics, Bk. III, Part. I, qu. 31, p. 541 (vol. 34, Great Books).

[2] See par. 232.

[3] See par. 233-236.

body taken commonly (infinite divisibility) should be prohibited to bodies by the nature of place, as would be the case if the nature of place itself demanded that bodies be composed of indivisible particles.

368. Second, if the places of bodies were a finite number of parts of absolute space, so that the parts of space corresponded in their dimensions to the ultimate indestructible particles of matter, it would follow that bodies could come to rest only in certain positions in absolute space, but not in others. For an atom could not come to rest partly inside and partly outside of a space (place) equal to it, for then it would not be resting in a place, but rather would be resting only partly in one place and partly in another. But if a body can rest without being in a place, why propose the existence of place at all? This difficulty could be avoided only by proposing the existence of an actual infinity of interpenetrating spaces, but it was to avoid proposing an actual infinity that the objection was proposed.[1]

369. Third, the objection we have been considering would seem to be outside the intention of Newton, for he speaks of the infinite divisibility of space.

> ...space is divisible in infinitum...[2]

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[1]This argument rests upon the fact that we are more sure of the infinite divisibility of motion than we are of the infinite divisibility of bodies.

[2]Newton, Optics, Bk. III, qu. 31, p. 543 (vol. 34, Great Books).

But how did Newton suppose that space could be divided? Though he does not tell us, it is reasonable to suppose that he thought space was divided by the very surfaces or divisions of bodies in it. Indeed, there could be no other method of dividing his space. It must be that for Newton, the division of a body into parts or the division of a body from other bodies results in the division of the space it occupies. This being the case, Newton would hardly have held the space to be already divided into parts before the body occupying it was divided. In this conception, then, the problem of an actual infinity of space does not arise. Thus, the atomism of Newton is irrelevant to an understanding of how he could suppose there to be a distinct part of space for every body or every actual part of a body.

370. This objection to the application of Aristotle's argument to Newtonian space must be rejected, then, both because it cannot really solve the difficulties raised by Aristotle's argument, as we have seen, and because it must be contrary to Newton's understanding of space.

371. Having solved the preceding difficulty in part by showing that Newton would surely object to Aristotle's argument on other, opposed grounds, it remains to consider whether the application of Aristotle's argument can be avoided on these other grounds. As we have seen, no doubt Newton supposes that the division of a body results in the division of the space it occupies. On the other hand, Aristotle's

argument supposes that the division of a body cannot result in the division of the space occupied by that body. Our problem, then, is to determine which of these views is correct.

372. Now, in dealing with Aristotle's position in this respect above,[1] we saw that for Aristotle, if the division of a body results in the division of the space it occupies, the dimensions of the two, the body and the space, cannot be really distinct quantities, but must be one and the same thing. Note that if Aristotle's argument is understood in this way, it does not rest upon the view that two distinct magnitudes cannot be coextensive. This is another question. His argument merely supposes that if there are coextensive magnitudes, the division of one of them does not result in the division of the others

373. Nor can this be doubted. For if two magnitudes were to interpenetrate they could hardly be distinguished one from another by their positions. They would, in fact, have to be distinguished according to subjects. Otherwise, instead of being two magnitudes, they would be one magnitude.[2] Indeed, it would seem that Newton regards these two magnitudes in just this way, for he proposes that if the subject of the bodily magnitude were removed, and thus the magnitude itself, the extension which is space would remain.[3] This implies

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[1]See par. 221-229.

[2]See St. Thomas, III[a] Supp. q. 83, a. 3, ad 2.

[3]At least this was his opinion if we are to accept the position of Clark as being that of Newton. See par. 340.

that what is the subject of the one is not the subject of the other. Considered in this way, it is plain that the division of one does not imply the division of the other. Why should the division of the quantity of one subject imply the division of the quantity of another? The only way in which one could reasonably suppose that the division of one magnitude entailed the division of another interpenetrating multitude would be to suppose that the two are not different in subject. But this would make the two magnitudes really one. Therefore, we can see that Newton is unjustified in supposing that the division of a body entails a division of its space. Thus, the force on Aristotle's argument cannot be avoided. Place cannot be a Newtonian absolute space.[1] Aristotle's definition remains the only satisfactory one.

[1] Obviously, this argument applies to Newton's relative space as well. But even Newton did not consider relative space to be true space.

A RECONSIDERATION OF ARISTOTLE'S PLACE

374. We will now consider certain advances which have been made in natural science since the time of Aristotle, advances not entirely unrelated to the Newtonian position presented above. Then, in a limited way, we will attempt to analyse the physical foundations of place in the light of these advances. In this way we will attempt to judge the present day validity of Aristotle's definition of place.

375. It will be recalled that Aristotle conceived the universe as terminated by an outer sphere which was immobile as a whole,[1] the center of this sphere, the center of the universe, being also immobile. Further, as we have seen, Aristotle supposed that there was a certain order in the universe. Proceeding from the center toward the outer extremities of the universe, the natural places were arranged in the order earth, water, air and fire,[2] with the celestial spheres at the outer extreme of the universe. This order was seen to have two aspects. On the one hand, the more perfect or more noble elements were considered to be above

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[1] See par. 271-272.
[2] See par. 299.

the less perfect ones.[1] On the other hand, the order was such that the elements would be less likely to corrupt each other, i. e., no two elements which touched each other in their natural places were totally contrary to each other. Thus, for instance, the element which was hot and dry would not have its natural place next to an element cold and wet.[2] We also saw that the order of the elements ultimately could not be explained by this latter factor, so that the order of the natural places must be accounted for primarily on the basis of the order of the elements in nobility.[3]

376. Since the natural places (those places to which the various elements naturally tend) were thought to have fixed positions in the universe, a body was thought to move or be at rest with respect to the universe as a whole when it moved toward its natural place or was at rest in it. Put in Newtonian terms, it was thought that when a body was in absolute (true)motion, it was in motion both with respect to its natural place and with respect to the universe as a whole. With the universe conceived in this way, if body A were in motion (relative to a natural place or to the universe as a whole), and body B were gradually changing its position with respect to A, no one would be inclined to call this

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[1]See par. 300.
[2]See par. 301.
[3]See par. 302.

change in the position of B relative to the single body A a true motion. B would be considered to move truly only and to the extent that it moved with respect to some place and hence with respect to the universe as a whole. Thus, in this universe, a relative motion (a change in position with respect to some body chosen more or less arbitrarily) is not necessarily a true motion. Further, since the earth was considered to be really at rest in the universe, it was relatively easy to calculate the true motion of a body. The earth could always be used as a reference body. What moved with respect to the earth truly moved.

377. However, by the time of Newton, the universe had long ceased to appear ordered in the way Aristotle seemed to suppose. Instead of being at rest, the earth was thought to rotate on its axis and to move about a rotating sun.[1] While the fixed stars were not observed to move with respect to each other,[2] or to the solar system according to the most economical explanation of the facts, yet no good reason could be given for supposing they did not actually move. Thus, no known body seemed to be immune from motion. But if there were no bodies that one could reasonably suppose to be truly immobile, how could one determine whether a body was truly in motion or truly at rest? Or was it necessary to propose

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[1] Galileo, Dialogue Concerning the Two Chief World Systems, pp. 50-56.

[2] Until Halley discovered this motion in 1718. See G. J. Whitrow, The Structure and Evolution of the Universe, p. 16.