the existence of some "true" motion?

378. Suppose body A changes its position relative to B, but does not change its position relative to C. Is it more true to say that A and C move toward B than it is to say that B moves toward A and C? If there is no true difference between the two situations, there is no difference for any single body between being in motion and being at rest.

379. Because of the new knowledge another related problem arose concerning natural place. We have seen that in the universe as conceived by Aristotle, bodies naturally tend to move toward certain places and to rest in them, these places having definite, fixed positions in the universe and therefore being immobile each with respect to the others. But by the time of Newton this non longer appeared to be the case either. Rather, it was observed, bodies tend[1] to move toward each other and to remain together. If a body were near the earth, its "natural place" would be on the earth but if the same body were near Jupiter, its "natural place" would be on Jupiter. Since these "natural places" were observed to be moving with respect to each other, one could hardly say that they were immobile with respect to the universe as a whole. Therefore, because the only known "<u>natural</u> places" (i. e. "places" to which natural things tend to move) were

[1]Obviously, we are speaking from a purely natural point of view. Mathematical physics does not discuss the "tendencies" of bodies.

as mobile as ordinary bodies were, either these "natural places" were really not places or place was not immobile relative to the universe as a whole.

380. Perhaps by contrasting this situation, once again, with the Aristotelean conception, we may clarify the problem. For Aristotle the surface which is a place remains one place in number during any given time by virtue of possessing one definite position in the universe during that time, regardless of whether the subject in which the surface exists remains one and the same in number or not. For instance, the place of a ship at anchor in a river remains one and the same in number though the water whose surface is the place of the ship is constantly flowing by the ship.[1] The unity of a place comes from its position in the universe, not from the unity of its subject. But, as we have seen, in the Newtonian universe, bodies tend to move toward, and rest together with other bodies, though these other bodies themselves may well be moving relative to each other. Thus, the natural tendancy of a body in a given situation and during some interval of time is not to move toward some place one in number, but toward some body or system of bodies, regardless of the place of that body or system of bodies (if we can talk about place in such a universe). Thus, even if place be supposed to exist, it would appear that body A would

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[1]See par. 246-249.

tend toward a particular place, or rest there only because of the presence of another Body (B) near that place, but A might just as well have moved to some other place if B were somewhere else. It would seem, then, that one place could be no more natural to it than another.[1]

381. To summarize these problems in view of the new knowledge, on the one hand it is difficult to detect any "motion" other than what Newton would call relative motion and on the other hand it seems that bodies naturally tend toward other mobile bodies rather than toward immobile natural places in the Aristotelean sense.

382. One can easily see the order in which these problems must be treated from what has been said already. No doubt the question whether there is such a thing as natural place is posterior to the question whether place exists. But, of course, we are quite certain place exists, since things do move from place to place. Further, we have seen by induction that place must be as Aristotle defined it. Our present intention, then, is to determine how Aristotle's doctrine applies to Newton's universe and our problem is that, at first glance it appears to apply not at all, for one cannot easily find an immobile surface which could be a place, or rather, it is difficult to understand how an immobile surface is to be distinguished from a mobile one.

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[1] St. Thomas, I <u>De Caelo</u>, Lect. II, n. 17(10).

Since "natural place" adds something to "place" we will begin by considering how place can be said to exist in a Newtonian or post-Newtonian universe. Then we will take up the problem of natural place.

383. We have seen that Aristotle proposed place to be immobile with respect to the universe as a whole. That the universe itself, taken as a whole, cannot be in motion is plain from the very nature of the universe. Perhaps this can best be seen by contrasting the completeness belonging to any particular body with that belonging to the universe. Following Aristotle, St. Thomas explains how particular bodies are complete as follows:

> And he says that each particular body, according to the common definition (rationem) of body is such, i. e. complete, insofar as it has all dimensions. But nevertheless it is terminated at the next body, insofar as it touches it. And thus each such body is in a certain way multa, i. e. complete, insofar as it has all dimensions and incomplete insofar as it has another body outside it at which it is terminated...[1]

But the universe, while having the completeness of individual bodies, is still more complete.

> And he says that the whole, i. e. the universe, the parts of which are particular bodies, must be complete in all ways, and as the same universe itself signifies omniquaque, i. e. complete in all ways, and not according to one way so that it is not complete according to another, because it has all dimensions, and includes all bodies in itself.[2]

Since the universe includes all bodies in itself, it could

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[1] St. Thomas, I De Caelo, Lect. II, n. 17(10).
[2] Ibid.

hardly be said to move from place to place. Any place into which it could move would have to be itself part of the universe. Thus, it must be that the universe itself, as a whole, is immobile.

384. If someone should suppose the physical universe to move as a whole from place to place it would be because he supposes place to be a part of an infinite space such as Newton supposes. But we must reject the existence of an infinite space if we must reject the existence of any actual infinite in nature. While we have not explicitly considered the question of the existence of a separated space, we have seen indications that it is not necessary to propose its existence. However, if some finite space were thought to exist, it would belong to the physical universe and thus could not in itself make possible a motion of the universe as a whole. In order for the universe as a whole to move from place to place, this space would have to move also, and the entire problem arises again, to and from what could it move? Further, even if a separated space were supposed to exist and to be something separated from the physical universe, since it could not be place, as we have shown, it would still be impossible for the universe to move as a whole. We may conclude, then, that the universe as a whole is immobile, and not immobile as what is merely at rest or what is moved with difficulty is said to be immobile, but rather as what is in no way apt to be moved is said to be immobile.[1] Therefore,

[1] St. Thomas, V *Physicorum*, Lect. IV, n. 683(6).

in our present analysis we will always consider the universe to be both finite[1] and immobile as a whole.

385. Though our present work is not directed principally at an analysis of the limits of the universe, yet a consideration of the nature of these limits is relevant to an analysis of the definition of place. As is plain from our examination of Aristotle's definition,[2] place is immobile relative to the universe as a whole. But as St. Thomas says:

> ...the whole form (ratio) of place in all containers is taken from the first container and placing thing, namely the heavens.[3]

While it is not altogether clear whether St. Thomas is here referring to the entire universe[4] or to the ultimate sphere as "the heavens", he is probably referring to the outer sphere, since the entire universe contains what is in it as a whole contains a part, not as a place contains what is in it.[5] If St. Thomas is referring to the ultimate sphere, "the whole form of place" is taken from it because the outer sphere as a whole for Aristotle and St. Thomas partakes of the immobility of the universe as a whole. Indeed, the immobility of a universe whose limit is not also immobile becomes very

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[1]Since we must avoir proposing the existence of an actual infinite in nature.

[2]See par. 245-250.

[3]St. Thomas, IV Physicorum, Lect. VI, n. 469(15).

[4]See St. Thomas, I De Caelo, Prooemium, n.4(4) -5(5) for "heavens" used as referring to the entire universe.

[5]See par. 193-200.

obscure, as we will see below. But if the ultimate sphere partakes of the immobility of the entire universe, place, in being immobile relative to the universe as a whole, is immobile with respect to the outer sphere. This outer sphere, then, together with the immobile earth in the center of the universe, gave Aristotle and St. Thomas a definite, immobile, bodily frame of reference to which all motion and rest (and hence place) could be relative. Being relative to this frame of reference they were thought to be relative to the immobile universe itself. This conception of the universe made it comparatively easy to understand how a body could be said to move or to be at rest relative to the universe as a whole. But note, Aristotle did not propose this definite, immobile, bodily limit to the universe merely to make his doctrine concerning place easily intelligible. Rather, by supposing an outermost rotating sphere he explained the apparent motion of the fixed stars.[1] Further, because of the apparent unchanging nature of the celestial bodies he had good reason to suppose that they were of a different nature than the elements we observe on or near the earth. However, once the apparent motion of the stars was accounted for by proposing the rotation of the earth, there was no longer any reason to

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[1] As At. Thomas understands it: "...stellae fixae sunt in suprema sphaera secundum opinionem Aristotelis, qui non posuit aliam sphaeram esse supra sphaeram stellarum fixarum." I De Caelo, Lect. XX, n. 199(2).

suppose the outer limit of the universe as rotating. Without rotation, the evidence for the shape of the universe becomes much more tenuous. When the reason for a fifth element disappeared,[1] the nature of the outer limit became still more mysterious. Yet it is reasonable to suppose that a finite universe must have an outer limit. Since this is the first conception that naturally occurs to one, we will begin by considering how place could be said to exist in a universe with an outer limit and consistent with the main lines of astronomical observation from the time of Galileo and Newton up to the present. In conclusion we will see very briefly, and from a limited standpoint, how place can be said to exist in a finite but limitless universe.

386. If astronomical observation has suggested anything for the last three hundred years it is that the physical universe extends approximately homogeneously in all directions as far as can be seen.[2] If the universe appears to extend homogeneously in all directions and without visible limits, one might easily be led to suppose it to be infinite.[3] Of course, on the general principle of economy this supposition is to be rejected, as we saw when treating the infinite. But

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[1]See Galileo, Dialogue Concerning the Two Chief World Systems, beginning at page 51.

[2]See par. 112.

[3]As indeed the post-Newtonians supposed. Of course a belief in an infinite space entered into this conception. See Koyré, From the Closed World to the Infinite Universe, pp. 274-275.

having rejected the notion of an infinite universe, it must be admitted that astronomical observation tells us nothing about what the limits of the universe must be like. Under such circumstances it would appear to be mere speculation to attempt to determine the sort of limit the universe must have. Yet an analysis of some of the possibilities (considered in the abstract) will be useful in coming to an understanding of how place could be conceived today.

387. One might begin by temporarily supposing the limits of the universe to be immobile and unchanging in shape since one should not propose the existence of a motion for which there is no evidence. Further, its shape might be proposed to be wholly similar part after part, or it might be thought to be irregular in some way. If the outer limit were supposed to be immobile relative to the universe as a whole and irregular but unchanging in shape there would be no difficulty in understanding theoretically what it would be for a body to be in motion or rest. A body approaching or receding from some part of the outer surface of the universe would be in motion. One remaining in the same position with respect to the outer surface would be in place, the surface of the body surrounding it being immobile relative to the outer surface of the universe and hence relative to the universe as a whole.

388. However, if the outer surface of the universe

were sufficiently regular in shape[1] and perfectly homogeneous in subject, having actual parts only indistinctly distinguished one from another[2] or if for some reason this outer surface were thought to rotate relative to the universe as a whole,[3] it would not be possible to determine whether or not a body was moving relative to the universe as a whole merely by comparing this body over a period of time with the outer surface of the universe. For by comparing the body in question with the surrounding surface one could not determine whether or not the body was moving relative to the universe but remaining the same distance from the outer surface of the universe. To determine whether such a motion was present, there would have to be something else present, to which the body in question could be referred.

389. Conveniently, Newton indirectly suggested a method of determining the presence of such a motion. It will be recalled that he distinguished between absolute and relative rotation by an effect present in absolute but absent in relative rotation.[4] According to Newton, when a body is revolving absolutely, its parts tend to recede from the axis of rotation with a centrifugal force which increases as the speed of rotation increases. Of course, we have seen that

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[1]For instance a sphere.
[2]As is the case with something simply continuous.
[3]As it did for Aristotle.
[4]See par. 336-339.

Newton supposes absolute rotation to be a motion with respect to absolute (true) space. Now, in refuting the opinion that place is a space we have refuted this interpretation of absolute rotation. For we have seen that when a body rotates, although the body as a whole does not move from place to place, its parts do. In other words, rotation is a motion with respect to place. Since place cannot be a space, "absolute" rotation cannot be a motion with respect to an absolute space, at least not in the way Newton supposed. Yet the empirical distinction between the two kinds of rotation remains. Absolute rotation gives rise to centrifugal force, relative motion does not.

390. Now, though we must reject Newton's hypothesis that absolute rotation is motion with respect to absolute space taken as place, yet we must admit that his hypothesis comes close to being a suitable one if it is reinterpreted in the light of what we have previously determined. For it would be quite reasonable to suppose that absolute rotation is rotation with respect to the universe as a whole, relative rotation being a rotation with respect to something else considered, more or less arbitrarily, not to rotate. This could only be an hypothesis, but it could be a good one. Even in more modern physics such an hypothesis is tenable. Thus P. W. Bridgman, referring to a different method of determining "absolute" rotation (the Foucault pendulum) has this to say:

Given two worlds like our own in empty space, but surrounded by impenetrable clouds, and each provided with a Foucault pendulum, then we believe that it is physically possible that we may find on one of these worlds the plane of rotation of the pendulum gradually changing in direction, while on the other it remains stationary. This difference we regard as possible without other accompanying physical phenomena which are causally related to the rotation of the pendulum (of course we have to make the two worlds of infinitely rigid material and eliminate other phenomena which we regard as purely incidental), so that we apparently have here a contradiction of our cardinal physical principle of essential connectivity. We are certainly not inclined to give up our principle, and we believe that as a physical fact, if the clouds could be evaporated, an observer in one world would find that he was rotating with respect to the system of fixed stars, whereas the corresponding observer on the other world would find that he was stationary. Our principle of essential connectivity is therefore maintained, in that the rotation of the place of the pendulum is connected with respect to the rest of the universe of the entire world in which the pendulum is mounted. As far as I am aware no other way of maintaining our principle has ever been suggested. But this demands that we give up our physical hypothesis of the possibility of isolating a system. There is here no question of limiting behavior; we believe that no matter how far our rotating world gets from the rest of the universe the Foucault pendulum would always behave in the same way; the system can never be isolated, but such local phenomena as the invariance of the plane of the pendulum are always essentially determined by the rest of the universe.[1]

391. Now, how would the hypothesis that absolute rotation was rotation with respect to the rest of the universe solve our present problem? We said above[2] that in knowing whether a body was approaching or receding from the outer surface of the universe we would not necessarily know whether it was moving with respect to the universe as a whole, for

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[1]P. W. Bridgman, The Logic of Modern Science, pp. 180–182.

[2]Par. 388.

the body might be moving while remaining the same distance from the outer surface. If the outer surface were entirely continuous, homogeneous, and of a regular shape (such as a sphere) one could not perceive such a motion of the given body by comparing it to a part of the outer surface since these parts would be indistinguishable one from the other. And of course it is possible that for some reason the outer surface itself is in rotation (though this may be irrelevant since no reason can be seen for supposing it to be the case). But if it be supposed that Newtonian absolute rotation is actually rotation with respect to the universe as a whole, if a body should be found at the center of the universe (or placed there), and if the absolute rotation of the body should be determined in the Newtonian fashion or by the Foucault pendulum, then by observationally determining (from the body in the center) the angular motion of the body whose motion one wished to measure, making allowance for the known absolute rotation of the body at the center, one could discover whether or not the body in question were truly moving but remaining the same distance from the outer surface. And, of course, one could determine whether the body from which the observation was made was truly in the center by measuring its distance from the outer surface in several directions.[1] Thus having made the assumptions indicated

[1]Obviously this is a very abstract analysis.

above, it is plain that the motion of the body in question and also its rest relative to the whole universe could be understood and even theoretically observed. Hence, we could also grasp what place must be in such a universe. It is the containing surface at rest relative to the universe as a whole in the way indicated above, i. e., neither approaching nor receding from the limits of the universe nor moving "parallel" to them.[1]

392. It may be remarked here that if the universe were as described, with its outer extreme fixed in the manner suggested above, one might well refer to an "absolute" space after all, not an infinite space but still an "absolute" space in the sense of a space not relative to just any body whatever. In the course of this work we have ofter adverted to the conception of place falling under the category of quantity. It will be helpful to recall certain things we have determined about it. We have seen that the magnitude of a body may be considered in two ways. If some body is contained by another body, when we wish to measure the size of the contained body we take the terms of our measurement to be the extremes of the contained body. But when we wish to

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[1]Note that we came to a knowledge of place, here, from a knowledge of motion. This is entirely reasonable because, as was seen above (par. 189), we are aware of the existence of place because we are aware of the existence of motion. In our knowledge, then, how place exists is dependent upon how motion exists.

measure the space or place enclosed by the containing body, we take our measurement as terminating, not at the surface of the contained body, but at the interior containing surface of the containing body. Both measurements yield the same result since the outer extreme of the contained body touches the inner extreme of the containing body. Yet we think that we have measured different things.[1] We have also seen that there is no need to propose the existence of separate interpenetrating magnitudes because of this distinction in our conception of measurement. There is no need to propose any physical basis for this distinction except the potency of the magnitude contained by the container or as the magnitude of this body.[2]

393. Now in a similar (but non identical) manner we can consider that we measure two things when we measure the volume within the outer surface or limit of the universe. We can measure 1) the sum of the volumes of all the bodies in the universe or 2) the space within these extremes, the room for bodies in the universe, i. e. within the limits of the universe. But this does not mean there are two distinct physical magnitudes existing here. Rather, there is no reason to suppose more than one, which reason may regard in these two ways. At least, nothing has been proposed in the

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[1]See par. 22-25.
[2]See par. 27; 358-359.

present work which makes it necessary to assume more than this.

394. This second way of taking the measurement of the universe would seem to provide a rational foundation for a space in some way similar to Newtonian absolute space in the kind of universe we are now discussing, though certainly not identical to that proposed by Newton himself. We have seen that we must deny the infinity of space and we must not propose its existence as something physically distinct from the quantity of bodies. We must also deny that place is a space or part of a space. And of course Newton claimed all these things for his space. Yet in an important respect the space enclosed by the outer surface of the universe, as we have just described it, is very similar to Newton's absolute space. It is strictly and entirely immobile because it is immobile relative to the outer surface (which is immobile relative to the universe as a whole according to the present hypothesis). Hence bodies which truly move from place to place must move relative to this space in some way.

395. Further, in this kind of universe the distance a body moves must be a distance through this space because the magnitudes of the other various bodies in the universe may well be moving relative to the outer surface also. Since the distance a body moves must be some extension immobile relative to the whole universe, the distance a body moves

must be a distance in this quasi-absolute space.

396. It might be noted that just above we said this way of considering the magnitude of the universe was similar to Aristotle's conception of place in the category of quantity. We did not say it was identical because there are no two distinct surfaces at the limit of the universe, that of a containing body and that of a contained body, whereas these two surfaces are implied in the conception of place in the category of quantity.[1]

397. Note also that this space cannot be physical place because a division of bodies does not give rise to a division of this space. For reason grasps this space only by abstracting from a distinct consideration of the various bodies in the universe. Otherwise this space could not be distinct even in reason from the magnitude of the universe taken as the sum of the magnitudes of the various bodies in it.

398. But it may be objected that Aristotle himself claims that the parts of this kind of space (place in the category of quantity) correspond perfectly to the parts of the body with which they are coextensive. Hence, he says:

> ...it follows that the parts of place also, which are occupied by the parts of the solid, have the same common boundary as the parts of the solid.[2]

If this is the case, it seems that in dividing a body we are,

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[1]See par. 23-25.

[2]Cited in par. 22.

in fact, dividing the space (place) it occupies also.

399. But by speaking in this way Aristotle does not wish to indicate that there are always actual distinct parts in the place (space) corresponding to the actual distinct parts of the body in the place. To maintain this would be to destroy the different conceptions of the body and the place (space) which we have. For we have just seen that in thinking of the space occupied by a body we do not consider the body itself occupying that space. Otherwise the space would be known precisely as the quantity of the body occupying it. Rather by speaking in this way Aristotle merely wishes to indicate that the two dimensions (that of the body and that of its logical place or space) are truly and entirely interpenetrating so that wherever the one is, the other is also. Thus, the potential or indistinct parts of the place (space) correspond to the parts (whether potential or actual) of the body occupying it. But dividing the body does not produce actual parts in the space. Otherwise, we repeat, the place (space) could not be distinguished from what is in it.[1]

400. Having seen how place may be said to exist in this sort of universe, we may take up the question of natural place in such a universe. Properly speaking, one must admit that it should not be supposed to exist since on the one hand

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[1]Thus our previous argument actually applies to this space.

no evidence can be found for its existence and on the other there is strong evidence that it does not. There is no evidence that bodies tend to move toward certain positions immobile relative to the universe as a whole. Rather, bodies are observed to tend toward other bodies (or centers of gravity), i. e., the natural motion of a body is toward other bodies.[1] Since these other bodies are observed in motion relative to each other, they can hardly be at rest each with respect to the universe as a whole.

401. To contrast the Aristotelean and the Newtonian positions, for Aristotle,

> If one were to move the earth to where the moon now is, the various fragments of earth would each move not towards it but to the place in which it now is.[2]

But for Newton, if the earth were moved from where it now is, the "fragments of earth" would move not "to the place in which it now is" but to the earth in its new "place". Since Newton's views have been confirmed in this respect, whereas Aristotle's have not, it would be foolish to prefer Aristotle's opinion to that of Newton. Thus, in view of the evidence, natural place should not be held to exist.

402. We saw above that though it was not Aristotle's

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[1]Obviously we are ignoring inertial motion and the combination of the two into one by Einstein, but this is another question.

[2]Aristotle, IV On the Heavens, Ch. II, 310b2. See also St. Thomas, II De Caelo, Lect. XXVI, n. 525(5).

or St. Thomas' view that place itself was a final cause, they did believe that being in a place (which belongs under the category where) was a final cause.[1] But they held this only insofar as "place" is taken materially (i. e. insofar as the surrounding surface is thought to remain one in number because its subject remains one in number). Nevertheless, for them formal and material place corresponded to a certain extent. If a body remained in the same formal place (i. e. if it did not move relative to the universe as a whole), it usually remained in the same material place.[2] In view of the new knowledge, we must admit that formal and material place do not correspond in this way.

403. Of course, from this it does not follow that a natural body (in the kind of universe we are now considering) cannot move from place to place for the sake of something. But the point is that things do not appear to move to a place for the sake of being in the place except per accidens (because of the body now there) since they are naturally indifferent to this or that formal place.

404. Yet, speaking grosso modo, natural things do tend to a "natural place", taking "place" materially. In this sense, the earth is the natural place of the heavy bodies near it, even while the earth itself is actually moving.

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[1] See par. 282-291.

[2] Par. 299-311.

405. Of course, mathematical physics (as such) could never discuss natural place. Yet, as we will see below, it may be of aid in attempting to understand the immobility of formal place.

406. However, it may be objected that the solution we have given to the problem of how local motion and place are to be understood in our universe has been based upon an assumption which is really not justified. For we assumed that there was an immobile surface limiting the universe. The reason given was that there is no evidence for any motion at the outer limit of the universe.[1] Since we do not know of any outer limit of the universe falling under our astronomical observation, it is evident that there is no direct evidence for any motion of the outer surface. But there is considerable indirect evidence against an immobile outer limit to the universe. First, there is the fact that bodies are moving relative to each other. Thus, from induction it would be reasonable to judge that all bodies are moving or at least can move relative to the others (moving relative to each other, they must be all or nearly all moving relative to the universe as a whole). Hence it would seem to be contrary to our experience to suppose that there is an immobile body or system of bodies at the limit of the universe, or anywhere else. Second, as we have just seen, we cannot

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[1]See par. 387.

hold that there are natural places for bodies taking "place" formally. But without the existence of a natural place it would indeed be strange if some body or system of bodies should be at rest in some definite formal place. From these reasons it seems far more probable that there are no immobile limits to the universe.

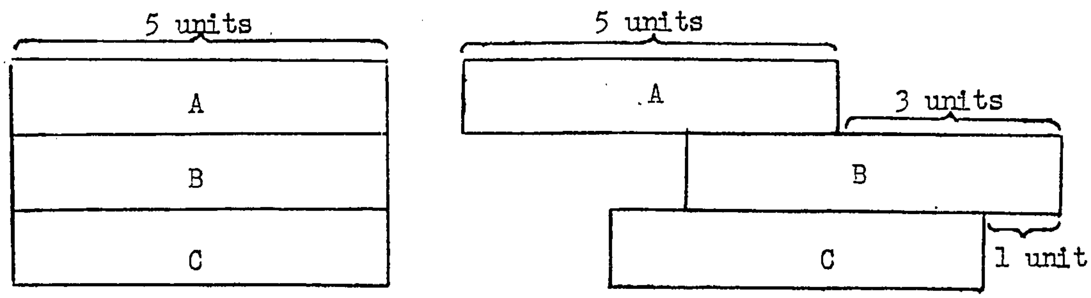
407. But to this conclusion it may be objected that to deny immobile limits to the universe is to destroy the immobility of the universe as a whole. For as we say that some small body is not moving as a whole when its outer surface is not moving, not passing outside of where it was, so it would seem to be with the universe; its immobility must be such that its outer surface is immobile.

408. However, this is not entirely correct. While it is true that the immobility of the universe as a whole is much more obscure if the universe does not have an immobile outer surface, yet the universe may be said to be immobile as a whole without such a surface. Thus, it may be said that there is no motion common to all the bodies in the universe in addition to the motion of these bodies relative to the universe itself. In this sense, to say that the universe as a whole is immobile is to deny that the universe is a system of bodies which may move as a whole through some sort of Newtonian absolute space. Understood in this way, the immobility of the universe as a whole does not demand a fixed outer limit.

409. But if a universe without a fixed outer surface can be said to be itself immobile in this way, can one also truly say that any given body is moving or at rest relative to such a universe? Since it is difficult to conceive how one would be justified in proposing the existence of an immobile center in a universe without a fixed limit, it seems one could not propose any fixed position to exist in such a universe. How, then, could a place have one. But, as we have seen, place must be immobile relative to the universe as a whole, always having the same position relative to the entire universe. If there is no place in the universe, there can hardly be any local motion in the universe. This is certainly a puzzling conclusion, and one contrary to sense experience. Indeed, to maintain it would be to deny the possibility of natural science.

410. By coming to a more precise understanding of a given problem we often approach a solution to it. Therefore, we will try to obtain a more precise understanding of the problem by considering it in a simplified case. Let us suppose the existence of three bodies which are arranged at the time t-1 as in figure I and at a later time t-2 as in figure II. Now, in examining the change from figure I to figure II there are three explanations which first occur to the mind. (1) One might suppose that the motions of the various bodies, A, B and C are immediately relative to the

Figure I   Figure II



whole system, the system as a whole giving the frame of reference for the motions of the various bodies. (2) Or one might suppose that certain of the bodies, e. g. B and C, move relative to the other body, e. g. A, which other body itself is at rest or moving relative to the system as a whole. (3) Or one might suppose that each body moves simply relative to each other body, the only motion present being the approach or recession of a pair or group of bodies to each other, not of the one body of a pair or group as opposed to a motion of the others in the pair or group.

411. Now, considering this system of three bodies to be a simplified case of a universe without an immobile outer surface or limit, let us examine each of these methods of explaining the change from figure I to figure II.

412. We will begin with the first explanation. According to this explanation, each of the bodies moves (or rests) relative to the universe (or complete system of bodies). Thus, if the distance between two bodies becomes greater, one of the bodies may be said to be moving, the other not,

depending upon which of them moves relative to the universe as a whole. Supposing motion to take place in this way, what shall we say happened to bring about figure II from figure I. Certainly one could say that B has been moved 3 units to the right, C having been moved 2 units to the right. But one could equally say that A has been moved 3 units to the left, and C 1 unit to the left; or that A has been moved 2 units to the left, and B 1 unit to the right. One might also say that A has been moved 1 unit to the left, B 2 units to the right and C 1 unit to the right.[1] In other words, if the change in the system is explained in this way, there is no physical difference between a situation in which a given body is at rest while the other bodies in the system are moving, and the situation in which this given body is moving with some other body at rest. There is no difference between a particular body being in motion and that body being at rest, as long as there is a corresponding compensation in other bodies. Whatever a body acquires by its own local motion it can acquire equally well by the motion of some other body.

413. That this explanation is not a suitable one in the light of Aristotelean doctrine is quite plain from

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[1]Though there are many other possibilities, one could not say, for instance, that A has been moved 1 unit to the right, B 4 units to the right and C 3 units to the right since this would destroy the immobility of the system (universe) as a whole. See par. 407-408.

Aristotle's argument against the existence of motion in the category of relation.

> Nor is there motion in respect to relation, for it may happen that when one correlative changes the other, although this does not itself change, is no longer applicable, so that in these cases the motion is accidental

St. Thomas explains this passage as follows:

> For in whatever genus motion is found, nothing of that genus is newly found in something without a change of that thing, as a new color is not found in something colored without an alteration of that thing. But it is contingent for something relative truly to be said newly of something when the other co-relative has changed, though the thing itself has not changed. Therefore, motion is not *per se* in relation, but only *per accidens*, namely insofar as a new relation follows some change, as equality or inequality follows a change according to quantity, and similarity and dissimilarity from change according to quality.[2]

It is not our intention to examine this text in detail. However, from the text itself this much should be plain. For Aristotle and St. Thomas a body can acquire in no other way the act it acquires by its own motion *per se*. Since a body can acquire a new relation by the motion of some other body (e. g. a body may acquire equality by the growth of some other body), it follows that there can be no motion *per se* in the category of relation. Rather, new relations arise from motions in another genus, such as quantity.

414. Now, as we have seen, according to the first explanation given above it makes no difference at all which

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[1]Aristotle, V *Physics*, Ch. II, 225b11.

[2]St. Thomas, V *Physicorum*, Lect. III, n. 666(7).

body is said to be in motion and which at rest. What a body acquires by its own motion it can acquire equally well by the motion of something else. This explanation, then, is in conflict with the understanding of Aristotle and St. Thomas who deny that what a body acquires by its own motion, per se, it can acquire by the motion of another body. Further, in general it is not difficult to see that if motion is something real in particular bodies it must make a difference whether a given body is said to move or to be at rest. This first explanation is therefore to be rejected.

415. Can the change from figure I to figure II be accounted for by proposing the second explanation given above? Evidently not, for this explanation reduces to the first one in the system already described, i. e. a system without a fixed outer limit. According to this second explanation, the motions of the various bodies are all referred to one body, which is said to move or be at rest with respect to the system as a whole. But A, B or C can be the body to which the motions of the other bodies are referred. It makes no physical difference. Further, this reference body, whether A, B or C can be moving or at rest. This makes no difference either. Thus, according to this explanation, it is the individual bodies in the universe which move or are at rest, but there is no difference between a body which is moving and one which is at rest. What it

acquires by its own motion, it can acquire equally well by the motion of the other bodies. This explanation, then, is untenable for the same reason as the first. Besides, the problem would still remain. For how could the one body be said to move or be at rest relative to the universe as a whole.

416. Note that in a way one could say that Aristotle understood local motion according to this second explanation but this was because he supposed the existence of an outer sphere having a fixed position as a whole relative to the universe. Thus, any body moving relative to this sphere (and its center) must be moving relative to the universe as a whole, and a change in the position of a body relative to this outer sphere could be accomplished only by a motion of that body. The motion of no other body could accomplish it. But without a fixed outer limit, this view falls into the difficulty outlined above.

417. Now, it remains to deal with the third explanation of motion in a universe without a fixed outer limit. This explanation may be understood by contrasting it with the first one. According to the first explanation, bodies A, B and C were each moved relative to the system as a whole in such a way that the motion of A belonged to A exclusively, not to B or C. The difficulty with this explanation was that by carefully examining figures I and II no physical difference

was discovered between the presence and the absence of a motion in A, so long as a compensation was made in the motions of the other bodies B and C. But according to the third explanation, the one we are now considering, one should not say that a given motion belongs to some single body, for instance A, but rather the motion belongs no more to the body A than to the other bodies relative to which it moves, for instance B and C.

418. At first glance it might appear that to hold this position is, in fact, to deny that local motion is motion as defined by Aristotle in book III of the Physics.[1] There motion was shown to be an imperfect act, and one belonging to the mobile.[2] But if motion does not belong to any of the individual bodies in the universe, where can one find this imperfect act and how can it belong to the mobile?

419. It must be admitted that the answer to this question is indeed obscure. However, this much can be said, the various bodies in the universe (in our simplified illustration the bodies A, B and C) are certainly ordered differently in figures I and II. Might not the imperfect act which is local motion belong not to this or that particular body itself, but to the entire universe? Evidently, the system as it was

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[1]Aristotle, III Physics, Ch. I; St. Thomas, III Physicorum, particularly Lect. II, nn. 285(3) and 287)5) and Lect. III, n. 296(6).

[2]Aristotle, III Physics, Ch. II, 202a6; St. Thomas, III Physicorum, Lect. IV.

in figure I was potentially ordered as it later came to be in figure II. And when passing from figure I to figure II the order of the parts gradually changed. While passing from figure I to figure II the system acquires something of figure II incompletely but possesses it more and more perfectly as it approaches figure II. It would appear, then, that the gradual passage from potency to act which is motion is found not in particular bodies, but rather only in the entire system or universe.

420. To this explanation two objections may be raised. First, it was maintained above that the universe as a whole was immobile, whereas now we are maintaining that only the entire universe is mobile. Obviously, this objection must be met by a distinction. When we said that the universe as a whole did not move we meant that the universe as a whole did not move relative to anything outside it, there being no place for it to go. When we say now that it is only the entire universe which moves we mean that it is only the entire universe which can possess the imperfect act which is local motion; otherwise there is no physical difference between being in motion and being at rest. According to this explanation, then, when one body approaches or recedes from another body, what really happens is that the individual bodies acquire new relations to each other by virtue of a motion of the universe itself, for example from figure I to figure II, this notion of

the universe not being with reference to anything outside the universe. This will become more plain below.

421. The second objection which may be raised is that this conception is opposed to our common knowledge. For when we throw a stone are we not aware that it is the stone which is moved? And is it not true that within each natural thing there is a principle of its own motion? To deny this would seem to deny Aristotle's definition of nature. If individual bodies do not themselves move, surely one could not maintain that they have within themselves a principle of their own motion.

422. This objection is really twofold, and must be answered in two distinct steps. Now, as to the stone, no doubt something is done to it when it is thrown. Yet the result of throwing the stone would not be at all simple, even if it were supposed that there were a fixed outer limit to the universe. For even then, the resulting motion of the stone would remain (on the level of common observation) relatively unknown. For the increasing distance between the stone and the one who threw it need not be entirely the result of the motion of the stone. When a man throws a stone, the stone acts upon the man just as the man acts upon the stone.[1]

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[1] "To every action there is always opposed an equal reaction: or, the mutual actions of two bodies upon each other are always equal, and directed to contrary parts." (Newton, Mathematical Principles, p. 13). See also, Aristotle, III Physics, Ch. II, 202a5; St. Thomas, III Physicorum, Lect. IV, n. 301(5).

Thus, the muscular sensation we have when we throw a stone comes not from our action upon the stone, but rather from the stone's action upon us. If the stone did not act upon us, we would feel nothing. The increasing distance between the man and the stone must, then, result from the motions of both the stone and the man. But it seems that we are still quite certain that the stone does move. However, this is not entirely true, even in a universe with a fixed limit.[1] For it might well be that the entire immediate system (man, stone, earth) was moving relative to the fixed outer limit before the stone was thrown, and that when the stone was thrown it was brought to a state of rest relative to the outer surface. Or course, as long as we propose a fixed outer limit we must admit that in a system such as that we have just been descriging, some body must have certain amount of motion relative to the outer limit, but our common observation does not permit us to determine which bodies are in motion and which are at rest. We cannot distinguish between motion and rest in particular bodies by common observation. But now, having eliminated the fixed outer surface, it is no longer possible to maintain that certain bodies are moving, as opposed to others which are not, at least from what we have seen thus far. Otherwise we fall into the difficulty outlined above.[2] Nor does this contradict

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[1]Of course, we could always be sure of the relative motion of the stone, but this belongs to the stone no more than to the man who threw it.

[2]See par. 412-414.

our common experience which only enables us to distinguish between purely relative motion and rest in particular bodies, common observation telling us only that there must be motion somewhere, since all that we observe is the increasing or decreasing distance between things. In a universe without a fixed limit, perhaps it can only be the entire universe which moves, and this as a result of the relative motions of the bodies in it, which are now ordered in this way, now in that.

423. However, the second part of this objection remains to be answered. Does not this view of motion destroy nature as Aristotle conceived it?[1] Since Aristotle posited an outer sphere which was immobile as a whole, he could suppose that local motion belonged to individual bodies such as A, B and C. Since this is so, and since bodies move differently,[2] he held that these individual bodies have natures, intrinsic principles of their own local motions. But does the lack of such a motion exclude the existence of any nature or intrinsic principle of motion in them?[3]

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[1]Aristotle, II <u>Physics</u>, Ch. I; St. Thomas, II <u>Physicorum</u>, Lect. I.

[2]By this we do not mean that bodies would not have natures if they did not move differently, but the fact that they have different motions indicates more plainly that they have natures.

[3]Obviously we are discussing nature as it is a principle of local motion, not as it is a principle of other kinds of motion, e. g. alteration. At present we are interested in nature only as it is a principle of local motion in some say.

424. The answer to this question is no. If nature were a force within bodies, then to deny the "absolute" motion of individual bodies would be to deny that bodies have a nature. Hence Newton, who supposed motion to proceed from a force applied to bodies, was led to suppose that individual bodies must each move absolutely. But nature is not a force within things, nor is it anything absolute.[1] When nature is understood in this way it is plain that no body taken absolutely and entirely by itself can have a nature (except in another sense). A body can have a nature only as it is in relation to other bodies and the rest of the universe. This is true even in a universe having a fixed limit. But in a universe without a fixed limit perhaps we must go further than this. It may be that no body has within it a principle of local motion except in cooperation with all the other bodies in the universe, the resultant motion, then, proceeding from the associated natures of all the bodies in the universe and belonging to no singular body alone. Besides, our knowledge of the natures of things is posterior to our knowledge of their motions. Thus, we cannot argue from their natures to their motions. And surely local motion as we observe it around us does not require

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[1] "Ponitur autem in definitione naturae principium quasi genus, et non aliquid absolutum, quia nomen naturae importat habitudinem principii...Unde deridendi sunt qui volentes definitionem Aristotelis corrigere, naturam per aliquid absolutum definire conati sunt, dicentes quod natura est vis insita rebus, vel aliquid huiusmodi." St. Thomas, II Physicorum, Lect. I, n. 145(5).

a fixed outer surface in the universe for its existence.

425. Now we can clarify our understanding of local motion in a universe without a fixed limit.[1] The motion belonging to singular bodies is a purely relative motion. However, purely relative motion is not motion as understood by Aristotle and St. Thomas because for them a body cannot acquire by its own motion *per se* the act it can acquire by the motion of some other body.[2] And purely relative motion is motion of this sort. The act which A acquires by moving towards B, it could acquire by a motion of B toward A.

426. However, this is not true of the universe as a whole. The bodies in it are now in this order, now in that. This change in the order of the whole cannot be acquired by a motion of anything other than this system. Hence, it is only in the whole that motion as understood by Aristotle and St. Thomas can be found. The motion of the whole appears to belong to the whole *per accidens* because it appears to result from the relative motion of the parts. But because motion in the Aristotelean sense does not belong to the parts taken singly (since such motion is purely relative), but only to the whole, in fact, local motion in the Aristotelean sense belongs *per se* to the whole, not to the parts, the purely relative motion of the parts belonging to them only by virtue of the motion

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[1]Our analysis here is a limited one, as will be made plain below.

[2]See par. 413.

(the the Aristotelean sense) of the whole.

427. Having accepted this analysis, it follows that all the bodies in the universe are always moving. For from induction we can surely judge that there is always some body (A) moving relative to some other body (B). It follows, then, that no body anywhere in the universe can be at rest relative to both A and B. Therefore, every body is always moving relative to A or B. Every body, then, is always in relative motion.

428. Now, what are we to say concerning place from our analysis of motion and rest in the universe without a fixed outer limit. For after all, we analyzed motion for the sake of a knowledge of place. It is evident from our analysis of Aristotle's definition that place must be immobile with respect to the universe as a whole. If it were not so, a place could be moved from place to place. But in that case, the places from which and to which the original place was moved would be entirely sufficient. There would be no need to propose the original, mobile place. Place, then, cannot be immobile merely with respect to this or that particular body, for instead of being immobile with respect to the universe as a whole,[1] it would be only relatively immobile. But how can place be more than relatively immobile? How can it be immobile

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[1] Which cannot move from place to place.

relative to the universe as a whole when the universe has no fixed outer limit giving it an immobile frame of reference? From our rather limited standpoint[1] here, only one way can be seen. If we suppose that place exists only in the instant the indivisible of time which is not a period of time, then place can be immobile relative to all the bodies in the universe (being thus surely immobile relative to the universe as a whole). This is so because no body can move in the instant, but only in time.[2] According to the understanding we have reached thus far, then, a place one in number may be distinguished from a mobile containing surface in that the mobile containing surface may remain one in number over a period of time, whereas the place can remain one in number only in the instant. From this analysis it appears that the various bodies in the universe are now in one place, now in another, though they have themselves individually only relative motions, possessing these, indeed, only because of the motion of the system of the whole universe.

429. From this position it follows that bodies never rest in a place (taking place formally) for they are in a place only in the instant, whereas a body which rests does so in time.[3] But this appears reasonable of one notes that it is a

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[1] We will say more about this below.

[2] St. Thomas, IV *Physicorum*, Lect. XXII, n. 623(4)-624(5).

[3] *Ibid*., Lect. XX, n. 608(9)-609(10).

commonplace of astronomy that all things are in motion. If all things are in motion, it is not surprising that they are in place only in the instant.

430. Obviously this gives place a very limited existence but when it is considered that temporal things physically exist in act only in the now, the indivisible of time, the existence of place only in the instant seems less incredible.

431. Finally, what has been determined in this work may be applied to modern, scientific, macroscopic theory. For Einstein the universe, though finite, is without an outer limit. It is finite in the way a circle is finite.[1] If one went far enough in any direction according to the straightest line possible one would come back to approximately the same point from which one began. Evidently, we cannot enter into an analysis of Einstein's physics but this much we can say, our explanation of the way place exists in a finite universe without a fixed limit applies equally to a finite but limitless universe and this is what Einstein proposes. Indeed, by eliminating the mysterious boundary we have discussed, the need for an explanation such as our is made more plain. In such a universe one no longer looks for an utterly immobile reference body.

432. In reflecting upon our solution to the problem

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[1] See par. 120.

of the immobility of place it will be recalled that we have several times indicated that we were considering the problem from a limited stand:oint. Our analysis might be characterized as geometrical. We have attempted to understand the immobility of place by examining how it could have an immobile position in the body of the universe, taking up in turn several possible world sustems. This method might be called the direct approach, for it is an enquiry into the way place exists from what place is, a surface "having a determined position in the universe."[1] But while place must ultimately be understood in these terms, perhaps it may be investigated in a more indirect way also. We hinded at this possibility previously, when we attempted to determine the immobility of place partly from an effect of "absolute" rotation.[2] We must now point out that an examination of motion and rest by an analysis of the laws and theories of mathematical physics may make it possible to obtain a more complete, though indirect, understanding of the immobility of place. For instance, an examination of the degredation of energy implied in local motion may indicate that there is a motion in particular bodies which is not purely relative. Such a knowledge would never be more than probable, but it should not be neglected for this reason. Of course, such an analysis goes beyond the scope of this paper. Of this

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[1]St. Thomas, IV Physicorum, Lect. VI, n. 4?3(9).
[2]See par. 388-391.

much we can be sure, however, place must have at least as much existence as we have indicated above.

433. From this long and rather involved examination of Aristotle's definition, we can see that it is a very difficult one to understand. Yet, the definition remains a valid one for us, even today, though the advance in scientific knowledge since his day has considerably altered cosmology and hence its concrete application. Nor is this strange, since we begin by knowing things in a certain but confused way, only gradually attaining a more distinct knowledge of them. Unfortunately, this more distinct knowledge is usually less certain, as is doubtless the case with our knowledge of place.

THE END.

BIBLIOGRAPHY

ARISTOTLE

The Works of Aristotle, translated into English, ed. W. D. Ross, Oxford, 1928, 1930.[1]
Vol. I: *Categories*[2]
Vol. II: *Physics*
On the Heavens (De Caelo)
Vol. VIII: *Metaphysics*
Categories, translated into English by H. P. Cooke, Cambridge, William Heinemann Ltd (Loeb).

ST. ALBERT DE GREAT[3]

De Praedicabilibus, Opera Omnia, Paris, Vives, 1890, vol. I.
De Sex Principiis, Opera Omnia, Paris, Vives, 1890, bol. I.

A. E. BABIN

The Theory of Opposition in Aristotle, Notre Dame, 1940.

NANDOR LASZLO BALAZS

Space-Time, an article in the *Encyclopedia Britannica*, vol. XXI, 1960.

P. W. BRIDGMAN

The Logic of Modern Science, New York, Macmillan, 1960.

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[1] This is the basic translation used in this work. However, the translations in the Ross edition have been slightly altered, where necessary, to make them more suitable.

[2] Unless the Loeb edition is specifically cited, the translation of the *Categories* is always cited from the Ross edition.

[3] The text of every logical work of St. Albert has been transcribed from the Borgnet edition, long out of print, and made available in mimeograph by Michel Doyon, 1215 Chemin Ste Foy, Québec 6, Canada (1950-1956).

EDWIN ARTHUR BURTT

The Metaphysical Foundations of Modern Science, Garden City, Doubleday Anchor Books, 1954.

EUCLID

The Thirteen Books of Euclid's Elements, translated by Heath in three volumes, New York, Dover, 1956.

PHILIPP FRANK

Modern Science and Its Philosophy, New York, George Braziller, 1955.

GALILEO GALILEI

Dialogue Concerning the Two Chief World Systems, Ptolemaic and Copernican, translated by Stillman Drake, Berkeley, University of California Press, 1953.

GEORGE GAMOW

The Creation of the Universe, New York, Mentor, 1957.

MAX JAMMER

Concepts of Space, Cambridge, Harvard University Press, 1954.

JOHN OF ST. THOMAS

Cursus Philosophicus, Turin, Marietti, 1950.

ALEXANDRE KOYRE

From the Closed World to the Infinite Universe, Baltimore, Johns Hopkins Press, 1957.

SIR ISAAC NEWTON

Mathematical Principles of Natural Philosophy, translated by Motte, revised by Cajori, Berkeley, University of California Press, 1960.
Optics, Great Books of the Western World, ed. Hutchins, Chicago, Encyclopedia Britannica, Inc., vol. 24, 1952.

VINCENT SMITH

The General Science of Nature, Milwaukee, Bruce, 1958.

ST. THOMAS AQUINAS

In Octo Libros Physicorum Aristotelis Expositio, Turin, Marietti, 1954

In Libros Aristotelis De Caelo et Mundo Expositio, Turin, Marietti, 1952.

In Librum Primum Aristotelis De Generatione et Corruptione Expositio, Turin, Marietti, 1952.

In Aristotelis Librum De Anima Commentarium, Turin, Marietti, 1948.

In Duodecim Libros Metaphysicorum Aristotelis Expositio, Turin, Marietti, 1950.

Summa Theologiae, Turin, Marietti, 1950.

In Decem Libros Ethicorum Aristotelis ad Nicomachum Expositio, Turin, Marietti, 1949.

De Potentia, Questiones Disputatae, vol. II, Turin, Marietti, 1953.

In Librum Boetii De Trinitate Expositio, Opuscula Theologica, vol. II, Turin, Marietti, 1954.

De Natura Generis, Opuscula Philosophica, Paris, Lethielleux, 1949 (authentic for Grabmann, spurious for Mandonet).

Summa Logicae, Opuscula Omnia, ed. Mandonnet, Paris, Lethielleux, 1927, vol. V (Spurious).

HERMANN WEYL

Philosophy of Mathematics and Natural Science, Princeton, 1949.

G. J. WHITROW

The Structure and Evolution of the Universe, New York, Harper and Brothers, 1959.