

# THE EXISTENCE OF ABSOLUTE SPACE

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One of the clearest examples showing that classical physics is but a limited case of relativity physics is the history of Newton's famous "bucket experiment." The classicists, such as Newton, the positivists, such as Mach, and the twentieth-century relativity physicists have all referred to this example in defending their conceptions of space. Not only do the various physicists use this example in their discussions of the nature of space, but the current status of discussion about the pail shows that the absolute character of space is still held, although with modifications. The purpose of this paper is to state the history of the discussion concerning the bucket experiment (which is actually just an illustration) intending to show that *there are still senses in which space is considered absolute*.

Newton conceived space to be absolute and claimed to have proof of its absolute nature. He maintained that absolute space is a great void which objects occupy. It exists independently of objects, and if there were no objects, then space would still exist. Thus, this space has a character independent of objects, one of which, as we shall presently see, is to affect objects. Newton's oftquoted definition of space is that absolute space is its own nature, without relation to anything external, remains always similar and immovable; i.e., that absolute space is always the same, related to nothing, and immovable. Newton also recognized relative space which changes, related to objects, and moves within absolute space. That there are relative spaces can be determined, he maintained, through a study of translatory motion; while the determination of the existence of absolute space involves inferences based upon a study of rotational motion. One can more clearly grasp the nature of Newtonian absolute space by contrasting it with the relative space of Leibniz.

Leibniz opposed the Newtonian position by contending that space is the observed relation of coexistent phenomena. Space is not a substance, but an idea derived from a series of observations of groups of fixed existents (called places) taken together. If there were no objects then there would be no space—just the opposite of Newton. Leibniz endeavoured to disprove Newton's position with his famous principle of the identity of the indiscernables, one part of which can be stated as ". . . if there is no method of distinguishing between what are two distinct states of affairs, then there is in fact only one state." He used this to reply to an argument by Clark, a Newtonian disciple, who contended that the whole universe might be moved in absolute space. Leibniz said that it would be impossible to distinguish between the positions of a group of bodies in two different parts of absolute space. And if this indiscernability is an actuality, then there is no reason to contend that a change from one part of space to another has taken place. Newton's absolute space is a meaningless concept. Hence, space presupposes the existence of objects. I conclude from Leibniz's discussion that there is no doubt but that Clark-Newton would have been thoroughly ploughed had their argument rested upon translational motion; Newton, however, relied upon rotational motion to prove his point.

The following is Newton's argument for absolute motion. This is referred to as the "pail experiment":

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, 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, and the swifter the motion becomes, the higher the water will rise, till at last, performing its revolutions at the same times with the vessel, it becomes relatively at rest with it. This ascent of the water shows its endeavor to recede from the axis of motion, and the true and absolute circular motion of the water, which here is directly contrary to the relative, becomes known and may be measured by this endeavor. . . . And therefore this endeavor does not depend upon any translation of the water in respect of the ambient bodies, nor can true circular motion be defined by such translation (Cajori, 1934).

The following diagram will make this clearer:

Consider three glass pails:

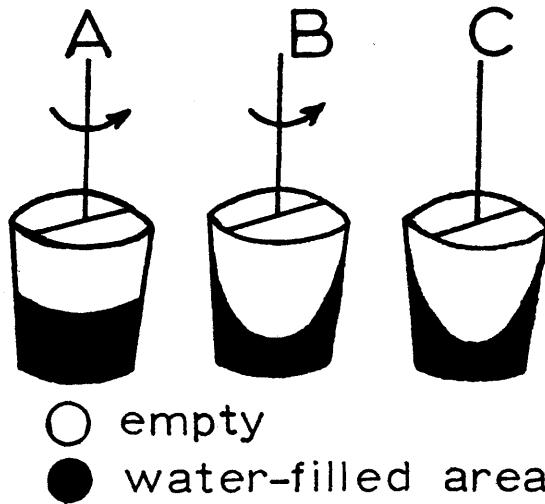


FIGURE 1. G—velocity of the glass. W—velocity of the water. K—constant.

A	B	C
Glass in motion; Water not in motion $G - W = K$	Both Glass and Water in motion $G - W = 0$	Glass not in motion; Water in motion $W - G = K$

Here Newton maintained that if all motions were relative, then there should be no difference between the situation in A and in C, but obviously there is a difference, viz., in the water level, which is due to centrifugal force. Newton says that this is due to rotation in absolute space. Absolute space acts upon the bodies within it, for how else is one to account for the difference of water states? Some critics of Leibniz (Jammer, 1954) have noted that he never successfully answered this particular argument although he tried to do so. It is felt that for this reason Newton, rather than Leibniz, became accepted on this point until the time of Mach.

The main critic of Newton's argument for absolute space, in the period just before Einstein stated his General Theory of Relativity, was Mach. He attempted to prove that it was not necessary to assume absolute space to account for centrifugal forces in rotational motion:

Newton's experiment with the rotation vessel of water simply informs us that the relative motion of the water with respect to the sides of the vessel produces no noticeable centrifugal forces, but that such forces are produced by its relative rotation with respect to the mass of the earth and other celestial bodies (Mach, 1902).

“Newton,” says Mach, “must be able to prove his argument would be sound under the condition that space were absolutely empty. As such a condition is impossible to experience, Newton’s argument is not empirically based . . . hence not scientific.” “Furthermore,” Mach contends, “Newton holds to a contradiction, viz., a space which acts, but cannot be acted upon.” Mach, however, was unable to give a quantitative explanation of these centrifugal forces, and so his position remained unaccepted.

Einstein, differing from Mach, gave greater significance to the famous bucket experiment:

(Newton) had recognized that the observable geometrical magnitudes (distance of material points from one another) and their change in the process of time to not completely determine movements in a physical sense. He shows this in the famous *bucket experiment* . . . He recognized that space must possess a sort of physical reality if his laws of motion are to have a meaning, a reality of the same sort as the material points and their distances (Einstein, 1927).

Einstein held that space did possess a sort of physical reality, and thereby he can be said to have given “absolute space” meaning. His finite and unbounded universe consists of objects and their gravitational fields. The stars and their gravitational fields provide the shape of the universe, and their directions provide the axes of an inertia frame with respect to which absolute rotation can be measured. Thus, “. . . absolute space and time are restored to the universe as a whole” (Whetrow, 1959). It is certainly true that absolute space here means something different than the meaning given by Newton, but note that Einstein himself attributes to space-time an absolute nature:

Just as it was consistent from the Newtonian standpoint to make both the statements, *tempus est absolutum*, *spatium est absolutum*, so from the standpoint of the special theory of relativity we must say, *continuum spatii et temporis est absolutum*. In this statement *absolutum* means not only physical real, but also independent in its physical properties having a physical effect (Einstein, 1955).

Einstein’s space-time finite and unbounded universe has just such physical properties. And it is my point to show that there is a significance sense in which Einsteinian space-time is said to be absolute.

There is still another philosopher-scientist, d’Abro, who gave significance to the bucket experiment, and who contends that the experiment plus the results of the relativity theories, as well as the speculations by Abbe LeMaitre about the universe, give rise to still another conception of absolute space:

Physical experiments had established the identity of two types of masses, the inertia and the gravitational. Hence the forces of inertia and gravitation should be essentially the same. But there is a marked difference between the distribution of forces of inertia and those of gravitation. Forces of inertia can be cancelled by the observer changing his motion. We cannot permanently get rid of the force of gravitation. . . . It follows that the non-Euclideanism of space, present in a gravitational field, must come from a deeper source. In particular, it must arise from an intrinsic non-Euclideanism in space-time which surrounds matter since it is only a curved non-Euclidean space-time that can never be split up into flat space and flat time. Matter . . . causes space-time to become curved. . . . Space-time is primarily an absolute four dimensional continuum of events. When devoid of matter and energy its structure is flat. When matter is present, the flat structure yields gently both around matter and in its interior. . . . (For Mach to have been correct) matter would have to create space-time and its structure . . . *not merely modify a locally preexisting structure* (d’Abro, 1950).

This concept of space-time is in sharp contrast to Einstein’s, as in the latter space would be nonexistent if there were no matter. d’Abro maintains that space-time has a character independent of matter; i.e., it is affected by matter but not determined by it. This space-time is referred to as being “quasi-Euclidean” by d’Abro and Lemaitre. And Einstein, himself, says:

If the universe were quasi-Euclidean, then Mach was wholly wrong in his thought that inertia, as well as gravitation, depends upon a kind of mutual action between bodies (Einstein, 1955).

It is true that when Einstein wrote this statement he did not believe the universe to be quasi-Euclidean, but ten years later in 1932 he stated that his objections in the above work ". . . to a world model of finite density in Euclidean space no longer applied if space could be considered as expanding" (Whitrow, 1959). And it is just on this basis that d'Abro believes his space-time theory is more adequate than Einstein's. d'Abro contends that Lemaitre's expanding universe theory is more adequate than the finite and unbounded world model. Lemaitre asserts that there is a nucleus of matter expanding in an infinite universe. Such a universe would be Euclidean because it is infinite and independent of matter, but only quasi-Euclidean because it is affected by the matter in it. This latter point brings out the fact that d'Abro bases his views upon the General Relativity theory. There are many world models that are so based, and there are many that are not. The Lemaitre model is not as universally accepted as d'Abro implies. That space-time is, however, independent of matter is held by d'Abro and many others and in this sense is absolute.

The purpose of this paper is to bring out the various senses in which space was and is held to be absolute. Newton held that absolute space was independent of matter but affected it, as evidenced by the pail experiment. Einstein held to an absolute space-time, although it is dependent upon the existence of matter and its fields. d'Abro holds that space-time was absolute in being independent of matter but affected by it. Thus, the concept of absolute space is not a discarded one.

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