PHILOSOPHY OF SPACE AND TIME various authors

Philosophy of space and time is the branch of philosophy concerned with the issues surrounding the ontology, epistemology, and character of space and time. While such ideas have been central to philosophy from its inception, the philosophy of space and time was both an inspiration for and a central aspect of early analytic philosophy. The subject focuses on a number of basic issues, including—but not limited to—whether or not time and space exist independently of the mind, whether they exist independently of one another, what accounts for time's apparently unidirectional flow, whether times other than the present moment exist, and questions about the nature of identity (particularly the nature of identity over time).

Ancient and medieval views

The earliest recorded Western philosophy of time was expounded by the ancient Egyptian thinker Ptahhotep (c. 2650–2600 BC), who said: "Do not lessen the time of following desire, for the wasting of time is an abomination to the spirit." The *Vedas*, the earliest texts on Indian philosophy and Hindu philosophy dating back to the late 2nd millennium BC, describe ancient Hindu cosmology

, in which the
universe
goes through repeated cycles of creation, destruction and rebirth, with each cycle lasting 4,320,000 years.
Ancient
Greek philosophers
, including
Parmenides
and
Heraclitus
, wrote essays on the nature of time.
[1]

In Book 11 of St. Augustine's *Confessions*, he ruminates on the nature of time, asking, "What then is time? If no one asks me, I know: if I wish to explain it to one that asketh, I know not." He settles on time being defined more by what it is not than what it is.
[2]

In contrast to ancient Greek philosophers who believed that the universe had an infinite past with no beginning, medieval philosophers and theologians developed the concept of the universe having a finite past with a beginning. This view was inspired by the
creation myth
shared by the three
Abrahamic religions
:
Judaism
,
Christianity
and
Islam
. The
Christian philosopher
,
John Philoponus
, presented the first such argument against the ancient Greek notion of an infinite past. His were adopted by many including, most notably,
early Muslim philosopher
,
Al-Kindi
(Alkindus); the
Jewish philosopher

,
Saadia Gaon
(Saadia ben Joseph); and the
Muslim theologian
,
Al-Ghazali
(Algazel). They used his two logical arguments against an infinite past, the first being the "argument from the impossibility of the existence of an actual infinite", which states:
[3]

"An actual infinite cannot exist."

"An infinite temporal regress of events is an actual infinite."

" ∴ An infinite temporal regress of events cannot exist."

The second argument, the "argument from the impossibility of completing an actual infinite by successive addition", states:[3]

"An actual infinite cannot be completed by successive addition."

"The temporal series of past events has been completed by successive addition."

" ∴ The temporal series of past events cannot be an actual infinite."

Both arguments were adopted by later Christian philosophers and theologians, and the second argument in particular became more famous after it was adopted by Immanuel Kant in his thesis of the first
antinomy
concerning time.

[3]

In the early 11th century, the Muslim physicist, Ibn al-Haytham (Alhacen or Alhazen), discussed space perception and its epistemological implications in his *Book of Optics* (1021). His experimental proof of the intromission model of vision led to changes in the way the visual perception of space was understood, contrary to the previous emission theory of vision supported by Euclid and Ptolemy. In "tying the visual perception of space to prior bodily experience, Alhacen unequivocally rejected the intuitiveness of spatial perception and, therefore, the autonomy of vision. Without tangible notions of distance and size for correlation, sight can tell us next to nothing about such things." [4]

Realism and anti-realism

A traditional realist position in ontology is that time and space have existence apart from the human mind. Idealists deny or doubt the existence of objects independent of the mind. Some anti-realists whose ontological position is that objects outside the mind do exist, nevertheless doubt the independent existence of time and space.

Kant, in the *Critique of Pure Reason*, described time as an *a priori* notion that, together with other *a priori* notions such as space, allows us to comprehend sense experience. For Kant, neither space nor time are conceived as substances, but rather both are elements of a systematic framework we use to structure our experience.

Spatial measurements are used to quantify how far apart objects are, and temporal measurements are used to quantitatively compare the interval between (or duration of) events.

Idealist writers such as J. M. E. McTaggart in *The Unreality of Time* have argued that time is an illusion (see also The flow of time below).

The writers discussed here are for the most part realists in this regard; for instance, Gottfried Leibniz held that his monads existed, at least independently of the mind of the observer.

Absolutism and relationalism

Leibniz and Newton

The great debate between defining notions of space and time as real objects themselves (absolute), or whether they are merely orderings upon actual objects (relational), began between physicists Isaac Newton (via his spokesman, Samuel Clarke) and Gottfried Leibniz in the papers of the Leibniz-Clarke Correspondence.

Arguing against the absolutist position, Leibniz offers a number of thought experiments with the purpose of showing that there is contradiction in assuming the existence of facts such as absolute location and velocity. These arguments trade heavily on two principles central to his philosophy: the principle of sufficient reason and the identity of indiscernibles. The principle of sufficient reason holds that for every fact there is a reason that is sufficient to explain what and why it is the way it is and not otherwise. The identity of indiscernibles states that if there is no way of telling two entities apart then they are one and the same thing.

The example Leibniz uses involves two proposed universes situated in absolute space. The only discernible difference between them is that the latter is positioned five feet to the left of the first. The possibility of the example is only available if such a thing as absolute space exists. Such a situation, however, is not possible according to Leibniz, for if it were, where a universe was positioned in absolute space would have no sufficient reason, as it might very well have been anywhere else. Therefore, it is contradicting the principle of sufficient reason, and there could exist two distinct universes that were in all ways indiscernible, thus contradicting the identity of indiscernibles.

Standing out in Clarke's (and Newton's) response to Leibniz arguments is the bucket argument: Water in a bucket, hung from a rope and set to spin, will start with a flat surface. As the water begins to spin in the bucket, the surface of the water will become concave. If the bucket is stopped, the water will continue to spin, and while the spin continues the surface will remain concave. The concave surface is apparently not the result of the interaction of the bucket and the water, since the water is flat when the bucket first starts to spin, becomes concave as the water starts to spin, and remains concave as the bucket stops.

In this response, Clarke argues for the necessity of the existence of absolute space to account for phenomena like rotation and acceleration that cannot be accounted for on a purely relationalist account

. Clarke argues that since the curvature of the water occurs in the rotating bucket as well as in the stationary bucket containing spinning water, it can only be explained by stating that the water is rotating in relation to the presence of some third thing—absolute space.

Leibniz describes a space that exists only as a relation between objects, and which has no existence apart from the existence of those objects. Motion exists only as a relation between those objects. Newtonian space provided the absolute frame of reference within which objects can have motion. In Newton's system the frame of reference exists independently of the objects which are contained in it. These objects can be described as moving in relation to space itself. For many centuries, the evidence of a concave water surface held authority.

Mach

Another important figure in this debate is 19th century physicist, Ernst Mach. While he did not deny the existence of phenomena like that seen in the bucket argument, he still denied the absolutist conclusion by offering a different answer as to what the bucket was rotating in relation to: the fixed stars.

Mach suggested that thought experiments like the bucket argument are problematic. If we were to imagine a universe that only contains a bucket, on Newton's account, this bucket could be set to spin relative to absolute space, and the water it contained would form the characteristic concave surface. But, in the absence of anything else in the universe it would be difficult to confirm that the bucket was indeed spinning. It seems equally possible that the surface of the water in the bucket would remain flat.

Mach argued that, in effect, the water experiment in an otherwise empty universe would remain flat. But if another object was introduced into this universe, perhaps a distant star, there is now something relative to which the bucket could be seen as rotating. The water inside the bucket could possibly have a slight curve. To account for the curve that we observe, an increase in the number of objects in the universe also increases the curvature in the water. Mach argued that the momentum of an object, whether angular or linear, exists as a result of the sum of the effects of other objects in the universe (Mach's Principle).

Einstein

Einstein, a prominent physicist in the 20th century, proposed that relativistics are based on the principle of relativity
. This theory holds that the rules of physics must be the same for all observers, regardless of the frame of reference that is used, and that light propagates at the same speed in all reference frames. This theory was motivated by
Maxwell's equations
. These equations show that electromagnetic waves propagate in a vacuum at the
speed of light
. However, Maxwell's equations give no indication of what this speed is relative to. Prior to Einstein, it was thought that this speed was relative to a fixed medium, called the

luminiferous ether
. In contrast, the theory of special relativity postulates that light propagates at the speed of light in all inertial frames, and examines the implications of this postulate.

All attempts to measure any speed relative to this ether failed, which can be seen as a confirmation of Einstein's postulate that light propagates at the same speed in all reference frames. Special relativity is a formalization of the principle of relativity which does not contain a privileged inertial frame of reference such as the luminiferous ether or absolute space, from which Einstein inferred that no such frame exists.

Einstein generalized relativity to frames of reference that were non-inertial. He achieved this by positing the Equivalence Principle, which states that the force felt by an observer in a given gravitational field and that felt by an observer in an accelerating frame of reference are indistinguishable. This led to the conclusion that the mass of an object warps the geometry of the space-time surrounding it, as described in Einstein's field equations
.

In classical physics, an inertial reference frame is one in which an object that experiences no forces does not accelerate. In general relativity, an inertial frame of reference is one that is following a geodesic of space-time. An object that moves against a geodesic experiences a force. An object in free fall does not experience a force, because it is following a geodesic. An object standing on the earth, however, will experience a force, as it is being held against the geodesic by the surface of the planet. In light of this, the bucket of water rotating in empty space will experience a force because it rotates with respect to the geodesic. The water will become concave, not because it is rotating with respect to the distant stars, but because it is rotating with respect to the geodesic.

Einstein partially advocates Mach's principle in that distant stars explain inertia because they provide the gravitational field against which acceleration and inertia occur. But contrary to Leibniz' account, this warped space-time is as integral a part of an object as are its other defining characteristics such as volume and mass. If one holds, contrary to idealist beliefs, that objects exist independently of the mind, it seems that Relativistics commits them to also hold that space and temporality have the exact same type of independent existence.