432018 PHILOSOPHY OF PHYSICS (Spring 2002)

Lecture 11: An introduction to space and time

Preliminary reading: Sklar, pp. 11-18.

We now turn our attention to Relativity Theory. In the next two lectures we will initiate our study of this twentieth century theory by looking at some earlier views about the nature of space. To do this, we start by briefly examining

- some of the *issues* that arose in the context of this earlier debate (since it is important to keep these in mind when we turn our attention to Relativity Theory), and
- the *background* to this earlier debate (since it is important to understand what the people who proposed these views were reacting against).

We then turn to the two main pre-twentieth century views of space, namely Newton's 'absolutist' theory and Leibniz's 'relationist' theory. In the next lecture we shall look at the arguments that were most influential in this debate, specifically Newton's bucket 'argument' and some of the arguments put forward by Leibniz and Clarke (a proponent of Newton's views) in the famous Leibniz-Clarke correspondence.

We also have to consider the pre-twentieth century view of time and, to do this, we shall briefly consider Leibniz and Newton's views on time at the end of the next lecture. This is important since, when we come to Relativity Theory we will have to consider how time and space are 'combined' to give us a 'space-time'. But, although 'time' is an important concept in the Philosophy of Physics due to the role it plays in Relativity Theory, most of the usual philosophical debates about time[1] are normally considered within a metaphysics course and, as such, they do not concern us here.

1 Issues in the philosophy of space

There are, generally speaking, three questions that can be distinguished when philosophers address the 'problem of space and time'. And, depending on what you are trying to do when you address this 'problem', your 'solution' is going to be focused on one of these. In particular, we have:

1. The *metaphysical* question: 'What is the ontological status of space and time?' Or, put more succinctly, 'What *are* space and time?'. (For example, at least generally speaking, see Leibniz and Clarke.)
2. The *physical* question: 'Which concepts of space and time are most useful in physics?'. (For example, see Newton.)
3. The *epistemological* question: 'How do we acquire our knowledge of space and time?'. (For example, see Kant.)

To some extent, these three questions are hard to separate when addressing the general 'problem' of space and time. And, in particular, this has led many philosophers to motivate an answer to the metaphysical question based on considerations which apply to the epistemological one. As always, care must be taken when considering one of these questions from a viewpoint which is probably more appropriate to another.

2 Aristotle's view of space

Although, it does not directly concern us in this course, we start by briefly outlining Aristotle's theory of space. This is particularly useful since it allows us to see the view of space which Leibniz

[1] For example, the relationship between time and change, questions about whether time is best represented by an A-series or a B-series, *et cetera*.

and Newton were reacting against. We shall then introduce the Newtonian and Leibnizian views of space, taking care to see how they differ from the Aristotelian view.

Aristotle's view of space is complicated, largely due to the fact that it plays an 'active' role within his physics. That is, for Aristotle, the location of an object in space plays a role in determining how that object will move. So, basically, Aristotle's 'container' theory of space ran as follows:

- Space is the 'container' in which objects are found.
- Space is causally efficacious since, when following their 'natural motions', objects tend to their 'natural places'. (For example, when following their 'natural motion' bodies made of 'earth' tend towards the centre of the universe which, for Aristotle, was the centre of the Earth.)
- As such, space is neither isotropic (the same in all directions) nor homogeneous (the same in all places) due to the 'natural tendency' of bodies made of different 'elements' to travel in certain directions (e.g. 'up' or' down') and accumulate at certain places (e.g. near the centre of the Earth).

Indeed, discussions about the nature of space were common in ancient Greek philosophy. In particular, many 'puzzles' arose from the view that space is, literally, a container which is filled by material objects.[2]

The work of Galileo and its codification within Newtonian Mechanics does away with most of the Aristotelian framework. In particular, the view that space is causally efficacious is abandoned in favour of a view where motion is 'caused' by forces. As such, this new theory posits a space which is both isotropic and homogeneous — it is the stage on which physical phenomena are played out as opposed to one of the players. Consequently, in this 'classical' setting the only aspect of Aristotle's theory of space that survives is the idea that space is a 'container', and this remnant of the Aristotelian view is, pretty much, the crux of the disagreement between Leibniz and Newton.

3 Newton's 'absolutist' view of space

Newton's view of space is, generally speaking, a 'container' view. But, when we consider his view, it is important to clearly separate three different aspects of his account. Namely, one which we could call the 'conceptual need' for a container-like space, and two which purport to answer the metaphysical and physical questions which we distinguished earlier. Thus, we should consider Newton's view of space from three different perspectives, namely:

1. his claim that a container-like space is, in some sense, necessary for the existence of material bodies. (As we shall see, Leibniz's account of space is largely aimed at refuting this claim.)
2. his claim that it is required for his physics, i.e. his view of space is useful since it allows us to account for certain kinds of physical phenomena. (As we shall see, Mach disagrees with this claim.)
3. his view of what space *is*, i.e. his answer to the metaphysical question about the nature of space. (As we shall see, he claims that it is a *substance* and this isn't a tenable claim nowadays.)

In particular, when criticising Newton's view of space, we should be careful to avoid conflating the need for an *absolute* space (as argued for in 1. and 2.) with what he takes space to be — let's call it *substantival* space — the *substance* which forms the basis of his response to the metaphysical question raised in 3.[3]

[2] For example, when a material object is inside the container, is the boundary of the object a part of the object or a part of space? And, if a region of space is empty, then it contains nothing and so how can this 'nothingness' (or 'void') exist?

[3] Rather unfortunately, the modern view that space is, in some sense, 'out there' is often called 'substantivalism'. More on this later.

3.1 Space — the container

When, with Newton, we think of space as a 'container' we are generally thinking along the following lines,

> Space is an affectation of a thing *qua* thing ... space is an emanative effect of the first existing thing because *if anything is posited, space is posited*' [Newton, On the Gravity and Equilibrium of Fluids, my italics]

That is, Newton seems to be advocating the idea that we can only conceive of [material] objects if we conceive of a space where they exist. So, basically, we have the idea that such bodies can only exist if there is a space for them to exist *in*. Furthermore, he says that

> Space is a disposition of being *qua* being ... No being exists or can exist which is not related to space in some way ... Whatever is neither everywhere [as is God] or anywhere [as are bodies] does not exist. And hence it follows that space is an effect arising from the first existence of being, *because when any being is postulated, space is postulated*' [Newton, ?, my italics]

Thus, Newton again seems to be arguing that space is *necessary* for the existence of material objects, i.e. if there was no space, there could be no material objects since they would have 'nowhere' to exist.

3.2 Space — the absolute frame of reference

Once you have committed yourself to a 'container' view of space, it is natural to think that this 'container' can serve as an absolute frame of reference. That is, every material object has a location in this absolute space. Furthermore, we can then talk about absolute motions, i.e. whether or not a given material object is moving relative to this absolute space. We shall not dwell on this here since it will make more sense after we have discussed Leibniz's position.

3.3 Space — the substance

But, if you are going to have a space which is a 'container' and serves as an absolute frame of reference, we can ask what this space *is*. Newton claimed that space was a *substance*, and at the time, this was a reasonable thing to say. However, on the other hand, at the time, there were many different conceptions of 'substance' around. So, given that the concept of 'substance' has fallen into disrepute in modern times, this is probably the most untenable part of Newton's view of space.

However, to get an idea of the sort of substance Newton had in mind, let's see how he tried to explicate the metaphysical underpinnings of his view. Firstly, we have the idea that

> There is no idea of nothing, nor has nothing any properties, but we have an exceptionally clear idea of extension, abstracting the dispositions and properties of a body so that there remains only the uniform and unlimited stretching out of space in length, breadth and depth. [Newton, ?]

That is, we have the idea of substance *qua* conceptual ground for certain properties. Secondly, we have the idea that

> Although space may be empty of body, nevertheless it is not itself a void; and *something* is there because spaces are there, though nothing more than that. [Newton, ?]

That is, we have the idea of substance *qua* independently existing thing. So, we have reasons for believing that space is something in itself, independent of material objects, which is fundamental to our view of the material universe. What ontological category do such fundamental entities belong to? Well, at the time, it was believed that substances played this role.

Although, more cryptically, Newton also says that

> ...does [it] not appear from Phaenomena that there is a Being incorporated, living, intelligent, omnipresent, which in infinite Space, as it were in his Sensory, sees the things themselves intimately ... [Newton, Opticks, Book 3 Part I.]

But, despite this, the most important quote concerning *absolute* space is the one from the Principia, where he says that

> Absolute space, in its own nature, without relation to anything external, remains always similar and immovable. [Newton, Principia]

which stresses Newton's denial of much of the Aristotelian view of space. So, by modern standards, the ontological status of absolute space is hard to clarify and as such, we now turn to the main alternative.

4 Leibniz's 'relationist' view of space

Note: Leibniz's view of space is, by and large, a consequence of his 'deep' metaphysics as set out in works like *Monadology*. But, since no-one actually believes that his 'deep' metaphysics is tenable, modern discussions of his view of space normally try and avoid reference to this. In particular, this approach to Leibniz's view of space isn't as damaging as it may sound since Leibniz-like positions can be constructed which give a 'reasonable' account of space without much of the metaphysical baggage that he adopted.

As we mentioned earlier, the main difference between Leibniz and Newton on the issue of space is that Newton believed that there was a space which was 'out there', a substance which acted like a container that could be filled by material objects. Leibniz disagreed with this and considered space to be, in some sense, a 'construction' out of the spatial *relations* between material objects. Unlike Newton's position, this is quite counter-intuitive when you first consider it, and so let's build up to Leibniz's position.

4.1 Motivating 'relationism'

Leibniz's view of space is motivated by the following line of thought:

- If we consider all of the material things in the world at a single time, then we can note the spatial *relations* that obtain between them. (For example, that there are certain distances between them and that they are in certain configurations.)
- So, *space* is just the collection of all these *spatial relations* among the material things in the world. That is, space is just a *system of relations* amongst material objects.
- In particular, there is *no container* and *no space itself* waiting to be occupied by these material things. There are just material things and the spatial relations they bear to one another.
- Thus, Leibniz says 'I hold space to be something merely relative ... I hold it to be an order of coexistences, as time is an order of successions.' [Leibniz, Third Letter to Clarke.]

To make this clearer, perhaps an analogy will help:

> Consider the relations between members of a family. A family consists of a number of people and they are related to one another in the familiar ways. (E.g. If a, b, c and d are members of the family, then we would have relations like 'a is the father of b' and 'c is the brother of d'.) Clearly, the 'stuff' that makes up a family are the *people* involved, but the relations these *people* bear to one another are also perfectly real aspects of the world.

This may prompt us to ask:

- Do we think that familial relations exist independently of the people in the family? That is, could there be a 'relational space' that exists in and of itself, and waits to be occupied by the people?

Clearly, it's hard to make sense of this relational space, but this seems to be exactly what the 'container' theory of space presupposes! So, according to the relationist, there are things and there are the spatial relations between them. But, there is no independently existing container, the space itself, any more than there is an independently existing 'relational space' in the case of a family.

There is, however, a **difficulty**:

> What about unoccupied regions of space? That is, regions of space where nothing is located, i.e. where there are no material objects to stand in spatial relations to other material objects? Should we deny their reality?

4.2 Leibnizian 'relationism'

To counter this difficulty, Leibniz replies as follows:

- Consider the empty space between here and a star. There is nothing that bears the relationship to us of 'being halfway between us and the star'.
- However something *could* have that spatial relationship to us and the star.
- Thus, *unoccupied places* might be thought of as spatial relations that something *might* have to the objects of the world, but that nothing actually does have.
- Consequently, the family of relations that characterises space contains all *possible* and *actual* spatial relations. And, in particular, a *totally empty space* is the collection of all possible (but not actual) relations that possible (but not actual) material objects could bear to one another if such objects existed.

But, there is a **problem** for Leibniz:

- If space is just the collection of all *possible* relations amongst material objects, what is the 'ground' of these possibilities? For example, *physical possibilities* are understandable because of some underlying *actual* structure. For example, a piece of salt is soluble (i.e. *could* dissolve) because of its *actual* structure. But, when we consider the structure of space, what is the underlying reality that grounds the relations amongst these possibilities?

So we have a choice between:

- the *anti-relationist* position which solves this problem by appealing to the structure of space itself **but** owes us an account of what space *is*.
- the *relationist* position which has this problem **but** doesn't need to say anything more about the nature of space.

In the next lecture we will turn our attention to the major arguments for and against these two positions.