Week 4

Operationalism, verificationism

Bridgman, Reichenbach

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Outline

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1 Operationalism

Empiricism in physics

- Bridgman prefaces his discussion with a general comment: physics adopts, as its sole methodological principle, 'pure empiricism'.
- Experience is grounded only by experience, and we should abandon the search for an all-encompassing formula.
- The first claim will be elaborated later. But what exactly is the second claim here?
- Are we supposed to reject statements such as 'All is water'? Or are abandoning the quest for One Grand Theory?
- In any event, it's not as yet clear how new physics is supposed to differ from old physics.

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The old picture

- Bridgman's idea becomes a bit clearer in the ensuing example from Newton.
- Classical (=Newtonian) mechanics allowed concepts that were defined pretty much like mathematical and philosophical concepts are defined.
- In geometry I can define the concept of triangle, but there are no triangles to be found in nature. In philosophy I can define the concept of justice, but is there justice in the world?

  Question
  Why aren't there triangles in nature?

- So there was no guarantee that these concepts were not empty—that, for example, there was anything in physical reality corresponding to the concept of absolute time.

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Operationalism

- In other words, a repeat of Mach's critique: Newton did the foundations of physics as mathematics, and this created the problem of applicability for fundamental physical concepts.
- Relativistic physics, according to Bridgman, adopts a different method.
- Concepts are synonymous with sets of operations.
- It follows that Newton's concept of absolute time was meaningless.
- We shall look at two examples: the concept of simultaneity and the concept of length.

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Simultaneity in classical mechanics

- To say that two events in *different regions* are simultaneous we have to have clocks showing the same time in those places when the events occur.
- This presupposes the possibility of *synchronizing* those clocks.
- And how can this be done?
- Classical mechanics sees this as a practical obstacle.
- Simultaneity is held to be a property of events.
- Suppose there are two flashes of light.
- *Both of them can be dated in absolute time.*
- So, if their dates match (however we establish that), they are simultaneous.

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Simultaneity in relativistic mechanics

- First we must synchronise clocks in different space regions.
- We place a light source at the equal distance from points A and B (of course, 'distance' should also have operational meaning!).
- When the flashes are recorded in A and B, we set the clocks (of the same construction) to show the same time.
- Then the clocks will be said to be synchronised.
- So, two spatially separated events are said to simultaneous, if the synchronised clocks show the same time in their locations.
- Once we establish that the concept of simultaneity has meaning only given synchronised clocks, we see that simultaneity is essentially relative—that is, relative to the particular inertial system.
- This allows a simple illustration.

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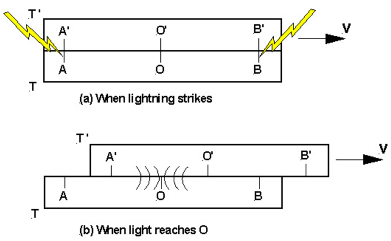
Relativity of simultaneity



Example 1. Suppose we have a train moving with constant velocity on the surface of Earth. Think of the railway as one inertial system T and of the train as another inertial system T'. A lightning strikes at two of its points A' and B', also denting two points A and B on the railway. Mark intermediate points O and O' on the railway and the train respectively. Suppose the lightnings are observed in O *at the same time*. But then they will not be observed in O' at the same time. So the lightnings will be simultaneous relative to T, but not simultaneous relative to T'.

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2 The concept of length

Length

- What is 'length'? Let's say we limit ourselves to the 'length' of a physical body at rest.
- In classical physics, you will begin with absolute space and absolute locations. The distance between these locations is fixed.
- So you will say that the length of the body is the distance between absolute locations where its two extreme ends are.
- So, again, length is a property of a body (at a given time, of course!).
- But in relativistic mechanics you should associate 'length' with operations.
- So you will begin with 'measuring rods'.

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Length in relativity

- Suppose we want to measure a stationary body.
- This is easy, but even then we must take multiple precautions: constant temperature, straight path (in moving the rod), and so forth.
- Suppose we measure a moving body. Then we imagine that every point in our coordinate system is equipped with synchronised clocks where observers stand guard.
- Of the two observers whose locations happen to coincide with the ends of the body at a certain time (that is, simultaneously) we ask to perform the same operations as were applied to the stationary body.
- Bridgman then discusses the possibility of measurement of large bodies, such as a large field.
- There, again, certain assumptions need to be made: that light moves in straight lines, and that the geometry of light beams is Euclidean. (Neither holds in General Relativity.)

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3 Further issues in operationalism

Further issues in operationalism

- Bridgman notes that, as every concept is associated with relevant operations, its continuing use depends on experiment.
- As experimental data expand, we may find that operations associated with the given concept no longer produce homogeneous results.
- Secondly, we dispense with 'absolute' concepts, such as 'absolute length' and 'absolute motion', if such concepts are supposed to have meaning independent of operations and particular observers (observers with specified properties).
- Finally, there are questions that traditionally occupied the minds of scientists, philosophers, and laymen, that can now be judged meaningless.

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Meaningless questions?

1. Was there ever a time when matter did not exist?
2. May time have a beginning or an end?
3. Why does time flow?
4. May space be bounded?
5. May space or time be discontinuous?
6. May space have a fourth dimension, not directly detectable, but given indirectly by inference?
7. Are there parts of nature forever beyond our detection?
8. Is the sensation which I call blue really the same as that which my neighbor calls blue?
9. May there be missing integers in the series of natural numbers as we know them?

10. Is a universe possible in which $2 + 2 \neq 4$?
11. Why does negative electricity attract positive?
12. Why does nature obey laws?
13. Is a universe possible in which the laws are different?
14. If one part of our universe could be completely isolated from the rest, would it continue to obey the same laws ?
15. Can we be sure that our logical processes are valid?

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Criticisms of operationalism

- First of all, what are operations? Presumably, they represent concrete laboratory experiments.
- But then not every legitimate concept can be operationally defined.
- Think of temperature: different thermometers may show different results.
- The standard practice is to introduce the concept of temperature theoretically, in the context of a particular theory (say, kinematic theory of gas).
- Or think of the constant acceleration g in the law of motion of a freely falling body.
- It does not acquire meaning because it can be measured, but rather because it appears in the equation.
- And if we extend the scope of operations to include mathematical manipulations (as Bridgman later did), then the notion becomes somewhat trivial.
- Another problem: tension between instrumentalism and empiricism.

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4 Meaning and verification

General remarks on logical positivism

- We can identify two major trends in logical positivism: the idea that philosophy's proper task is the study of meaning and the idea that much traditional philosophy is confusion and nonsense.
- So the question becomes: how do we determine the meaning of a proposition p?
- Suggestion: we determine the meaning of p by using the principle of verification—that is, by indicating the circumstances when p is true.
- Thus comes the verification theory of meaning (VTM).
- The problem with many a traditional philosopher was that they queried the truth of p without first understanding clearly what p meant.
- And more: sometimes they queried the truth of a proposition which had no determinate meaning.

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Basic elements of VTM

- In our selection, Reichenbach gives a mature statement of VTM.
- In Hume's and Mach's vein, we begin with observation sentences (Reichenbach calls them 'direct sentences').
- Next, we must introduce sentences about unobservables ('indirect sentences').
- They will include universal generalisations: 'For all x, x is F.'
- Then a question arises: how to connect between the two?
- We cannot say that direct sentences should be deduced from indirect ones: we assign meaning to generalisations on the basis of observation sentences!
- So better say that indirect sentences are inductively inferred from direct ones.

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5 The inner workings of verification

Verification: how it works

Example 2. The proposition ‘Jim has five coins in his pocket’ is meaningful, since we can describe the circumstance in which it is true—namely, when Jim has five coins in his pocket—though it may practically be difficult to conduct this verification procedure.

Example 3. The proposition ‘The world consists of monads’ is not subject to verification, and thus meaningless. So are the other propositions of traditional metaphysics.

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Verification: exercises

Which of the following propositions are meaningful, according to the principle of verification?

1. ‘Gravity acts on every physical object in the universe.’
2. ‘Nothing in the universe can exceed the speed of light.’
3. ‘Brad Pitt is courageous.’
4. ‘Cannibalism is a crime.’
5. ‘Gold is the best investment asset.’
6. ‘Paper is flammable.’
7. ‘This mobile phone is fragile.’

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The problem of induction

- One novel element in Reichenbach’s discussion is the link between induction and convention.
- The problem is: we begin with evidence about observables.
- So we cannot construct an inductive inference whose conclusion will be a statement about unobservables.
- If I have observed the sun rising in the past, I cannot draw conclusions about the sun rising in the future.
- What is missing is the premiss that the future will resemble the past.
- This is nothing but Hume’s classical problem.

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The place of convention

- Reichenbach offers a ‘solution’: we postulate the similarity between observables and unobservables.
- That is, we state that observables obey the same physical laws as unobservables.
- While for observables, physical laws (including the law of causality!) are empirical, for unobservables they are true by fiat.
- And so, the problem of realism is eliminated through conventions.
- Another interesting claim Reichenbach makes is that unobservables are no less real than observables.
- Let us try to elaborate on this a bit ....

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