# Lecture 19

## Conventionalism, realism, and the middle way

1. Realism: space(time) has geometric structure, and our goal is to describe it
2. Conventionalism: our goal in adopting geometric axioms is to establish a convenient framework for empirical research
   (a) A "non-truth-aimed" choice. i.e. conceived of as largely irrelevant to the question of fitting reality. Cf. choosing to write a paper in Times New Roman font as opposed to Helvetica
3. Middle way: perhaps Helmholtz, Mach, and Einstein are onto something?
   (a) "On the facts underlying geometry"
   (b) Hypothesis: there is a class of physical objects which are roughly stable (rigid) relative to each other, i.e. form an approximately Euclidean domain

## Einstein, "Geometry and Experience"

1. The puzzle (p 147): "how is it possible that mathematics, being after all a product of human thought that is independent of experience, is so admirably appropriate to the objects of reality"?
2. Einstein's solution: laws of mathematics (refer to reality $\leftrightarrow$ not certain)
   (a) Axiomatics has succeeded in separating the logical-formal from its objective or intuitive content [de-interpretation, cf. Hilbert]
3. Two interpretations of the axioms of geometry (e.g. "through two points in space there passes one and only one straight line")
   (a) Older interpretation: the axioms are self-evident under the self-evident interpretation of the words contained in them
   (b) Newer interpretation: the axioms are (a) to be taken in a purely formal sense, (b) void of content of intuition or experience, (c) free creations of the human mind, (d) first define the objects of which geometry treats [implicit definition]
   Aside on implicit definition: this would only work if the axioms also have names for concrete (physical) things. This way of thinking is still adopted under the name of "functionalism"
   "... mathematics as such cannot predicate anything about objects of our intuition or real objects" (p 148)

"... the system of concepts of axiomatic geometry alone cannot make any assertions as to the behavior of real objects of this kind, which we will call rigid bodies" (p 148)

4. Re-interpretation

   "... geometry must be stripped of its merely logical-formal character by assigning to the empty conceptual schemata of axiomatic geometry objects of reality that are capable of being experienced" (p 148)

   "To accomplish this, we need only add the proposition: Solid bodies are related, with respect to their possible relative positions, as are bodies in Euclidean geometry of three dimensions. Then the propositions of Euclid contain assertions as to the behavior of practically rigid bodies." (p 148)

5. Einstein versus Poincaré

   (a) Poincaré: rigid bodies are a fiction

   (b) Einstein: Poincaré is right in principle, but the objection "is by no means so profound as might appear from a hasty examination" (p 150)

   "... it is not a difficult task to determine the physical state of a measuring body so accurately that its behavior in relation to the relative positions of other measuring bodies will be sufficiently free from ambiguity to allow it to be sustituted for the 'rigid' body." (p 150)

   (c) Einstein: if we reject the equation "body of axiomatic Euclidean geometry" = "practically rigid body of reality", then conventionalism follows

   "If one rejects the relation between the practically rigid body and geometry, indeed one will not easily free oneself from the convention that Euclidean geometry is to be retained as the simplest." (p 149)

   (d) Rotating frames of reference $\Rightarrow$ non-euclidean geometry (p 149, top)

   (e) Open question: is Einstein suggesting that we presuppose that our measuring instruments ("rigid rods") are Euclidean? Are we to use a Euclidean framework to conclude that other parts of the world are best described by non-euclidean geometry?

6. What's fundamental?

   "It is also clear that the solid body and the clock do not play the part of irreducible elements in the conceptual edifice of physics, but that of composite constructs. ... But it is my conviction that in the present stage of the development of theoretical physics these concepts must still be invoked as independent concepts." (p 149)

## Mach, The Science of Mechanics

1. Ernst Mach (1838–1916) [Poincaré (1854–1912), Bertrand Russell (1872–1970), Einstein (1879–1955), Bohr (1885–1962)]

   `https://plato.stanford.edu/entries/ernst-mach/`

   "The frequent excursions which I have made into this province have all sprung from the profound conviction that the foundations of science as a whole, and of physics in particular, await their next greatest elucidations from the side of biology, and especially, from the analysis of the sensations."

2. "$K$ alters its direction and velocity solely through the influence of another body $K'$"

   (a) We cannot know how $K$ would act in the absence of $A, B, C, \ldots$

   (b) "Every means would be wanting of forming a judgment of the behavior of $K$ and of putting to the test what we had predicted — which latter therefore would be bereft of all scientific significance."

3. Open question: does this last statement of Mach's depend on the verification criterion of meaning?

4. What does Mach mean by saying that "the universe is not *twice* given"? (p 176)