Lecture 18
Newton on Scientific Method

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Philosophy 270
Spring 2010

Motion of the earth

Hypothesis 1 (816)

The center of the system of the world is at rest.

No one doubts this, although some argue that the earth, others that the sun, is at rest in the center of the system. Let us see what follows from this hypothesis.

Proposition 11 (816)

The common center of gravity of the earth, the sun, and all the planets is at rest.

Argument:

- If the center of gravity of the system moves, then it moves in a straight line at constant velocity (by the laws of motion).
- If the center of gravity moves in a straight line at constant velocity then, given enough time, it will move as far as you like. Therefore, the whole system will eventually be in a different place, and hence the center of the system must move.
- The center doesn't move (by Hypothesis 1).
- So, the center of gravity of the system doesn't move.

Proposition 12 (816)

The sun is engaged in continual motion but never recedes far from the common center of gravity of all the planets.

Argument:

- The sun is much more massive than any of the planets. It's mass is more than 1000 times that of Jupiter, and Jupiter is by far the most massive planet.
- *If the earth and all the planets were to lie on one side of the sun, the distance of the common center of gravity of them all from the center of the sun would scarcely be a whole diameter of the sun. In other cases the distance between those two centers is always less.* (817)
- So the sun is always close to the center of gravity of the system.

The earth moves

- The center of gravity of the system is at rest (Prop. 11) and the sun is always close to that (Prop. 12), hence it is nearly true that the sun is at rest.
- The earth moves a large amount relative to the sun, and hence it really moves.

Copernicus's view, that the sun is at rest, is nearly right.
Ptolemy's view, that the earth is at rest, is far from correct.

Question

1. How did Newton argue that the center of gravity of the system of the world is at rest? How does it follow from this that the earth moves?

Newton's scientific method

Opposition to hypotheses (943)

Thus far I have explained the phenomena of the heavens and of our sea by the force of gravity, but I have not yet assigned a cause to gravity. Indeed, this force arises from some cause that penetrates as far as the centers of the sun and planets without any diminution of its power to act . . . and whose action is extended everywhere to immense distances, always decreasing as the squares of the distances . . . I have not as yet been able to deduce from phenomena the reason for these properties of gravity, and I do not feign hypotheses. For whatever is not deduced from the phenomena must be called a hypothesis; and hypotheses . . . have no place in experimental philosophy.

What Newton meant

He can't mean hypotheses should never be stated, since he stated Hypothesis 1. (There is also a Hypothesis 2 later in Book 3.) He meant that hypotheses should not be regarded as proved true. He rejected the method of hypothesis because there are always many hypotheses that can fit the phenomena. Supporting quotations from Newton's letters (Thayer 1953, p. 6):

> *The word "hypothesis" is here used by me to signify only such a proposition as is not a phenomenon nor deduced from any phenomena, but assumed or supposed—without any experimental proof.*
>
> *If anyone offers conjectures about the truth of things from the mere possibility of hypotheses, I do not see by what stipulation anything certain can be established in any science; since one or another set of hypotheses may always be devised which will appear to supply new difficulties.*

Newton's method

> *In this experimental philosophy, propositions are deduced from the phenomena and are made general by induction. The impenetrability, mobility, and impetus of bodies, and the laws of motion and the law of gravity have been found by this method.* *(943)*

The method is explained more fully in Newton's *Opticks* p. 404.
Picture:

Method	**Example**
more general causes	law of gravity
↑	↑
causes	forces
↑	↑
phenomena	motions

Did Newton really follow this method?

Newton's adjustment of phenomena

- Newton's argument that the force on the moon is directed toward the earth was based on Phenomenon 6 (the line from the moon to the earth traces areas proportional to the times). But he noted that the phenomenon isn't exactly correct.

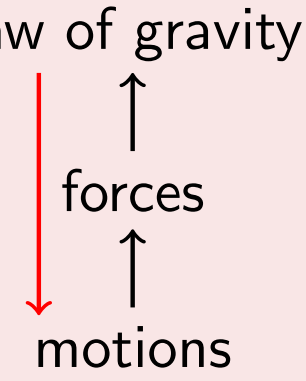
  > *Actually, the motion of the moon is somewhat perturbed by the force of the sun, but in these phenomena I pay no attention to minute errors that are negligible.* (801)

- His argument that the force on the moon is proportional to $1/d^2$ was based on the apogee of the moon being stationary. The apogee isn't really stationary, it goes forward $3^\circ 3'$ per revolution of the moon, but Newton said:

  > *This motion of the apogee arises from the action of the sun (as will be pointed out below) and accordingly is to be ignored here.* (803)

Criticism

- Newton here adjusts the motions for the gravitational action of the sun.



- In the method described by Newton, phenomena are supposed to be the basis for everything, not adjusted based on the conclusion to be reached. Thus Newton isn't following the method he described.

My view: Newton's reasoning is better represented by the method of hypothesis. The evidence for the law of universal gravitation is that it explains all the phenomena extremely well, is simple, and nobody can think of another hypothesis that does the same.

Questions

2. (a) When Newton said that "hypotheses . . . have no place in experimental philosophy," did he mean that hypotheses should not be stated? Justify your answer with at least one reference to Newton's writings. (b) Did Newton accept the method of hypothesis? What was his reason?
3. According to Newton, what is the right way to establish causes and general laws in science? Did Newton follow this method when he argued that the moon is held in its orbit by gravity? Justify your answer to the latter question. Give specific details.

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