Philosophical Issues in Physics
PHIL/PHYS 30389

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Einstein as a college student, ca. 1900

Albert Einstein. "Physik und Realität." ***Journal of The Franklin Institute*** **1936**

It has often been said, and certainly not without justification, that the man of science is a poor philosopher. Why then should it not be the right thing for the physicist to let the philosopher do the philosophizing? Such might indeed be the right thing at a time when the physicist believes he has at his disposal a rigid system of fundamental concepts and fundamental laws which are so well established that waves of doubt cannot reach them; but it cannot be right at a time when the very foundations of physics itself have become problematic as they are now. At a time like the present, when experience forces us to seek a newer and more solid foundation, the physicist cannot simply surrender to the philosopher the critical contemplation of the theoretical foundations; for, he himself knows best, and feels more surely where the shoe pinches. In looking for a new foundation, he must try to make clear in his own mind just how far the concepts which he uses are justified, and are necessities.

Einstein to Robert Thornton, 7 December 1944.

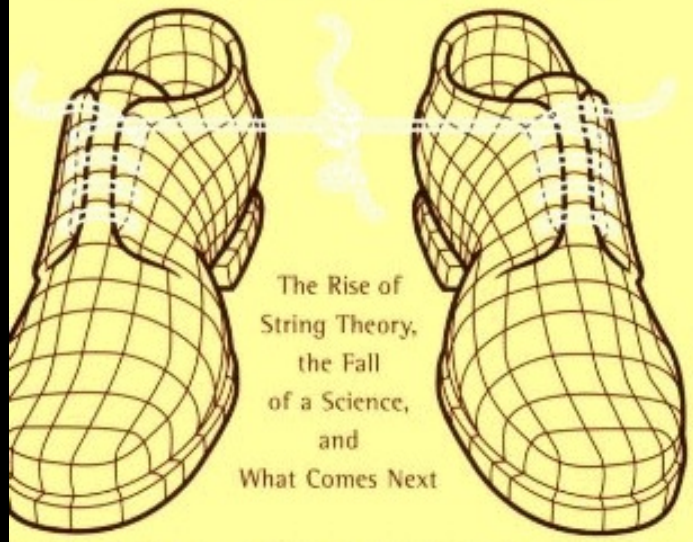
I fully agree with you about the significance and educational value of methodology as well as history and philosophy of science. So many people today—and even professional scientists—seem to me like somebody who has seen thousands of trees but has never seen a forest. A knowledge of the historic and philosophical background gives that kind of independence from prejudices of his generation from which most scientists are suffering. This independence created by philosophical insight is—in my opinion—the mark of distinction between a mere artisan or specialist and a real seeker after truth.

Albert Einstein. "Ernst Mach." ***Physikalische Zeitschrift*** **1916**

How does it happen that a properly endowed natural scientist comes to concern himself with epistemology? Is there no more valuable work in his specialty? I hear many of my colleagues saying, and I sense it from many more, that they feel this way. I cannot share this sentiment. When I think about the ablest students whom I have encountered in my teaching, that is, those who distinguish themselves by their independence of judgment and not merely their quick-wittedness, I can affirm that they had a vigorous interest in epistemology. They happily began discussions about the goals and methods of science, and they showed unequivocally, through their tenacity in defending their views, that the subject seemed important to them. Indeed, one should not be surprised at this.

splendid, edifying report from the front lines of theoretical physics . . . A wonderful gift."
— SAN FRANCISCO CHRONICLE

THE TROUBLE WITH PHYSICS



The Rise of String Theory, the Fall of a Science, and What Comes Next

LEE SMOLIN

Metaphysics - The Fundamental Nature of Reality

Epistemology - The Nature and Limits of Human Knowledge

Value Theory - Ethics and Aesthetics - The Good and the Beautiful

Logic - Principles of Sound Reasoning

Metaphysics - The Fundamental Nature of Reality

Examples:

1. **Determinism and Chance**
2. **Continuous versus Discrete Ontologies**
3. **The Nature of Space and Time**

Epistemology - The Nature and Limits of Human Knowledge

Examples:

1. Rationalism or Empiricism - Is science based on rational insight into the first principles of nature or is it based on experience?

2. Can we know any empirical truths with certainty?

3. Confirmation or falsification?

4. Realism versus Instrumentalism

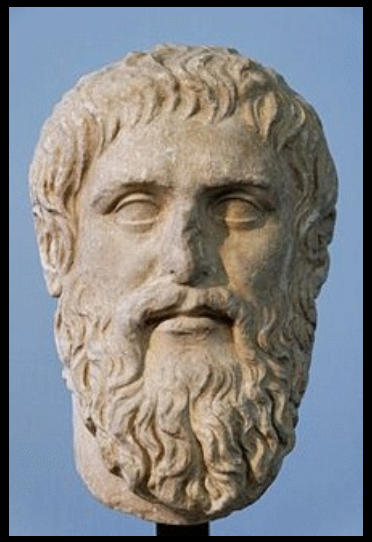
5. Underdetermination of Theory Choice

Raphel. The School of Athens. 1509-1510. Stanza di Raffaello, Vatican.

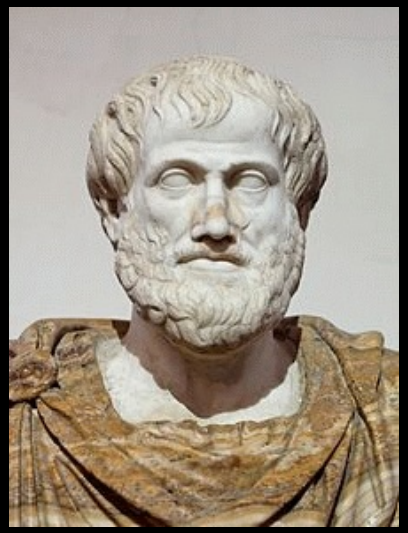
Plato, on the left, points upward; Aristotle, on the right, points downward.

Why?

A Crash Course on Ancient Greek Natural Philosophy



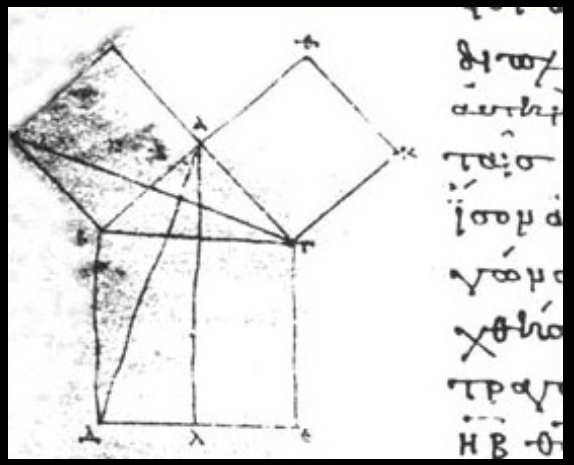
Plato - Ca. 427 - 347 B.C.E.
Athens. Student of Socrates.



Aristotle - Ca. 384 - 322 B.C.E.
Macedonia. Student of Plato;
teacher of Alexander the Great.

Plato's Natural Philosophy

1. Doctrine of the Forms



Truth, knowledge, and reality are to be found in the "heaven" of the forms.

Example: The Pythagorean theorem.

In the realm of the senses and ordinary physical bodies, all is illusion, at best mere opinion.

Philosophy = philo - sophia = love of wisdom.
Death as the true philosopher's goal.

Learning as anamnesis - "recollection."
Education as elucidation.

Example: The slave boy's proof of the Pythagorean theorem in the *Meno*.

Aristotle's Natural Philosophy

1. Doctrine of hylomorphism

   Everything is a combination of form and matter.

2. Essential and accidental forms.

   Essential forms make something the kind of thing that it is; all other properties are "accidents."

3. Form being in the world, we can have true knowledge through both reason and the senses.

4. Teleology and the four causes:

   Material cause
   Formal cause
   Efficient cause
   Final cause

Aristotle's Natural Philosophy

5. Doctrine of matter, natural place, and natural motion.

Terrestrial realm:

Earth - center of the universe
Water - concentric spherical shell around the center of the universe
Air - next concentric spherical shell
Fire - outermost spherical shell

Natural motion always straight up or down toward natural place

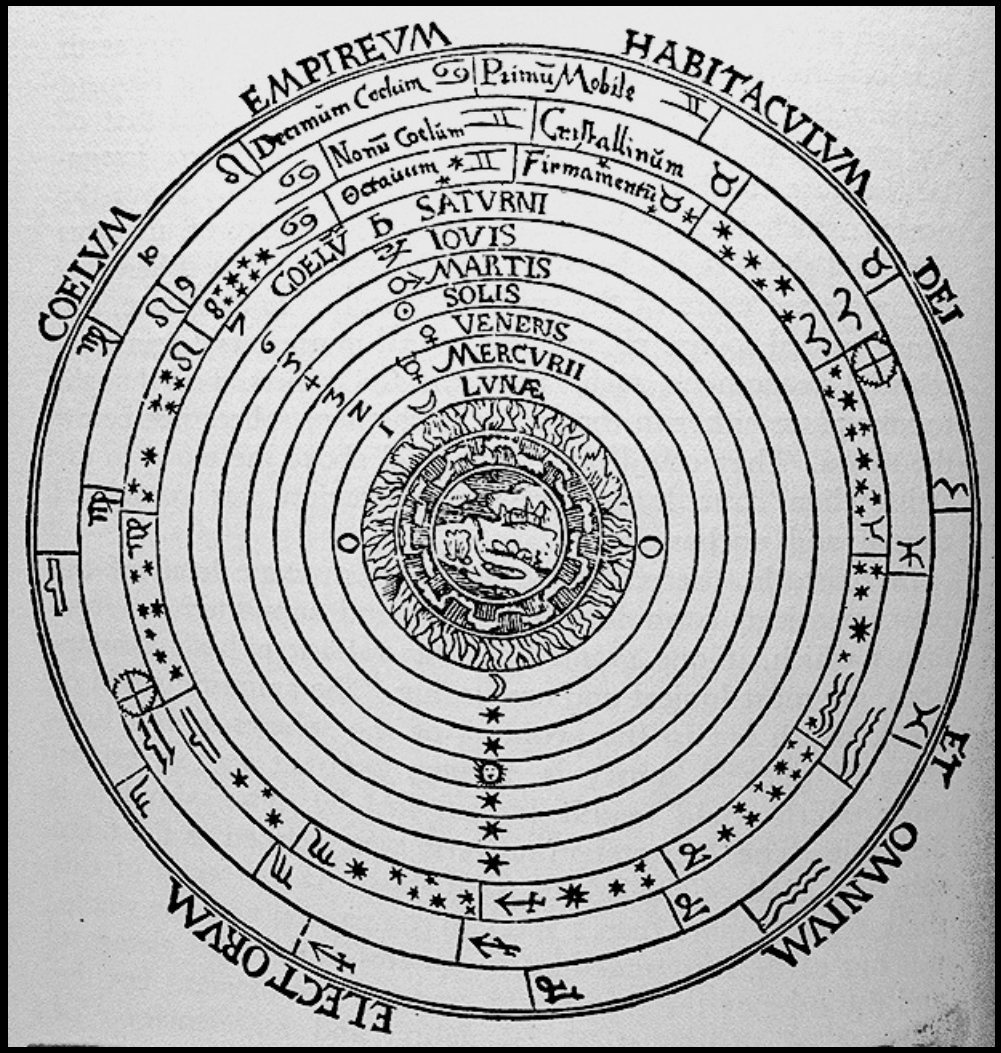
Celestial realm:

Aetherial substance - spherical shell surrounding the terrestrial realm

Natural motion always perfectly circular motion

Prime mover:

The "unmoved mover"



Aristotle’s cosmology.

Aristotle's Natural Philosophy

6. Natural motion and enforced motion

   All motion contrary to nature is "enforced" motion and requires the continuous operation of an efficient cause to sustain motion contrary to nature.

   Example: Motion of a cart.

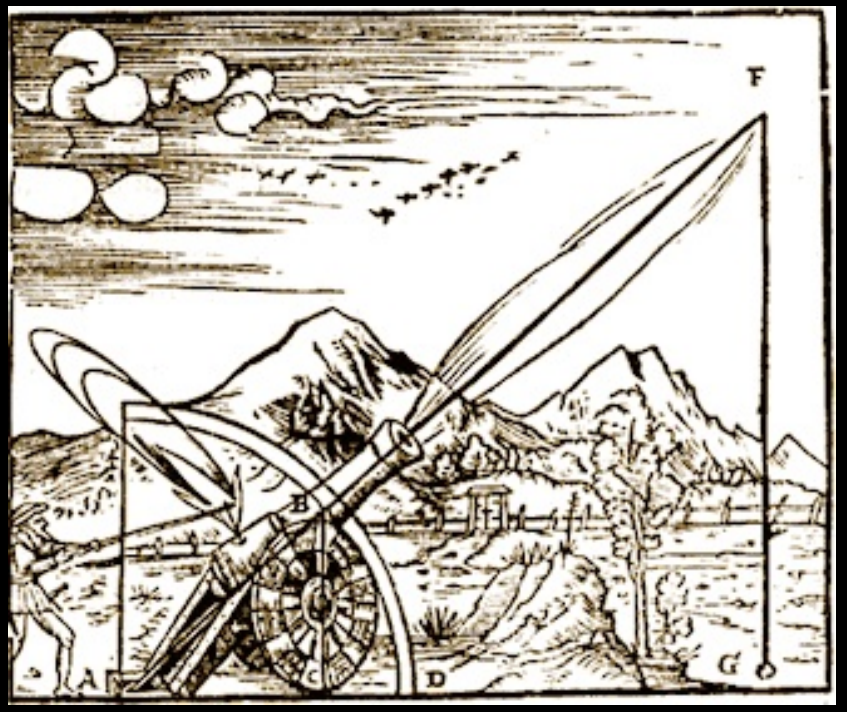
Family riding in a horse (or mule) drawn wagon. Part of an inscribed stele, Thessaloniki, 1st - 2nd century AD. Thessaloniki Archaeological Museum.

Aristotle's Natural Philosophy

6. Natural motion and enforced motion

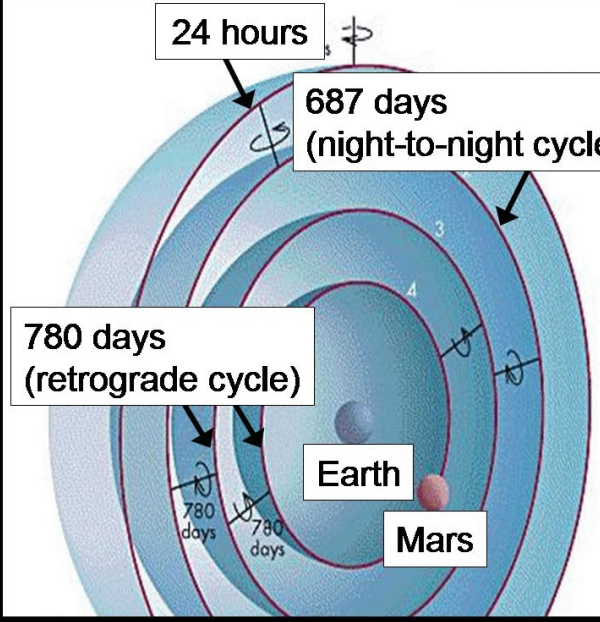
   All motion contrary to nature is "enforced" motion and requires the continuous operation of an efficient cause to sustain motion contrary to nature.

   Example: Projectile motion.



Noviomagus [Daniel Santbech]. *Problematum Astronomicorum et Geometricorum*. Basel, 1561.

Eudoxus' Cosmology - Ca. 408-355 B.C.E.



A planet is fixed to a system of "crystal orbs" around Earth, like a collection of nested fish bowls.

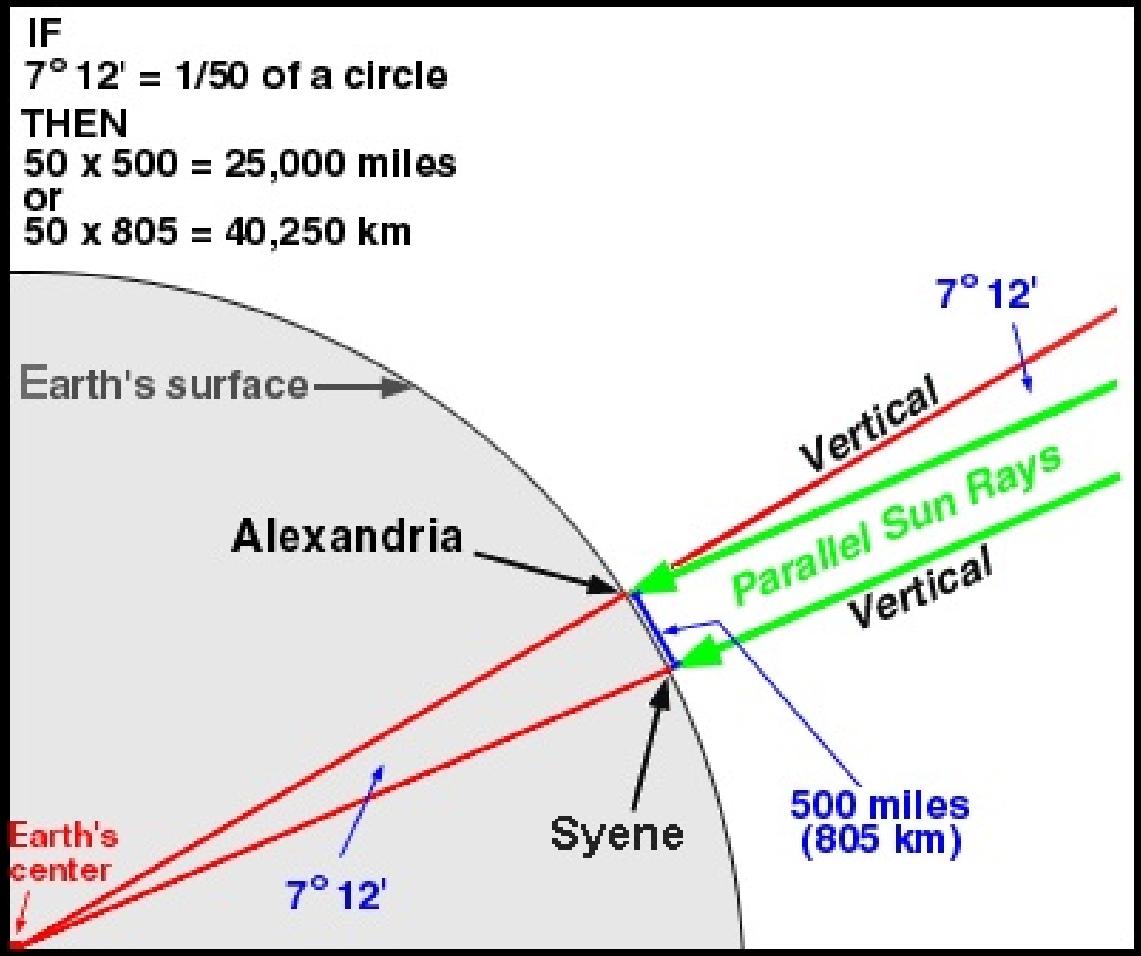
Each spherical orb spins at a different rate, giving the planet its daily and night-to-night motion.

The planet's retrograde motion is due to the two innermost orbs, which induce a figure-8 path by counter-rotating at the same constant speed.

PLAY MOVIE

Eratosthenes' Estimation of the Size of the Earth

- Ca. 276 - 194 B.C.E.



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The Ptolemaic System - Ca. 90-168 C.E.

Almagest

Planetary Hypotheses

Claudius Ptolemy. Alexandria.

Retrograde Motion

PLAY MOVIE

The Ptolemaic System

The three major Ptolemaic devices:

1. Eccentrics
2. Epicycles
3. Equant points

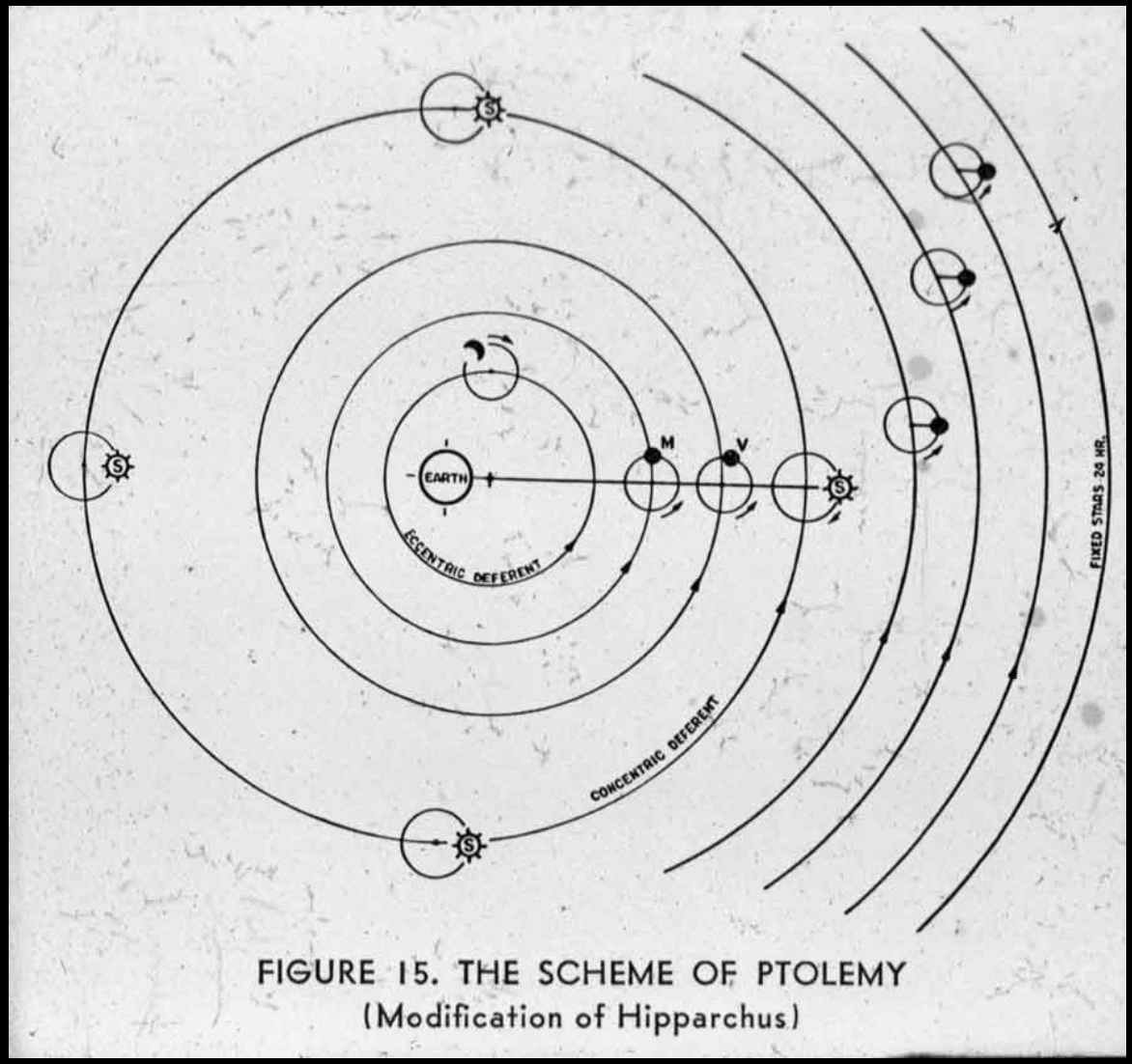

FIGURE 15. THE SCHEME OF PTOLEMY
(Modification of Hipparchus)

Newton's Derivation of Kepler's Second Law

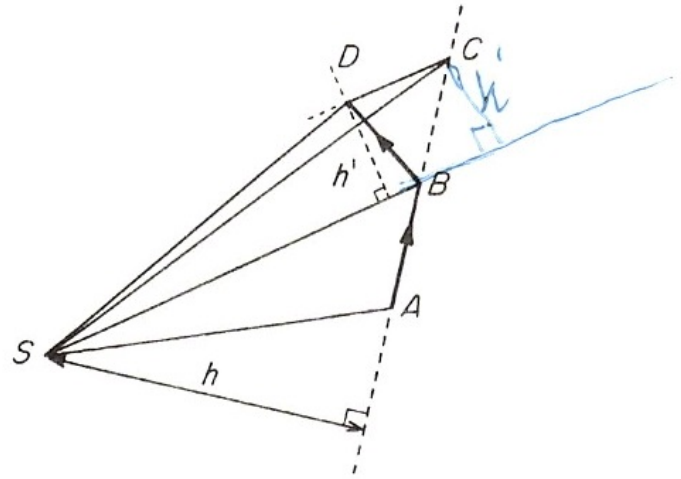

FIGURE 9.1 Newton's geometrical argument for Kepler's second law

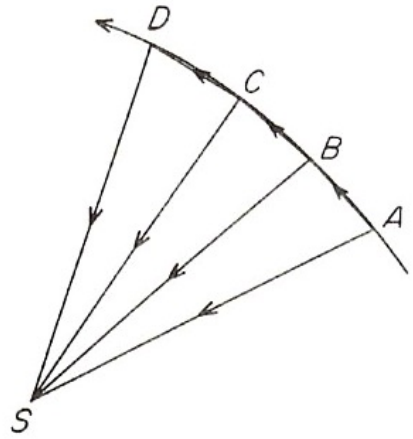

FIGURE 9.2 A continuous limit from incremental arguments

Newton on the Tides

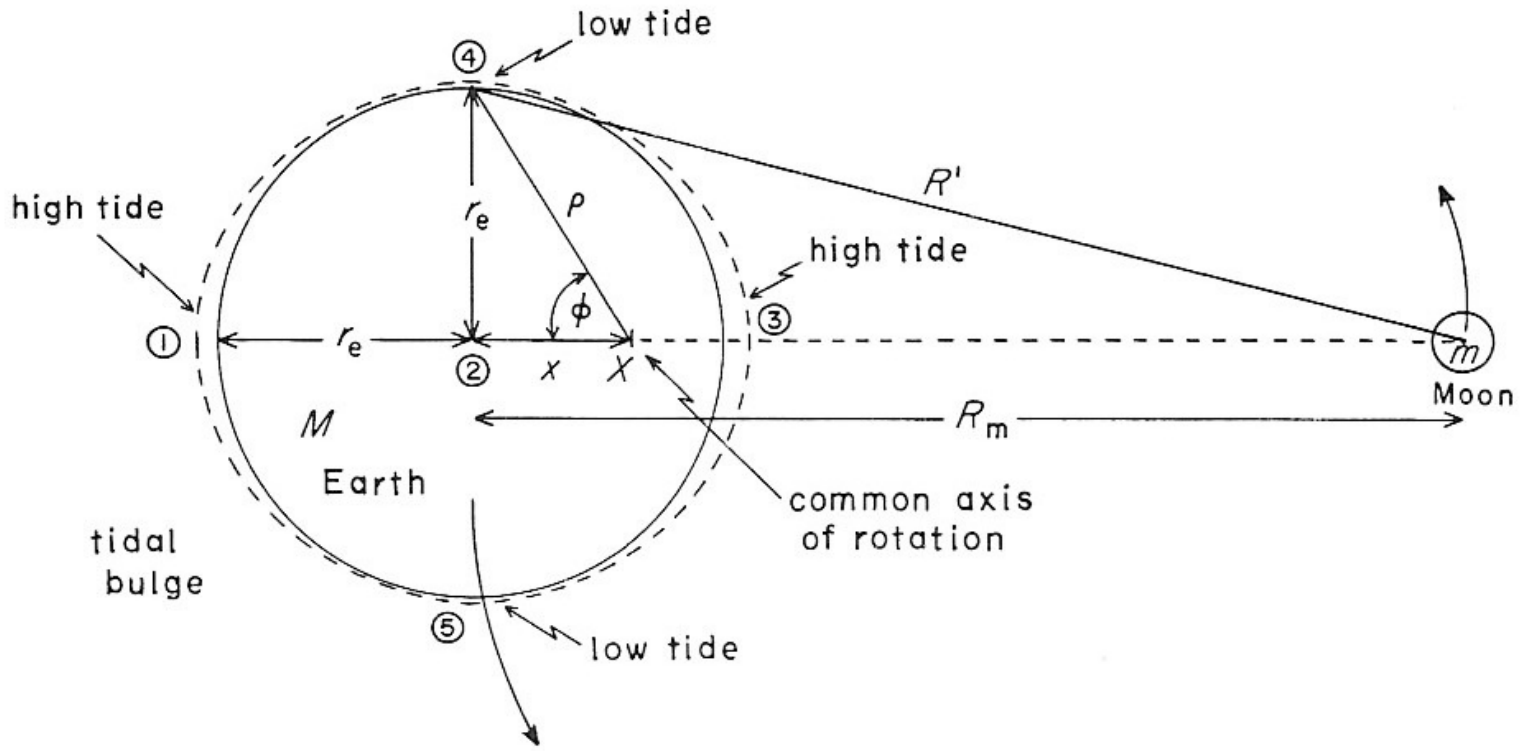

FIGURE 9.7 **Tides in the earth–moon system**