Concepts of Physics: Homework 1

Due: 31 August 2022

1 Retrograde motion

The concept of retrograde motion is important for deciding between possible models of the solar system.

a) Briefly describe what retrograde motion is.

b) Describe whether a simple geocentric model can ever predict that retrograde motion will be observed. Explain your answer.

c) Describe whether a simple heliocentric model can ever predict that retrograde motion will be observed. Explain your answer.

d) Describe a special circumstance in which a heliocentric model would predict that retrograde motion will not be observed.

2 Model predictions for brightness of planets

Consider what the simple geocentric model of the solar system and the heliocentric model of the solar system would predict for the brightness of the planet Mars, observed at night. In the following the distance from Sun to the planet is irrelevant.

a) Does the geocentric model predict that the brightness of the planet will stay the same or change? Explain your answer.

b) Does the heliocentric model predict that the brightness of the planet will stay the same or change? Explain your answer.

c) Explain how you could use this to decide between the two models. What would you have to observe? What are the possible observations and how would they decide between the two models?

3 Position of Venus

The planet Venus appears as the "morning" or "evening" star. It is always seen close to sunrise or sunset. Consider what various models can predict about this.

a) Imagine a simple geocentric model where Venus orbits at a different rate to the Sun. Will it always appear close to sunrise or sunset? Or could it appear at midnight? Explain your answer.

b) Now consider Copernicus' heliocentric model. According to this model will Venus always appear close to sunrise or sunset? Or could it appear at midnight? Explain your answer.
Hint: For each model, draw schematic diagrams with orbits of these objects at various moments. Use these diagrams to make predictions.

4 Phases of a planet

Planets can display phases, like the Moon does. Consider the planet Jupiter and the phases that it could display.

a) Consider a geocentric model in which Jupiter orbits between Sun and Earth. Sketch three situations where the phase of Jupiter would be "new," "half" and "full." If any of these is impossible, describe why.

b) Consider a geocentric model in which the Sun orbits between Jupiter and Earth. Sketch three situations where the phase of Jupiter would be "new," "half or partial" and "full." If any of these is impossible, describe why.

c) Consider Copernicus' heliocentric model. Sketch three situations where the phase of Jupiter would be "new," "half or partial" and "full." If any of these is impossible, describe why.

d) If you could observe the phases of Jupiter, explain how you could use the observations to decide which model may be correct and which may be incorrect.

Hint: For each model, draw schematic diagrams with various possible arrangements of Jupiter relative to Sun and Earth, both of which you can keep fixed. In each case carefully show the shaded and illuminated sides of Jupiter. Use these diagrams to make predictions.

5 Indirect vs. direct evidence for circular planetary motion.

Consider the motion of the planet Saturn. How do we know that it moves in a nearly circular orbit around the sun rather than about the earth? A direct method for doing this would be to observe the position of Saturn, the Earth and the Sun from a distance during one entire orbit of Saturn. This would require observing the three from a space probe at a significant distance from the Sun. The only candidates for this are the Voyager and Pioneer planetary space probes which reached suitable distances from the sun in the late 1990's. Suppose that these were used to photograph Saturn, the Earth and the Sun, once per week and that these photographs were played back as a movie.

a) Sketch the paths of Saturn, the Earth and the Sun according to the simple geocentric model of the solar system.

b) Sketch the paths of Saturn, the Earth and the Sun according to Copernicus' notion of the solar system.

c) Look up the time taken for Saturn to complete one orbit (a "Saturn year" or the "orbital period") and write this down together with the source of your information. Has there been enough time for these probes to have observed one complete orbit of Saturn? Sketch the approximate portion of Saturn's orbit could that the probes could have observed? Could a hypothetical movie produced by these probes be used to support either the ancient Greek notions or those of Copernicus?

A movie of this type could be regarded as "direct" evidence for Copernicus' notion of the solar system. Such observations were not actually done by these or any other space probes.

In fact, the orbits of the planets needed to be known in advance so that the probes could approach various planets closely (they did this successfully).

d) Based on discussions in the class and the text describe evidence for the paths of Saturn, the Earth and the Sun according to Copernicus' notion of the solar system. Would you consider this as "direct" or "indirect" evidence (i.e. does the evidence actually show the paths of the planets or do you have to deduce the possible path from the evidence?)

6 Hobson, *Physics, Concepts and Connections, 5ed*, Ch. 2 Review Question 7, page 51.

7 Hobson, *Physics, Concepts and Connections, 5ed*, Ch. 2 Conceptual Exercise 6, page 51.

8 Reading exercise: chemical mass ratios

Read the "How do we know ..." section on page 35. This series of exercises offers examples and exercises that you could construct to check that you understand the content of the text correctly.

a) Describe the piece of evidence that suggested to Dalton that chemical compounds are built up from atoms of elements.

b) Describe whether the evidence was definitive proof of the existence of atoms.

c) Do Concept Check 2 on page 35. After you have done this check the answer at the end of the text.