Atoms to Universe
Physics 340
Assignment 2

1) Compare and contrast Ptolemy's and Kepler's model for the motion of the planets in at least 5 aspects. What were the advantages of Kepler's model?

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Ptolemy: Planet's orbits are circles

Kepler: Planet's orbits are ellipses

Ptolemy: Orbits are compounded of main orbit (deferent) and epicycle

Kepler: Orbits of planets circle the sun, there is no epicycle

Ptolemy: Deferent cicles the earth

Kepley: Orbit orbits the sun

Ptolemy: Orbits do not intersect each other (Ie, no planet has a distance from the earth that is both greater than and less than any other planet's distance from the earth)

Kepler: Orbits around the sun do not intersect each other (but they could)

Polemy: Due to above, Venus always stays between earth and sun, so Venus orbit does not intersect Sun's orbit.

Kepler. Venus travels around the sun and is sometimes further and sometimes closer to earth than is the sun.

Ptolemy: planet orbits in its circle so that angular motion looks uniform around the orbit from the equant (a point where nothing is located) , not the earth or the sun.

Kepler: Planets orbit sun so that equal areas are swept out by the line from the planet to the sun in equal times.

Ptolemy: Planets ordered so as to have the orbits just fit inside each other. Ie, maximum distance from the earth of an inner orbit just equals minimum distance of the next planet.

Kepler: Planets ordered so as to make epicycle of outer planets, and deferent of inner planets all the same size, and the same as the orbit of the sun in Ptolemy's description. Ie, epicylcles result of parallax from earth orbiting sun.

Ptolemy: Heavens (Stars) rotate about the earth once a day

Kepler: Earth rotates, stars stay fixed.

Similarities:

Kepler– Ellipse has two focii, with the center of the ellipse lying half way between them.

Ptolomy: Equant lies equidistant from the center of the circle to the earth, but on other side of the center.

Kepler: Tilt of planet's orbit with respect to ecliptic constant.

Ptolomy: Tilt of deferent for outer planets to ecliptic constant (The epicycles are parallel to the ecliptic)

2)Galileo saw that Venus had the full range of phases, from full to new and back again. What aspect of Ptolemy's model for Venus did this contradict?

Ptolomy wanted that no orbit or any planet or the sun crosses any other orbit– He had Aristotle's crystiline spheres in mind, and one planet could not go through another planet's crystiline sphere. This meant that Venus always had to be closer to the earth than the sun was. Thus you could never see the sun lighting more than 1/2 of Venus as seen from the earth. Galileo saw the sun lighting almost the whole of venus sometimes, and lighting almost none of Venus at other times, so Venus had to be both further than the sun from the earth (so the sun could illuminate almost all of Venus) and closer to the earth than the sun (so almost none was illuminated).

3) From the point of view of Copernicus, what did Ptolemy's epicycles accomplish?

They were the reflection in the planet of the earth going around the sun. They were the result of the changing parallax of the planet as the earth moved.

4) By what ratio do 6 Pythagorian tones miss being an octave? By what ratio do three Just thirds miss being an octave?

One Pythagorian tone has a frequency ratio of 9/8. Six tomes would have a ratio of 9/8 multiplied by itself six times of $\left(\frac{9}{8}\right)^6 = 2.0273$ This is a fraction 1.0136 times an octave (2) which is less than a semitone higher than an octave (a small semitone is $256/243 = 1.0535$ so this is much smaller than that– it is about 1/4 of a small semitone.

Three Just thirds miss being an octave: Three just thirds are 5/4 three times or $\left(\frac{5}{4}\right)^3 = 125/64 = 1.9531$. An octave is a ratio of 2, so an octave is 1.024 bigger than three just thirds. This is about 1/2 of a semitone above. Thus an octave is about 1/2 of a semitone above three just thirds.

5) If one starts with the Just scale on C. Now go up a fifth to G. What notes would one have to change to make a just scale starting on G? By how much would one have to change the F to make it a perfect fourth above G?

The Just scale has the the following setup of tones

$< C > T_P < D > T_J < E > S_J < F > T_P < G > T_J < A > T_P < B > S_J < C >$

where $T_P = \frac{9}{8}$ is the Pythagorean tone, $T_J = \frac{10}{9}$ is the Just tone (from a Pythagorean Second($\frac{9}{8}$) to a Just third($\frac{5}{4}$), $S_J = \frac{16}{15}$ the distance from a just third to a Pythagorean fourth ($\frac{4}{3}$) This would be the tuning of the white keys on a just tuned piano.

If we start the scale on G instead, the step from G to A is now a just tone, rather than a Pythagorean tone. If one wanted the true just interval from G to A one would have to very slightly sharpen the A. The B would be OK (It would be a just tone and a pythag tone above G) and the C would be OK as would the D and the E. But the F would have to be sharpened to convert the $S_J$ above E into an $T_P$. That would convert the $T_P$ to G into and $S_J$.

Ie, to make a perfect New just scale, one would have to very slightly sharpen the A (much less than a semitone– from 10/9 above G to 9/8 above G, or by 81/80= 1.0125 which is about 1/4 of a semitone) and would need to sharpen the F by a semitone to F#(from 16/15 above the E to 9/8 above the E, which is about 135/128= 1.0545 above F).

BEcause of the small sharpening needed for the A, and because a second is not a harmony anyway, might leave the A unchanged, and just shapen the F from a Just semitone above E to a Pythagorean tone above E.

[ Brief table of commonly used prefixes: n = nano = $10^{-9}$ = 1/1,000,000,000
$\mu$ = micro = $10^{-6}$ = 1/1,000,000
m = milli = $10^{-3}$ = 1/1,000
c = centi = $10^{-2}$ = 1/100
d = deci = $10^{-1}$ = 1/10
h = hecta= $10^{2}$ = 100
K = kilo = $10^{3}$ = 1000
M = Mega = $10^{6}$ = 1,000,000
G = giga = $10^{9}$ = 1,000,000,000 ]

It is interesting that in scientific notation, names are given only up to Y= Yotta= $10^{24}$, whereas in classical Japanese there are names for numbers at least all the way up to $10^{52}$.

http://en.wikipedia.org/wiki/Japanese_numerals.

(The Japanese use 10000=$10^4$ as the multiple for names, rather than our 1000.) Why in the 16th century anyone would need to give such a large number a name I do not know. This aside is of course totally irrelevant to the course.