A BRIEF DESCRIPTION BY NICOLAUS COPERNICUS CONCERNING THE MODELS OF THE MOTIONS OF THE HEAVENS THAT HE INVENTED

1. [INTRODUCTION]

I understand that our predecessors assumed a large number of celestial spheres principally in order to account for the apparent motion of the planets through uniform motion, for it seemed highly unreasonable that a heavenly body should not always move uniformly in a perfectly circular figure. They had discovered that by the arrangement and combination of uniform motions in different ways it could be brought about that any body would appear to move to any position.

Calippus and Eudoxus, attempting to carry this out by means of concentric circles, could not by the use of these[a] give an account of everything in the planetary motion, that is, not only those motions that appear in connection with the revolutions of the planets, but also that the planets appear to us at times to ascend and at times to descend in altitude, which concentric circles in no way permit. And for this reason a preferable theory, in which the majority of experts finally concurred, seemed to be that it is done by means of eccentrics and epicycles.

Nevertheless, the theories concerning these matters that have been put forth far and wide by Ptolemy and most others, although they correspond numerically [with the apparent motions], also seemed quite doubtful, for these theories were inadequate unless they also envisioned certain *equant* circles, on account of which it appeared that the planet never moves with uniform velocity either in its *deferent* sphere or with respect to its proper center. Therefore a theory of this kind seemed neither perfect enough nor sufficiently in accordance with reason.

Therefore, when I noticed these [difficulties], I often pondered whether perhaps a more reasonable model composed of circles could be found from which every apparent irregularity would follow while everything in itself moved uniformly, just as the principle of perfect motion requires. After I had attacked this exceedingly difficult and nearly insoluble problem, it at last occurred to me how[a] it could be done with fewer and far more suitable devices than had formerly been put forth if some postulates, called axioms, are granted to us, which follow in this order:

First Postulate

There is no one center of all the celestial spheres (*orbium*) or spheres (*sphaerarum*).

Second Postulate

The center of the earth is not the center of the universe, but only the center towards which heavy things move and the center of the lunar sphere.

Third Postulate

All spheres surround the sun as though it were in the middle of all of them, and therefore the center of the universe is near the sun.

Fourth Postulate

The ratio of the distance[b] between the sun and earth to the height of the sphere of the fixed stars is so much smaller than the ratio of the semidiameter of the earth to the distance of the sun that the distance between the sun and earth is imperceptible compared to the great height of the sphere of the fixed stars.

Fifth Postulate

Whatever motion appears in the sphere of the fixed stars belongs not to it but to the earth. Thus the entire earth along with the nearby elements rotates with a daily motion on its fixed poles while the sphere of the fixed stars remains immovable and the outermost heaven.

Sixth Postulate

Whatever motions appear to us to belong to the sun are not due to [motion] of the sun but [to the motion] of the earth and our sphere with which we revolve around the sun just as any other planet. And thus the earth is carried by more than one motion.
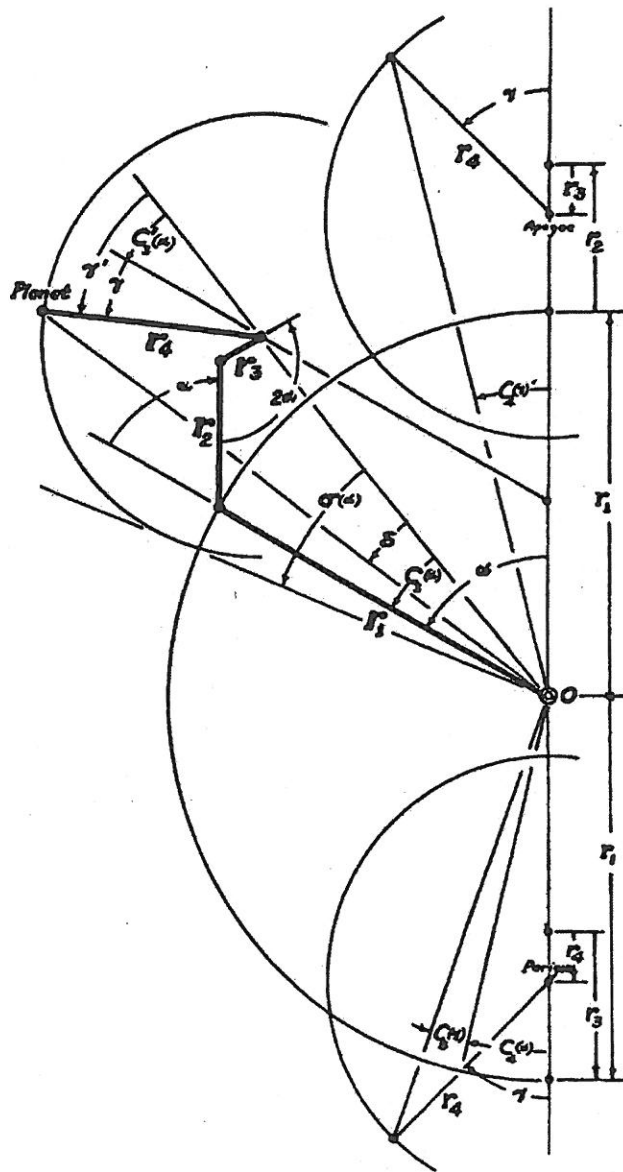
Seventh Postulate

The retrograde and direct motion that appears in the planets belongs not to them but to the [motion] of the earth. Thus, the motion of the earth by itself accounts for a considerable number of apparently irregular motions in the heavens.

Now that these postulates have been set down, I shall attempt briefly to show how carefully the uniformity of the motions may be preserved. I have decided, however, for the sake of brevity to leave the mathematical demonstrations out of this treatise as they are intended for a larger book. Nevertheless, the lengths of the semidiameters of the spheres will be set down here in the explanation of their circles, from which anyone not ignorant of mathematics will easily understand how very precisely such an arrangement of circles agrees with computations and observations.

In the same way, in case anyone believes that we have asserted the movement of the earth for no good reason along with the Pythagoreans, he will also receive considerable evidence [for this] in the explanation of the circles. And in fact, [the evidence] by which natural philosophers attempt so very hard to confirm the immobility of the earth depends for the most part upon appearances. All [their evidence] falls apart here in the first place since we overthrow the immobility of the earth also by means of an appearance.

Ibn al-Shāṭir's Planetary Theory (ca. 1350)

no eccenter, no equant

MOON

Ibn al-Shāṭir / Copernicus $r_2 = \begin{cases} 6;35 \\ 6;34,55 \end{cases}$ $r_3 = \begin{cases} 1;25 \\ 1;25,19 \end{cases}$

2η or γ'	$C_3(2\eta)$			$C_4(\gamma')$			$C_5(\gamma')$			$C_6(2\eta)$		
	Computed	Shāṭir	Copern.	Comp.	Sh.	Cop.	Comp.	Sh.	Cop.	Computed	Ibn al-Shāṭir	Copernicus
30	7;32	7;32	7;34	2;18	2;18	2;17	1;8	1;8	1;12	0;5,7	0;5,0	0;5
60	11;48	11;47	11;50	4;5	4;5	4;5	2;6	2;5	2;6	0;17,55	0;17,39	0;18
90	12;9	12;8	12;12	4;55	4;55	4;55	2;41	2;40	2;40	0;33,17	0;33,8	0;34
120	9;33	9;31	9;35	4;27	4;27	4;27	2;36	2;36	2;35	0;47,11	0;47,8	0;47
150	5;11	5;11	5;11	2;40	2;40	2;40	1;39	1;39	1;37	0;56,42	0;56,39	0;57

SATURN

Sh. / Cop. $r_2 = \begin{cases} 5;7,30 \\ 5;7,26 \end{cases}$ $r_3 = \begin{cases} 1;42,30 \\ 1;42,36 \end{cases}$ $r_4 = \begin{cases} 6;30 \\ 6;32 \end{cases}$

α or γ'	$C_3'(\alpha)$			$C_4(\gamma')$			$C_5(\gamma')$			$C_6(\alpha)$		
30	3;6	3;6	3;6	2;42	2;42	2;42	0;17	0;20	0;19	0;3	0;3	0;3
60	5;29	5;29	5;29	4;50	4;48	4;49	0;32	0;35	0;33	0;11	0;12	0;11
90	6;30	6;30	6;31	5;51	5;52	5;52	0;42	0;42	0;42	0;25	0;26	0;23
120	5;48	5;48	5;49	5;21	5;21	5;22	0;42	0;42	0;42	0;38	0;41	0;39
150	3;26	3;26	3;24	3;13	3;12	3;13	0;26	0;26	0;26	0;54	0;53	0;53

JUPITER

Sh. / Cop. $r_2 = \begin{cases} 4;7,30 \\ 4;7,19 \end{cases}$ $r_3 = \begin{cases} 1;22,30 \\ 1;22,26 \end{cases}$ $r_4 = \begin{cases} 11;30 \\ 11;30 \end{cases}$

	Computed	Sh.	Cop.	Comp.	Sh.	Cop.	Comp.	Sh.	Cop.	Computed	Ibn al-Shāṭir	Copernicus
30		2;31	2;31		4;32	4;32		0;21	0;21		0;3	0;2,50
60		4;24	4;26		8;18	8;17		0;42	0;42		0;12	0;13,10
90		5;14	5;15		10;24	10;24		0;58	0;58		0;26	0;26,57
120		4;40	4;41		9;54	9;54		1;3	1;2		0;43	0;41,50
150		2;44	2;45		6;13	6;13		0;45	0;43		0;55	0;55,15

MARS

Sh. / Cop. $r_2 = \begin{cases} 9;0 \\ 8;46 \end{cases}$ $r_3 = \begin{cases} 3;0 \\ 3;0 \end{cases}$ $r_4 = \begin{cases} 39;30 \\ 39;29 \end{cases}$

	Computed	Sh.	Cop.	Comp.	Sh.	Cop.	Comp.	Sh.	Cop.	Computed	Ibn al-Shāṭir	Copernicus
30	5;15	5;16	5;10	11;9	11;9	11;11	1;26	1;28	1;25	0;2,1	0;2,0	0;2,1
60	9;22	9;23	9;12	21;45	21;46	21;49	3;8	3;7	3;0	0;8,27	0;8,40	0;8,30
90	11;20	11;19	11;5	30;54	30;54	31;0	5;17	5;17	5;5	0;20,4	0;19,26	0;20,8
120	10;20	10;20	10;7	36;29	36;29	36;37	8;29	8;28	8;11	0;35,22	0;35,50	0;36,16
150	6;15	6;15	6;7	31;51	31;51	32;3	13;5	13;4	12;35	0;52,39	0;52,36	0;52,22

VENUS

Sh. / Cop. $r_2 = \begin{cases} 1;41 \\ 1;52 \end{cases}$ $r_3 = \begin{cases} 0;26 \\ 0;37 \end{cases}$ $r_4 = \begin{cases} 43;33 \\ 43;9 \end{cases}$

	Sh.	Cop.		Comp.	Cop.		Sh.	Cop.		Ibn al-Shāṭir	Copernicus
30	1;0	0;59		12;21	12;24		0;19	0;13		0;2	0;3,38
60	1;43	1;43		24;19	24;24		0;38	0;27		0;14	0;13,32
90	2;1	2;0		35;9	35;21		1;9	0;47		0;28	0;28,28
120	1;45	1;45		43;19	43;35		1;52	1;18		0;44	0;43,10
150	1;2	1;1		42;6	42;34		3;11	2;13		0;55	0;55,0

MERCURY

Sh. / Cop. $r_2 = \begin{cases} 4;5 \\ 4;25 \end{cases}$ $r_3 = \begin{cases} 0;55 \\ 1;16 \end{cases}$ $r_4 = \begin{cases} 22;46 \\ 22;35 \end{cases}$ $r_5 = r_6 = \begin{cases} 0;33 \\ 0;34,12 \end{cases}$

	Computed	Sh.	Cop.	Comp.	Sh.	Cop.	Comp.	Sh.	Cop.	Computed	Ibn al-Shāṭir	Copernicus
30	1;25	1;25	1;24	7;22	7;22	7;15	0;59	0;59	1;16	0;12	0;12	0;8,29
60	2;31	2;31	2;29	13;54	13;55	13;41	2;1	2;0	2;34	0;39	0;39	0;31,39
90	3;1	3;2	3;0	18;26	18;26	18;6	3;4	3;3	3;56	1;3	1;3	0;52,2
120	2;44	2;44	2;44	19;6	19;6	18;42	3;55	3;55	5;2	1;11	1;11	1;0,0
150	1;38	1;38	1;38	13;11	13;10	12;52	3;28	3;28	4;26	1;5	1;5	0;54,25
180	0;0	0;0	0;0	0;0	0;0	0;0	0;0	0;0	0;0	1;0	1;0	0;52,2