The sun's companions : the heliocentric orbits of mercury and venus : Reykjavík, Stofnun Árna Magnússonar, GkS 1812 4to, fol. 10v (1315-c. 1400)

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The Sun's Companions
The Heliocentric Orbits of Mercury and Venus, Reykjavík, Stofnun Árna Magnússonar, GkS 1812 4to, fol. 10v (1315-*c.* 1400)

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This diagram, preserved on folio 10v of the large illustrated miscellany in the Stofnun Árna Magnússonar with the shelf mark GkS 1812 4to (1315-*c.* 1400), describes and explains a pattern in the motions of the inner planets, Mercury and Venus. It accompanies an Old Norse text (at the top of the folio) that details the time it takes for these planets to complete their orbits around the earth, and an astronomical note (at the bottom of the folio) attributed to Johannes de Sacrobosco (d. 1256), the English-born Parisian scholar *er lifði a avnðverdvm dogvm Magnus konungs hakonar sonar* ("who lived during the early days of King Magnús Hákonarson").[1] The diagram is paired with another on folio 11r that shows the orbits of the remaining outer planets: Mars, Jupiter, and Saturn.

The diagram (also transcribed in *Alfræði Íslenzk* (Kålund, 1908-1918:2, ccxiii)) accounts for two observations in the motions of the inner planets, Mercury and Venus. Firstly, ancient astronomers saw that these planets did not stray far from the sun in the course of their orbits around the earth. This led the Roman philosopher and politician Cicero to call Mercury and Venus the *comites solis*, the sun's companions. Secondly, they saw that while the planets usually moved eastwards across the night sky, they did not appear to turn in their orbits around the earth uniformly. Rather, the planets appeared periodically to stall, and then reverse direction, seeming to move westwards relative to the stars instead of their usual eastwards. This phenomenon was described by ancient astronomers, whose observations were summarised by Pliny the Elder (*Historia Naturalis*, II.12), Seneca (*Naturales quaestiones*, VII.xxv.6-7) and Isidore of Seville (*Etymologiae*, III.lxviii-lxix). The diagram accounts for these two observations by introducing two cosmographical principles: the eccentric-epicycle, and the geo-heliocentric orbits of Mercury and Venus.

Iord	Earth
Sol	Sun
messinglig	brazen
Fyrsta staða Venus	First station of Venus

[1] All translations are my own, DK.

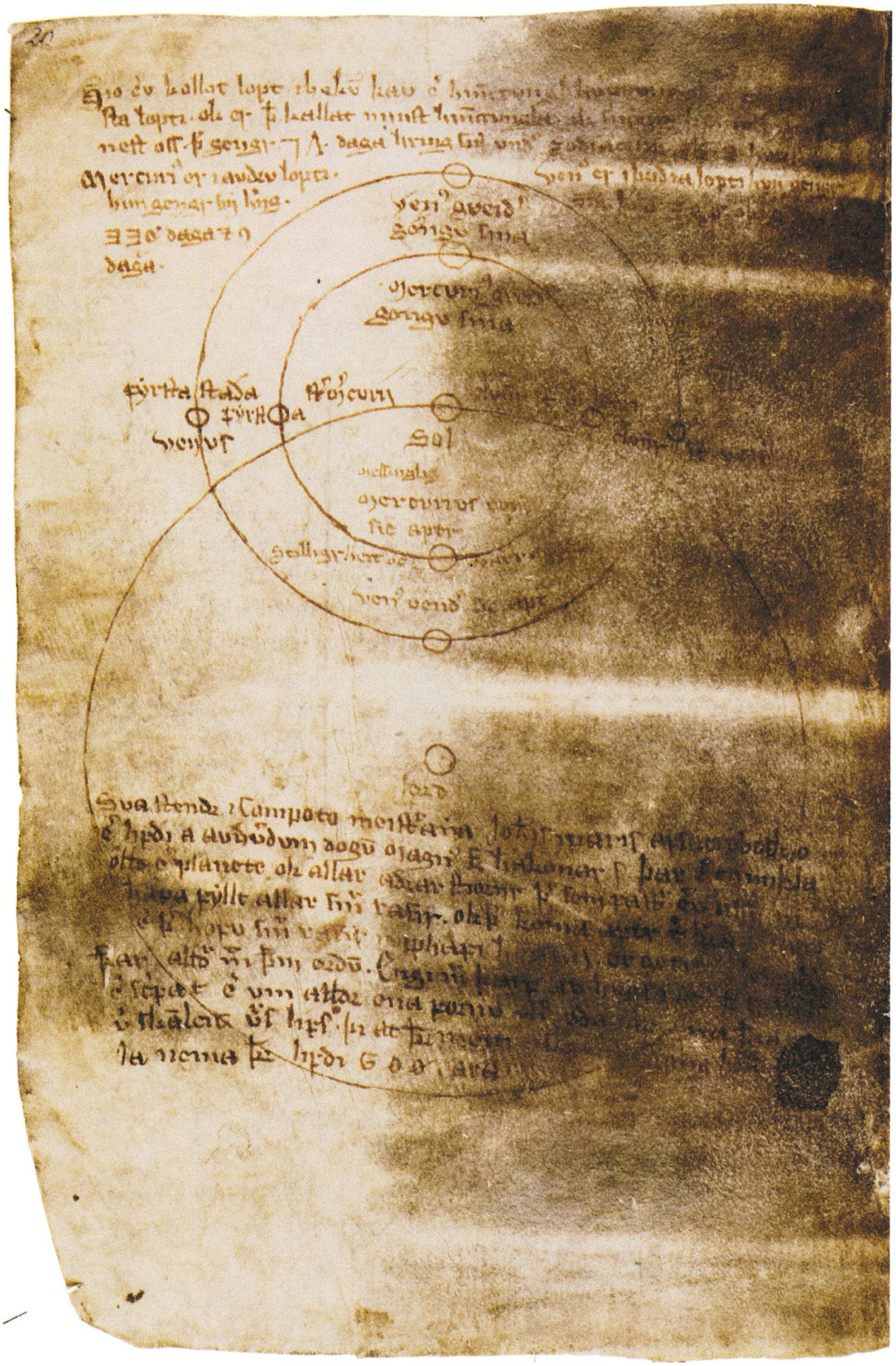

Diagram showing the geo-heliocentric orbits of the inner planets, Mercury and Venus, GkS 1812 4to, 10v (1315-c. 1400)
(© Stofnun Árna Magnússonar í íslenskum fræðum)

Venus greidir gongu sina	Venus proceeds in its course
Aunnr staða Venus	Second station of Venus
Venus vendir sic aptr	Venus turns itself around
Stilligr heit oc varringligr	Calm hot and copper [Mercury]
Fyrsta Mercurius	First [station] of Mercury
Mercurius greidir gongu sina	Mercury proceeds in its course
Aunnr staða Mercurius	Second station of Mercury
Mercurius vendir sic aptr	Mercury turns itself around

In modern terms, we know that the planets appear to move westwards relative to the stars because of the daily rotation of the earth on its axis, and that they appear periodically to change direction when they overtake, or are overtaken by, the earth in the course of their yearly orbits around the sun. However, for medieval natural philosophers, this phenomenon, known as apparent retrograde motion, troubled the Aristotelian model of the nested planetary spheres that guided their regular and symmetrical motions around the earth.

The Icelandic diagram shows the system developed by Claudius Ptolemy (*c.* 100-*c.* 170) to explain these planetary motions, the eccentric epicycle. Between the middle of the twelfth and thirteenth centuries, two cosmological systems were introduced into Western Europe: those of Aristotle and Ptolemy (Duhem, 1913-59:1, 488-97; Grant, 1987: 189; Simek, 1996: 16-19). The Aristotelian system was known through translations of Aristotle's natural books, and commentaries on them. Ptolemy described the eccentric epicycle in a treatise entitled *Hypotheses of the Planets.* This treatise was not known directly in the Latin Middle Ages, but was known in abstract through Arabic treatises, which became assimilated into the European canon in the twelfth and thirteenth centuries.

Both the Aristotelian and Ptolemaic systems held that the cosmos comprised seven planets located in a variable number of spheres, which accounted for variations in their movements (Grant, 1996: 104). The main difference between the two systems was whether or not these spheres were concentric with the earth. Aristotle described the cosmos as a series of concentric orbs with the earth at its absolute centre. However, medieval natural philosophers observed that this system could not account for the complexity of the planets' motions. Ptolemy, on the other hand, proposed that the planetary spheres were eccentric, which is to say that they did not have the earth at their absolute centres, and that the planets' orbits were epicyclic, that is, that the planets turned on smaller circles (*epicycles*) as they proceeded in their wider eccentric orbits (*deferents*) around the earth. Ptolemy's theory better represented planetary motions, and could account in particular for the periods in which their orbits appeared to stall and then move in the opposite direction. When the planet turned in its epicycle, it would appear momentarily to stand still, and then resume its course in the opposite direction.

The second principle illustrated by this diagram is the geo-heliocentric nature of these planets' orbits. Again, this theory is rooted in observation. In modern terms, we know that Mercury and Venus lie between the earth and the sun, and that they

cannot appear, from an earthly perspective, to stray far from the sun's path. This led ancient astronomers to suggest that Mercury and Venus circled the sun, centuries before Copernicus and Tycho Brahe developed their heliocentric and geo-heliocentric models of the solar system (Duhem, 1913-59: 1, 47). Ancient astronomers proposed that these planets turned on their epicycles around the sun, while the sun in turn drew a larger orbit around the earth.

The Icelandic diagram resembles others that illustrate widely-known astronomical works, such as William de Conches's *Dragmaticon philosophiae* and Sacrobosco's *Tractatus de sphaera* (Duhem, 1913-59: 3, 153-55; Eastwood and Graßhoff, 2004: 75-86, 133-35; Obrist, 2009). It shows the earth amid the sun's course, with Mercury and Venus at four positions in their epicycles centred on the sun. Sacrobosco's description of the epicycle explains what we see on the Icelandic diagram:

> *If, then, two lines are drawn from the centre of the earth to include an epicycle, one on the east and the other on the west, the point of contact on the east is called the "first station" ('statio prima'), while the point of contact to the west is called the "second station" ('statio secunda'). And when a planet is in either of those stations it is called "stationary" ('stationarius'). The upper arc of the epicycle intercepted between those two stations is called "direction" ('directio'), and when the planet is there it is called "direct" ('directus'). But the lower arc of the epicycle between the two stations is called "retrogradation" ('retrogradatio'), and a planet existing there is called "retrograde" ('retrogrades').*
> (Sacrobosco, *Tractatus de sphaera*, 114-115)

In its first position, *fyrsta staða Venus* ("first station of Venus"), the planet is shown in the stationary position that begins the epicycle. In its second position, the planet is shown in direct motion, with the inscription *Venus greiðir göngu sína* ("Venus proceeds in its course"). In its third position, *aunnr staða Venus* ("second station of Venus"), the planet is shown to come to a standstill, before it resumes its course in the opposite direction. In its fourth position, the planet is shown in retrograde motion, with the inscription *Venus vendir sik aptr* ("Venus turns itself around"), until it reappears on the other side of the sun and begins its epicycle anew. The Old Norse *fyrsta* and *aunnr staða* are loan translations of the Latin *statio prima* and *statio secunda* (cf. ON *solstaða*, "solstice"). The Latin *directio* and *retrogradatio* are not adopted as loanwords but have been allocated more descriptive terms: the planet proceeds in its course (*greiðir göngu sína*), and then turns itself around (*vendir sik aptr*) as it turns in its epicycle. The accompanying texts do not contribute to the diagram's description of these planets' circumsolar orbits, and more detailed explanations of the eccentric epicycles are not to be found in the Icelandic encyclopaedic literature that survives. These translation moments are especially valuable, therefore, for what they tell us about the transmission of these ideas into medieval Iceland.

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