1 Sacred Astronomy? Beyond the Stars on a Whipple Astrolabe*

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It has occasionally been my privilege to act as a stand-in gallery attendant in the Whipple Museum. This has afforded precious opportunities to observe visitors, who seem not to feel my scrutiny as they explore the atmospheric main gallery. Almost invariably they wander clockwise. They may pause first at the horses' teeth or glass fungi. But they are guaranteed to stop, and to stare, at the astrolabes case.

Astrolabes seem to hold a fascination for museum visitors, even – perhaps especially – if they have no understanding of their workings. A mathematical instrument that is as beautiful as it is precise, a medieval astrolabe can be appreciated on multiple levels, scientific or artistic. This is not as anachronistic as it might appear: when they were made, too, astrolabes – at least the ones that survive in museum collections – were ornate status symbols as well as functional tools. Even so, it is often hard to imagine the contexts in which these devices were first designed and used. Behind glass, their three-dimensionality and mutability obscured by the fixed presentation of one face to the observer, they may epitomise the 'decontextualised commodities' deplored by Ludmilla Jordanova.[1] Even for those of us who study them, they seem to recede into mystery even as new methods of analysis allow us to get closer to them than ever before: as the newly delineated complexities of their long lives blur simple

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1 L. Jordanova, 'Objects of Knowledge: A Historical Perspective on Museums', in Peter Vergo (ed.), *The New Museology* (London: Reaktion, 1989), pp. 22–40, on p. 25.

ascription, or as once-prized historic objects turn out to be modern fakes.[2] It is thus perhaps not surprising that, at least until recently, approaches to astrolabes have been narrowly antiquarian.[3] Understanding the conditions and motivations of their use was seen as less important than seeking ever greater precision about the time and place of their production. Needless to say, in order to use an object to illuminate its context we first need to know where and when that context was. Yet, even when we lack certainty about their provenance, there remain ways that astrolabes can be understood and can help us to better understand the Middle Ages more generally.

This chapter focuses on one astrolabe in the Whipple Museum's collection, Wh.1264 (Figure 1.1), as a way of highlighting these issues. It is an object that has not been extensively studied: it is not clear when or how it came to be in the Whipple collection, and it was not included in the foundational catalogues of astrolabes.[4] Some studies have considered it, but mainly as a way of elucidating other instruments.[5] However, it has recently played a supporting role in a detailed treatment of another instrument in Cambridge, and it has been included in an extensive programme of metallurgical analysis carried out by John Davis.[6] Such new methods as X-ray fluorescence

2 B. Jardine, J. Nall, and J. Hyslop, 'More Than Mensing? Revisiting the Question of Fake Scientific Instruments', *Bulletin of the Scientific Instrument Society*, 132 (2017), pp. 22–9.

3 These were epitomised by R. T. Gunther in his *Astrolabes of the World* (Oxford: Oxford University Press, 1932); *Early Science in Oxford* (Oxford: Oxford University Press, 1923); and *Early Science in Cambridge* (Oxford: Oxford University Press, 1937). For the influence of such approaches on the early development of the Whipple Museum, see S. Falk, 'The Scholar as Craftsman: Derek de Solla Price and the Reconstruction of a Medieval Instrument', *Notes and Records of the Royal Society*, 68 (2014), pp. 111–34.

4 Gunther, *Astrolabes of the World*; D. J. Price, 'An International Checklist of Astrolabes', *Archives internationales d'histoire des sciences*, 32 (1955), pp. 243–63; and S. L. Gibbs, J. A. Henderson, and D. J. de Solla Price, *Computerized Checklist of Astrolabes* (New Haven: Yale University Press, 1973). It is included, with the briefest description, in David Bryden's catalogue of sundials at the Whipple Museum: D. J. Bryden, *The Whipple Museum of the History of Science, Catalogue 6: Sundials and Related Instruments* (Cambridge: Whipple Museum of the History of Science, 1988), no. 342.

5 O. Gingerich, 'Zoomorphic Astrolabes and the Introduction of Arabic Star Names into Europe', *Annals of the New York Academy of Sciences*, 500 (1987), pp. 89–104; and C. Eagleton, '"Chaucer's Own Astrolabe": Text, Image and Object', *Studies in History and Philosophy of Science Part A*, 38 (2007), pp. 303–26.

6 J. Davis and M. Lowne, 'An Early English Astrolabe at Gonville & Caius College, Cambridge, and Walter of Elveden's *Kalendarium*', *Journal for the History of Astronomy*, 46 (2015), pp. 257–90. I am grateful to J. Davis for sharing the results of his endeavours with me.

Figure 1.1 Wh.1264, an English astrolabe, *c*. 1350. Image © Whipple Museum.

(XRF) analysis, diffraction analysis, and scanning radiography have the potential to revolutionise our understanding of instruments. Hard data about their chemical composition or metallic microstructure can, in combination with more traditional comparative techniques, support theories about their age, geographical origins, and methods of production, as well as testing old broad-brush dating tools such as precession data.[7]

Yet pinpointing the age and geographical origins of an astrolabe is problematic, for two contrasting reasons. First, these were never static objects. They moved freely across the national boundaries

7 In principle, the astrolabe rete and calendars should reflect the state of the skies at the time the astrolabe was made, and the position of the first point of Aries has often been used as an indication of this, but this approach is unreliable. See Gingerich, 'Zoomorphic Astrolabes and the Introduction of Arabic Star Names into Europe', p. 89; and G. L'Estrange Turner, 'A Critique of the Use of the First Point of Aries in Dating Astrolabes', in G. L'Estrange Turner, *Renaissance Astrolabes and Their Makers* (Aldershot: Ashgate, 2003), Part III, pp. 548–54.

marked on modern maps – and as they moved, they changed. Parts of these instruments – always intended to be dismantled and reconfigured – were lost; new parts were added; new engravings were made, altering the purposes or appearance of the instruments. Some may almost be regarded as compilations, or as having been composed and later re-edited. When we talk of astrolabes having replacement parts we may picture insensitive Victorian curators, and indeed astrolabes in British museums contain their fair share of nineteenth-century brass. Yet we must reflect that parts were most likely to be lost or broken when the instruments were in most active use. XRF analysis would seem to support this, as we find different parts of instruments containing quite different – but still medieval – alloys. Secondly, a precise guess of a date and place of origin, or even ascribing an instrument to a named individual, may overlook the continuity of artistic and particularly scientific trends across time and context. Contemporary scholars were remarkably uninterested in the geographical or even religious origins of scientific instruments or ideas.[8]

Nevertheless, even within such broader trends we find local specificities. One example of this is the religious motivation for scientific inquiry. Links between Christianity and astronomy were long underestimated, and although no serious historian now subscribes to the idea of a 'warfare of science with theology', historians may still disagree about how far Christian faith inspired an understanding of nature, or was simply set aside by natural philosophers.[9] Astrolabes have a part to play in exploring such questions. Just as an image of an instrument might symbolise learning in an illuminated bible (Figure 1.2), so the inclusion of religious information on an astrolabe could allow its patron or maker to express his devotional preferences.[10] This need not have been in an explicitly religious setting like a monastery; it seems to have occurred as much on instruments

8 O. Pederson has shown how unconcerned commentators were with the nationality of Johannes de Sacrobosco. See O. Pederson, 'In Quest of Sacrobosco', *Journal for the History of Astronomy*, 16 (1985), pp. 175–220.

9 See A. D. White, *A History of the Warfare of Science with Theology in Christendom* (New York: Appleton, 1896). See also the debate between E. Grant and A. Cunningham in the pages of *Early Science and Medicine*, 5 (2000), pp. 258–300.

10 On devotional motivations for practising astronomy, see S. Falk, 'Improving Instruments: Equatoria, Astrolabes, and the Practices of Monastic Astronomy in Late Medieval England', unpublished PhD thesis, University of Cambridge (2016), pp. 13–41.

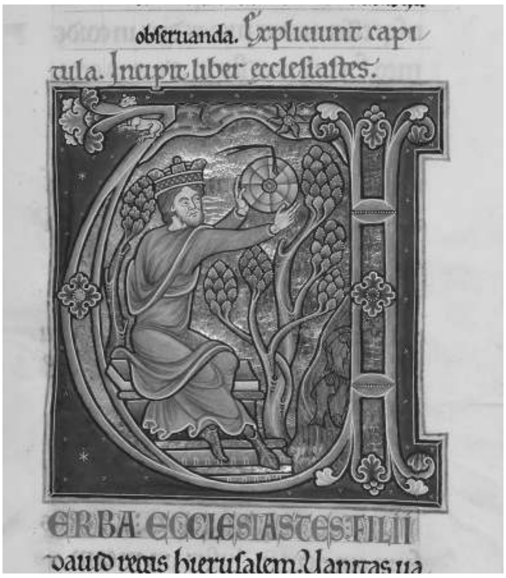

Figure 1.2 Solomon observing the stars, from a Franciscan Bible. The message here is ambiguous: the historiated initial adorns the opening to the Book of Ecclesiastes, in which the wise Solomon admonishes that 'in much wisdom is much grief: and he that increaseth knowledge increaseth sorrow' (1:18). Reproduced courtesy of the Bibliothèque Nationale de France (MS Latin 16745 (*c.* 1170–80), fol. 108).

made for lay patrons, and in any case the links between the larger monasteries and the universities and royal court were strong across the late medieval period.

The Whipple's English Astrolabe

Wh.1264 is an ideal object to show how such devotional preferences might be expressed. It has usually been dated to the late fourteenth century, and is among the larger Western astrolabes known from this period: its mater is 295 mm in diameter, and 40 mm thick; the entire instrument including its suspension ring and throne measures 348 mm in length. The mater was constructed by riveting a cast rim (with a depth of 5 mm) onto the backplate, with twenty-three regularly spaced pins that have been driven through the front. The throne is set into the rim and fixed in place with two rivets, though this joint has become a little loose. The throne is very small and plain: a round boss that is almost completely covered by the shackle; the bail is in the T–H form common to astrolabes of this period. The astrolabe is held together with a plain pin and horse, including three modern washers (one metal, two plastic) – it is not known when these were added. It has a double graduated rule atop the rete, and an alidade with pinhole sights at the back.

It was manufactured from a fairly typical medieval latten, an alloy of copper and zinc with smaller quantities of tin and lead. XRF analysis of the instrument by Davis shows that it contains an unusually low level of zinc (7.7 per cent) compared with other astrolabes of the period which are more likely to have 10–15 per cent.[11] The rete has slightly higher levels of zinc, showing how variable the smelting process could be, and the alidade, rule, and pin have significantly higher zinc levels (*c*. 20 per cent) which suggest these may be later replacement parts. The horse is certainly made of a modern brass.

There are no separate tympans for specific latitudes; the only stereographic projection is engraved within the womb of the mater. It is not labelled for a specific place or latitude, but the distance between the zenith and the celestial pole indicates that it was produced for use at latitude 52°. This corresponds to locations in central England where astronomy was extensively practised, such as the university of Oxford and monastery of St Albans; however, Davis and Lowne, connecting it with an astrolabe at Gonville & Caius College, have suggested that it may have been made for use at Norwich.[12] The almucantars, which mark celestial altitude, are drawn and labelled every two degrees: as closely spaced as, and more frequently labelled than, on any catalogued astrolabe. This would have made it exceptionally user-friendly when it came to finding the locations of stars. Yet this 600-year-old instrument was surely used in different ways at different times. Engraved and labelled among the almucantars with a finer tool and later script are the Great Houses, useful for astrology; much more crudely, hammered points just inside the rim were used to add the first few letters of the name of each month, as well as four dots in the shape of a diamond, twice between each month name and the next (Figure 1.3).

The absence of interchangeable tympans (plates) for different latitudes makes Wh.1264's origins and purpose harder to identify. The presence of modern washers to prevent the rete, rule, and alidade from rotating too loosely suggests that the astrolabe previously had tympans which have been lost. However, tympans must be held in place within the womb of the mater; this was usually accomplished by making the tympans with tangs that fit into a slot in the rim, though some later astrolabes instead had lugs in the rim and notches in the tympans. This astrolabe has neither system, and a stereographic projection is, somewhat unusually, engraved in the

11 Davis and Lowne, 'An Early English Astrolabe at Gonville & Caius College, Cambridge, and Walter of Elveden's *Kalendarium*', p. 280; and J. Davis, private correspondence, 6 April 2018.

12 Davis and Lowne, 'An Early English Astrolabe at Gonville & Caius College, Cambridge, and Walter of Elveden's *Kalendarium*', p. 257.

Figure 1.3 Detail from the womb of Wh.1264, showing the equator, almucantars, and unequal hours, and a finer Great House line (with corrected '6'). Note also the hammered-in month names and diamonds. Image © Whipple Museum.

womb, so it may be questioned whether it ever had separate tympans. In addition, the single stereographic projection has, unusually, neither a named location nor a latitude. These details would have been omissible if there was no need to distinguish between different projections; if, perhaps, its user had no plans to travel with it. On the other hand, if an astrolabe was intended for use at a single latitude, the mater could be reduced to a single plate, as we find on Wh.4552, a near neighbour in the Whipple's current display. The fact that Wh.1264 has a recessed womb surrounded by a rim suggests that it was at least intended to be equipped with tympans. In any case, astrolabes without tympans are rare, whereas it is relatively common for tympans to have been lost from astrolabes now on display in museums. Lacking any other evidence, we must assume that this is the case with this instrument. How the tympans would have been secured in place is not clear, though since the throne is a little loose it is possible that it was originally fitted differently, and that the refitted throne has filled a slot that was previously located just beneath, as is customary. Alternatively, perhaps the astrolabe is incomplete: its maker may have failed to fit the womb with lugs, just as he failed to mark the latitude; or, conceivably, he chose to add a rim for aesthetic reasons.

Tympans are not the only notable absence from this astrolabe. It is also missing any engraving within the top inner semicircle on the back (apart from a roughly scratched 'Hd'). In Western astrolabes from this period it is fairly common to see an unequal-hour scale there. John North has called the inclusion of these lines an 'empty ritual', noting how rarely the scales are accurately engraved or supplied with a counterpart giving solar positions; it might be added that such scales are usually unnecessary, since they are commonly also on the front of the astrolabe.[13] Their appearance on the back may indeed be ritualistic, reminding users of the astrolabe's time-keeping function and perhaps privileging that over its parallel astronomical uses. In this context, it is also notable that the rim of Wh.1264 is labelled with 360 degrees, rather than the twenty-four hours that were a common feature of Western astrolabes in this period.[14] One may, then, suggest that its maker was relatively uninterested in timekeeping functions. Needless to say, it can still be used to tell the time with some precision, during the day or night, at any season of the year. It has unequal-hour lines on the front, and the rule is graduated to allow conversion between equal and unequal hours, according to the midday solar altitude, at the latitude for which the astrolabe was made. The lack of an equal-hour scale on the rim certainly makes Wh.1264 less user-friendly for timekeeping, but even if the maker of this astrolabe was more interested in astronomical uses, or wanted to use the 360-degree scale on the rim to represent a conceptualisation of the cosmos as a geometrical entity, such intentions might not be reflected in the way it was used. Certainly, the 360-degree scale by no means precludes its use as a time-telling device.

Stars and Almucantars

It is possible to characterise the back of the astrolabe, with its calendar of feast days and surveyor's shadow square, as representing terrestrial things; the front, in contrast, carries the net of stars and so looks more directly towards the heavens. The rete has been considered by a few scholars who have sought to develop typologies of

13 J. North, 'Astrolabes and the Hour-Line Ritual', in J. North, *Stars, Minds and Fate: Essays in Ancient and Medieval Cosmology* (London: Hambledon, 1989), pp. 221–2, on p. 221. First published in *Journal for the History of Arabic Science*, 5 (1981), pp. 113–14.

14 The astrolabe illustrated in Chaucer's *Treatise* has the latter arrangement. See G. Chaucer, *A Treatise on the Astrolabe* (*c*. 1391), ed. S. Eisner (Norman: University of Oklahoma Press, 2002), pp. 142–3.

astrolabes according to their shapes, symbolism, and the stars they contain.[15] Wh.1264 fits into a group of astrolabes with quatrefoil and demi-quatrefoil motifs on their retes, which have been distinguished from other instruments whose retes are dominated by a Y-shape within the ecliptic circle. The latter group are sometimes characterised as 'Chaucerian' because the same Y-shape appears in illustrations within some early copies of the *Treatise on the Astrolabe*, but it is not clear whether the illustrations imitate the astrolabes, vice versa, or both in different cases.[16] Those astrolabes adorned with architectural decoration such as quatrefoils have been persuasively linked with similar examples of church architecture as a way of localising their production (or adaptation); such comparisons by themselves may be unconvincing, but can add important support to origins hypotheses based on other parts of the instruments.

The stars marked on astrolabe retes do not necessarily correlate closely with the decoration of their supporting framework. They have been analysed in terms of the selection of stars included, the positions given, and the names used. Gingerich has called the fourteenth century 'a key period in the transmission of Arabic star names into common English usage', and we certainly find these Arabic star names on Wh.1264.[17] (Many of these Arabic names, such as Altair and Vega, are still in common use today.) The lists of stars chosen were first systematically analysed as a series of 'types' by Paul Kunitzsch, and his Type VIII corresponds most closely to the Whipple rete.[18] This list, Kunitzsch demonstrates, combines one that appeared in Spain in the late tenth century and another compiled by John of London in 1246, in Paris. It contains forty-nine stars, forty-one of which appear on the rete of Wh.1264 (see Table 1.1).[19]

15 Gingerich, 'Zoomorphic Astrolabes and the Introduction of Arabic Star Names into Europe'; D. A. King, 'An Ordered List of European Astrolabes to *ca*. 1500', in D. A. King, *Astrolabes from Medieval Europe* (Farnham: Ashgate, 2011), p. xii; and J. Davis, 'Fit for a King: Decoding the Great Sloane Astrolabe and Other English Astrolabes with "Quatrefoil" Retes', *Medieval Encounters*, 23 (2017), pp. 311–54.

16 Eagleton, 'Chaucer's Own Astrolabe'; J. Bennett and G. Strano, 'The So-Called "Chaucer Astrolabe" from the Koelliker Collection, Milan', *Nuncius*, 29 (2014), 179–229.

17 Gingerich, 'Zoomorphic Astrolabes and the Introduction of Arabic Star Names into Europe', 96.

18 P. Kunitzsch, *Typen von Sternverzeichnissen in astronomischen Handschriften des zehnten bis vierzehnten Jahrhunderts* (Wiesbaden: Otto Harrassowitz, 1966).

19 An almost identical list of stars 'to be placed on the astrolabe' survives in an early-fourteenth-century collection of astronomical and astrological texts from the monastery of Bury St Edmunds: Cambridge University Library MS Add.6860, ff. 70v–71r.

TABLE 1.1 List of stars marked on rete of Wh.1264

Star Name on Wh.1264	Modern Name	Kunitzsch Type VIII Number
Mirak	β Andromedae	1
Batuchaythos	ζ Ceti	2
Cenok	α Arietis	4
Menkar	α Ceti	6
Algeneb	α Persei	7
Augetenar	τ Eridani	8
Aldeboram	α Tauri	9
Alhaok	α Aurigae	10
Rigil	β Orionis	11
Elgeuze	α Orionis	12
Alhabor	α Canis Majoris	13
[unlabelled pointer]	α Geminorum	14
Algomeiza	α Canis Minoris	15
Markeb	κ Velorum	16
[unlabelled pointer]	μ Ursae Majoris	17
Alfard	α Hydrae	19
Cor	α Leonis	20
[unnamed bird]	Corvus	22
Edub	α Ursae Majoris	23
Cauda	β Leonis	24
Algorab	γ Corvi	25
Alehimek	α Virginis	26
Benenaz	η Ursae Majoris	27
[unlabelled pointer]	? $\mu \approx$ Lib 20, $\delta \approx -18$	–
Alramek	α Bootis	28
Elfeca [broken off][a]	α Coronae Borealis	29
Yed	δ Ophiuchi	31
Alacrab	α Scorpii	32
Alhawe	α Ophiuchi	33
Thaben	γ Draconis	34
Wega	α Lyrae	35
Althayr	α Aquilae	36
Delfin	ε Delphini	37
Aldigege	α Cygni	39
Aldera	α Cephei	42
Musida Equi	ε Pegasi	43
Denebalgedi	δ Capricorni	44
Cenok	δ Aquarii	45
Humerus Equi	β Pegasi	46
Alferas	α Andromedae	47
Denebchaytos	β Ceti	48
Skeder	α Cassiopeiae	49

[a] The pointer is broken, leaving only 'El'. Gingerich ('Zoomorphic Astrolabes and the Introduction of Arabic Star Names into Europe') noted this as Elfeca without further comment; perhaps the rete was broken after he studied it.