Chapter 11: Medieval Astronomy in Europe

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It would be helpful to begin to spell out the geographic, chronological, and cultural limits of medieval European astronomy by distinguishing it from three other astronomical traditions with which it is related:

- the Classical World (ancient Greece; Hellenistic period; Rome) (see Chapter 9);
- Arabic and Islamic Astronomy (see Chapter 10); and
- astronomy from the Renaissance to the mid-twentieth century (see Chapter 12).

All of these boundaries are somewhat problematic. Medieval astronomy benefited from the heritage of both the Classical and Islamic worlds and contributed significantly to the astronomy of the Renaissance. Furthermore, some of the important traditions of Islamic astronomy were developed in parts of medieval Europe, most notably the astronomy of *al Andalus* (Islamic Spain and Portugal).

Turning to a positive definition, we can define the astronomy of medieval Europe as those astronomical practices that took place in Europe from the fall of the Western Roman Empire in the late 5th century to the Renaissance. From the perspective of art history, the Renaissance began in the 13th century in Italy, but from the perspective of the history of science the medieval traditions of astronomical study continued to flourish through the 14th and 15th centuries and only ended with the publication of Copernicus's *De revolutionibus* in 1543. Culturally and linguistically, this discussion is restricted to the astronomies of the Latin[1] tradition of Europe, as well as those that were expressed in various indigenous languages.

Chronologically, the Middle Ages are conventionally divided into an Early Medieval and a Later Medieval period. A chief marker of this division is the re-emergence of urban society in the 12th century, which was accompanied by several changes that transformed medieval astronomy. The first was the movement of astronomical study from monasteries and cathedrals to the emerging universities. Accompanying the rise of the universities was the change of the content of astronomical study, since both astronomy and geometry took on a renewed quantitative aspect founded on the study of ancient texts. The rise of urban life saw the development of learned and skilled professions, including architects who applied this astronomical knowledge in their work.

In the past two decades, the picture of astronomy in medieval Europe has undergone fundamental changes. Until recently, it had been customary to skip from the Greek and Roman astronomy of late antiquity to its recovery in the 12th century through Arabic intermediaries. In popular histories of astronomy, the Early Middle Ages was dismissed as a dark, thousand-year interlude between the fall of Rome and the Renaissance. Recent studies have displayed the extent and variety of early medieval astronomical study. Its primary emphasis was more on the interpretation and elaboration of received texts than on observations of celestial phenomena. It is only in the later Middle Ages, with the recovery of Ptolemaic texts, that astronomy was transformed to integrate quantitative observations with quantitative predictions using trigonometrically computed tables derived from geometrical models.

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[1] A separate study would be possible of astronomical sites in the medieval Greek world.

It is useful to consider six distinct, yet interacting, astronomical traditions in the European Middle Ages: the arithmetical tradition of computus, concerned with determining the date of Easter in the context of the Julian calendar; the practical tradition within monastic communities of determining times of prayer by observing the stars and the Sun; the ancient Roman tradition of astronomy as one of the mathematical disciplines within the seven liberal arts; the ancient Greek tradition of predictive mathematical astronomy stemming from the work of Ptolemy; a practical concern with the annual motion of the Sun along the horizon for various purposes including the orientation of churches; and finally, the various techniques of astrological prognostication.

Medieval Astronomical Traditions

	Computus	**Timekeeping**	**Roman liberal arts**	**Ptolemaic astronomy**	**Solar horizon astronomy**	**Astrology**
Period of significant activity	Entire Middle Ages	Entire Middle Ages	Before c. 1200	After c. 1100	Entire Middle Ages	After c. 900
Method	Predictive	Observational	Descriptive	Predictive	Observational	Predictive
Astronomical artefacts employed	None?	Structures and apertures; sundials, nocturnals, astrolabes, quadrants	None?	Astrolabes, quadrants, etc.	Oriented churches	Astrolabes, quadrants, etc.
Astronomical memorials	Zodiacs	Sundials, clocks	Zodiacs		Oriented churches; light interactions	Zodiacs
Principal bodies considered	Moon and Sun	Sun and stars	7 planets and stars	7 planets & stars	Sun	7 planets and stars
Types of phenomenon	Discrete	Continuous	Continuous	Continuous	Discrete	Various
Considered in terms	Quantitative temporal	Temporal and spatial	Qualitative spatial	Quantitative spatial	Spatial and temporal	Various

Computus was a practical astronomy, concerned with reconciling the periods of the Sun and Moon—in other words “the science of the numbering and division of time”.[2] Specifically, computus addressed the practical problem of establishing a reliable and uniform method for computing the date of Easter and the other moveable feasts in the Christian calendar. Its astronomy was bookish, relying on received values of astronomical periods such as the 19-year luni-solar cycle and the 365¼ day Julian (solar) year; observational instruments were not used to question computistical practice until late in the 11th century. A source of physical artefacts is found, however, in the computists’ discussions of the Sun’s orderly motion through the twelve signs of the zodiac. Aspects of the zodiac were presented in religious calendars and appeared as iconography in various works of art, including paintings and sculpture adorning buildings.

Timekeeping provided the earliest locus of medieval astronomical observations. When he sent a sundial to the Burgundian king, Gundobad, Cassiodorus described knowledge of the correct time as the thing that separates man from the beasts. Near the end of the 6th century Bishop Gregory of Tours described in his *De cursu stellarum* how the celestial order could be used to regulate monastic prayer at night. Through the 13th century a variety of texts presented

[2] Grosseteste, Robert (1926). *Compotus ... factus ad correctionem communis kalendarii nostri*. In Robert Steele, ed., *Opera Hactenus inedita Rogeri Baconi*, fasc. VI. Oxford: Clarendon Press. p. 213.

similar techniques for observing particular stars in relation either to the local horizon or to conveniently located structures.

In the 9th century, we begin to see different kinds of portable instruments being used to regulate nocturnal prayer. The earliest *horologium* was the star clock described in the early 9th century by Pacificus of Verona, which determined the time by observing a bright star (Polaris) rotating around the faint star that was then the pole star. Around the year 1000 we see the astrolabe recommended as an instrument to regulate times of prayer.

During the day, prayer could be regulated by the more permanent structure of the sundial. The 7th-century Escomb dial marks the times of the monastic prayers of Terce, Sext, and Nones while the more elaborate dial of the 7th-century Bewcastle Cross marks the twelve hours from sunrise to sunset. The earliest clocks appear in monasteries and these mechanical models of the regular motion of the heavens would come to supplant sundials on medieval churches, incorporating greater astronomical and calendrical detail by the later Middle Ages and Renaissance.

Fig. 11.0.1. Sundial on Bewcastle Cross (late 7th century). Photograph by Tom Middlemass, © Univ. of Durham Corpus of Anglo-Saxon Stone Sculpture, Vol. 2, Image 99.

Fig. 11.0.2. Vertical sundial, church of St Gregory, Kirkdale, York (1055 × 1065). Photograph by Tom Middlemass, © Univ. of Durham Corpus of Anglo-Saxon Stone Sculpture, Vol. 4, Image 568. The inscription reads:

Orm Gamal's son
bought Saint Gregory's minster
when it was utterly ruined
and collapsed and he

had it built anew from the ground
to Christ and to Saint Gregory,
in the days of King Edward,
and in the days of Earl Tosti

This is the day's sun-marker
at every hour
and Hawarð made me
and Brand the priest.

The liberal arts presented the general medieval cosmological picture through the study of ancient texts dealing with the four mathematical arts of the quadrivium: astronomy and geometry, music and arithmetic. This kind of astronomy employed the continuous figures of geometry to provide a qualitative understanding of the structure and motions of the heavens. The motions of the Sun and Moon were commonly described in relation to the zodiac, but neither observations nor computations formed a part of this tradition.

The Ptolemaic tradition, enhanced by Arabic improvements, brought a new concern with quantitative observations and computations to Western European astronomy in the 11th and 12th centuries. Astronomical specialists designed and employed instruments for both observations and calculations. This new astronomy found a home in the new universities of the 13th century, where it was taught and studied.

Solar horizon astronomy reflects the ancient recognition, expressed by Isidore of Seville (early 7th century AD), that the sun "will set in a different place tomorrow, and that it had in a different place yesterday.... When it rises, [it] holds a path through the south. Afterward, it goes to the west and plunges itself into the Ocean."[3] Isidore also maintained that the ancients built temples so that "whoever would take counsel or pray would look to the equinoctial east (*orientem spectabant aequinoctialem*)".[4] This tradition of turning east to pray was frequently elaborated by Christian writers and the astronomical principle was incorporated into the construction of many medieval churches.

In the last century, many surveys of medieval churches have been undertaken, although few of them have been published in detail and no large-scale surveys have been analysed with anything like the statistical rigour that has become routine in archaeoastronomical investigations. These surveys report mixed results; some claim to find orientations towards sunrise on the feast of the church's patron saint, while others deny such patronal orientations. In general, they indicate a tendency to build churches so that the congregation would face the rising Sun at some ritually or calendrically significant time of the year. A recent systematic survey of a carefully selected set of medieval English village churches has shown that the equinoctial direction, as defined by the astronomical principles of medieval calendars and computus, plays a significant role in the orientation of these churches.

Astrology used as its astronomical basis the calculation of the positions of the stars and the seven classical planets for any chosen date or time. Until very recently, the scholarly consensus maintained that before the reception of Ptolemaic astronomy in the 11th and 12th centuries, Europeans lacked the astronomical and mathematical techniques needed to support horoscopic astrology. Recent examinations of previously neglected texts, however, have demonstrated that they provide the necessary techniques. These include a method to compute the sign of the zodiac that was rising on the horizon at a chosen date and time and several methods to compute 'positions' of the planets which, while bearing no relation to astronomical reality, do provide sufficient data for astrological prognostication.

Situating astronomies in medieval Europe

These astronomical traditions flourished at different times. The computistical tradition was concerned with the astronomical basis of the ecclesiastical calendar and endured throughout the Middle Ages; in fact the question of the date of Easter underlay the Gregorian calendrical reform of 1582. The practical monastic tradition of keeping time by watching the stars is

[3] Isidore of Seville (2006). *The Etymologies of Isidore of Seville*, trans. Stephen A. Barney, W. J. Lewis, J. A. Beach and Oliver Berghof. Cambridge: Cambridge University Press. p. 102.

[4] Isidore of Seville (1962 [1911]). *Etymologiarum sive originum*, ed. W. M. Lindsay. Oxford: Clarendon Press. xv.4.7; cf. Isidore of Seville (2006) [see above], p. 309.

mentioned in the earliest Western monastic rules of the 5th century, and continued into the 13th century. By that time, however, observing instruments and mechanical clocks (both of which incorporated a geometrical picture of the cosmos) had made their way into the timekeeping tradition. The classic texts of the liberal arts tradition were written from the 4th through to the 7th centuries, and gathered glosses and commentaries from the 9th century to the 13th centuries. Beginning in the 12th century, however, they began to be supplanted by texts reflecting the mathematical astronomy of the Ptolemaic tradition. The astronomical orientation of religious structures was called for as early as Vitruvius (1st century BC) and Isidore of Seville (early 7th century AD); this concern continues through to William Durandus and William of St. Cloud (both late 13th century). However, determining when these astronomical principles were actually being followed in the construction of churches requires systematic measurements of the orientations of well defined groups of churches. Astrology, as already discussed, was clearly practiced as early as the 10th century.

The practitioners of these traditions were not members of an astronomical profession, unless we count as astronomers those masters who taught astronomy in the universities from the 13th century until the Renaissance. Astronomical knowledge was developed, preserved, and transmitted as part of a broader intellectual enterprise, overlapping with the theoretical study of natural philosophy, with the practical studies related to the maintenance of the religious calendar, and with those practical activities related to keeping the time of day for religious and civil purposes.

There is little evidence that medieval Europeans made quantitative measurements of celestial phenomena before the 11th century. Most Early Medieval astronomical observations for which we have written records were simple naked-eye observations that qualitatively described fundamental astronomical phenomena: the phases of the Moon, the occurrence of a solar or lunar eclipse, or the periodic appearances of a planet. It is only in the second millennium that quantitative measurements began to emerge in the Latin West, chiefly measurements of the elevation of the Sun and stars using the astrolabe and the various forms of the astronomical quadrant. These instruments reflected and contributed to the incorporation of quantitative geometrical concepts into medieval astronomy.

As regards the material heritage of astronomy in the European Middle Ages, the absence of professional astronomers and the limited role of observations raise several problems. Since medieval astronomy was not institutionalised as a profession, there were few, if any, astronomical observatories in the sense of sites purposefully designed to house instruments for astronomical observation and to preserve the records of those observations. In this period, the few instruments that exist were not the corporate property of scientific institutions but were, as far as we can tell, used either by the assigned timekeepers at religious institutions or owned by individuals who had a special interest in astronomy.

In approaching the material record of medieval astronomies, it is also important to recognise that most historical research into medieval science has focused on texts and their authors; we know more about them than about the places where medieval astronomy was practiced. In some cases, it is not even clear where an author was when he discussed a particular astronomical topic. This makes the designation of some astronomically significant sites somewhat problematic. Similarly, records of astronomical observations, teaching, and theory are not located at specifically astronomical institutions, but are intermingled with other documents in libraries and archives. Although there were no specially designed observatories, occasionally some structures were used for astronomical observations because of incidental characteristics of their design that facilitated such observations.

Astronomy in churches. Churches are among the most abundant medieval sites in all of Europe; every village had one and many of them survive to the present. For example, a recent study noted that there are more 18,000 churches in Britain, some 12,000 occupying sites established before the 13th century. By the 11th century, the construction of standardised village churches had reached a level that "groups of masons could provide 'off the peg' onecell and two-cell churches".[5] Churches do not form a single category but range from simple village churches to elaborate monastic and cathedral churches. Many of them embodied astronomical principles in a variety of ways: some were oriented astronomically; some used the changing light of sunbeams throughout the day and the year for timekeeping or symbolism; many incorporated formal timekeepers, from sundials to clocks, in their structure; and some were decorated with astronomical iconography or symbolism.

The astronomical orientations of many European medieval churches, ranging from great cathedrals to simple village churches, most of which were built after the year 1000, have been measured in varying detail. Although there have been many surveys of the orientation of individual churches—especially of major churches that are noteworthy for artistic or historical reasons—more significant from an archaeoastronomical perspective are systematic surveys of groups of contemporary churches in a single geographical region.[6]

A second class of astronomical interaction with churches involves the controlled use of sunlight within the church to illuminate selected portions of the interior at specific times of the day and of the year. The 13th-century Parisian astronomer, William of St Cloud, discussed how sunbeams, crossing the church from a southern window, could be used to mark midday and other times of day. He asserted that this was the intention of the builders, since they commonly placed an image of a cockerel—the traditional sign of calling monks to prayer—as a weather vane ('weathercock') to show the direction of the winds. A number of recent Italian studies have uncovered cases where paintings or statues of a saint were illuminated by a beam of sunlight on the saint's feast day (for an example see Case Study 11.2). A related concern with interactions of light and church structure is found in a more secular kind of astronomical interaction fashioned during the Italian Renaissance. Astronomically inclined clerics, concerned with the problems of the ecclesiastical calendar, the time of prayer, and other astronomical questions, introduced small apertures in the southern walls of their churches that projected the image of the sun onto permanent meridian lines (*meridiane*) marked or inset on the floor. With these they could determine the exact day of the equinoxes, the time of noon, and even measure the changing diameter of the Sun.

In the latter case, we have documentary evidence where the priests who installed these *meridiane* tell us of their astronomical purpose; more commonly we lack such documentation and thus face the standard archaeoastronomical problem of determining whether the astronomical properties of a structure are intentional. Two approaches that use only the archaeological evidence of the standing structure have been used to try to determine the intended astronomical significance of churches, either in the sense of their axial orientation or of the interaction of their structure with solar rays. From an archaeoastronomical perspective the sounder approach is to consider a geographically, chronologically, and stylistically well-defined group of churches to determine whether, as a group, they tend to share certain astronomical characteristics. But such a study of groups raises difficulties if we want to identify specific examples of individual churches displaying a particular astronomical characteristic. Since the characteristic was identified by a statistical study, although the ensemble of sites may display a particular astronomical characteristic to an extent more than one would expect by chance, individual members of the group may totally lack that characteristic. Conversely, if we were to select from the group only those churches that do display a characteristic, we would give the false impression that the astronomical characteristic under consideration is much more widespread than it actually is.

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[5] Blair, John (2005). *The Church in Anglo-Saxon Society*. Oxford: Oxford University Press. p. 414.

[6] These studies are too numerous to mention here, but for a brief discussion with bibliography see McCluskey, Stephen C. (2004), "Astronomy, time, and churches in the Early Middle Ages", in Marie-Therese Zenner, ed., *Villard's Legacy: Studies in Medieval Technology, Science and Art in Memory of Jean Gimpel* (Aldershot: Ashgate), 197–210, pp. 208–210.

The second approach found in the literature is to identify the astronomical characteristics of churches by studying an individual church to determine its precise astronomical orientation or the interactions of solar rays with other architectural elements. Often these studies are done as part of a broader investigation of an otherwise significant site. In this case, the astronomical associations can be incorporated as an element of a wider heritage approach in the case of a structure that is considered significant for other, non-astronomical, reasons. However, in many cases the astronomical characteristics of churches may only be adequately demonstrated by producing documentary evidence or by considering a regional group of related buildings of the same period that share those same characteristics.

Timekeepers of various kinds. A common theme in the Middle Ages was the use of astronomy for the reckoning of time, first for religious and later for civil purposes. Timekeepers ranging from sundials to ornate astronomical clocks were often incorporated as a semi-permanent feature of churches and other religious or civic structures. The Cathedral of Chartres, for example, incorporates two astronomical clocks and an ornate sculptural sundial. An elaborate example of such timekeepers is found in Strasbourg Cathedral, which includes numerous sundials and a sequence of elaborate astronomical clocks built in the 13th, 16th, and 19th centuries (see Case Study 11.3). All three clocks incorporated various principles drawn from medieval astronomical traditions, displaying the motions of the Sun and Moon, and in the later clocks the planets, as well as various calendrical and computistical parameters related to the fixed and movable religious feasts. Both of these cathedrals are on the World Heritage List, but these astronomical concepts are not mentioned in the nomination. Such astronomical elements should be incorporated as part of the significance of structures presently on the list and in future nominations.

Fig. 11.0.3. Sundial at Chartres Cathedral. Photograph © C.H. McCluskey

Structures embodying astronomical iconography or symbolism. A common theme in medieval artistic depictions, both in manuscript illustrations and in architectural decoration, is the movement of the Sun through the zodiac and its relation to human activities. Colum Hourihane (see bibliography) has provided an extensive catalogue of the appearance of these symbols in astronomical texts, in religious calendars, and as stained glass, paintings and sculpture decorating churches. The 12th-century sculptural decoration of the arches over the west facade of Chartres Cathedral, for example, depicts the signs of the zodiac and the related labours of the month. The same pattern is evident in the late 13th-century sculptures at the bases of the niches on the west façade of Strasbourg Cathedral and on the Baptistery of the Cathedral of Parma (see Case Studies 11.2 and 11.3). To the extent that the decorations of medieval churches were created as textbooks for the illiterate, these sculptures reflect an attempt to disseminate a general understanding of the relation of human activities to the cosmos.

Centres of learning and patronage. Perhaps the most historically significant, although less immediately apparent, category of medieval astronomical sites are those that housed various centres of learning where astronomy was developed, studied and taught. This includes monasteries, which housed the monastic schools of the early Middle Ages; cathedrals, homes to the cathedral schools; and their successor, the medieval universities, where the new Greco-Arabic astronomy was assimilated and transformed. Astronomy was not only a concern of these formal educational institutions; it was also a topic of discussion at many courts, as rulers played the Platonic (or Solomonic) role of the philosopher king. Among those are the courts of Theodoric the Ostrogoth at Ravenna, of the Visigothic King Sisebut at Toledo, and of the Emperor Charlemagne and his successors at Aachen.

Important examples of such centres are the monastery of Wearmouth–Jarrow at the time of Bede (see Case Study 11.1); the scholarly network centred on the Carolingian court in the 9th century; and the University of Paris in the 13th and 14th centuries. The Monkwearmouth and Jarrow Monastic Sites are on the United Kingdom's tentative list; the Carolingian cathedral at Aachen (Germany) was inscribed on the World Heritage List in 1978 under criteria (i), (ii), (iv) and (vi).

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Case Study 11.1: Monkwearmouth–Jarrow, United Kingdom

Presentation and analysis of the site

Geographical position: City of Sunderland (Monkwearmouth) and South Tyneside Metropolitan Borough (Jarrow), North Tyne and Wear, England, United Kingdom.

Location: Monkwearmouth: Latitude 54º 54´ 48˝ N, longitude 1º 22´ 29˝ W. Elevation 50m above mean sea level. Jarrow: Latitude 54º 58´ 49˝ N, longitude 1º 28´ 20˝ W. Elevation 75m above mean sea level.

General description: The twin monastery of St Peter (Monkwearmouth) and St Paul (Jarrow) lies near the mouths of the rivers Wear and Tyne.

Inventory of the remains: The relevant portions include the Anglo-Saxon monastery and Medieval Priory Scheduled Monument and St Peter's Church at Monkwearmouth and St Paul's Church and Churchyard and the St Paul's Monastery and Village of Jarrow Scheduled Monuments at Jarrow.

History of the site: The twin monastery was established in the seventh century by Benedict Biscop and by the early eighth century was an internationally renowned centre of learning with one of the most important libraries and scriptoria of its time.

Cultural and symbolic dimension: The significance of this site for the development of astronomy relates to the scholarly activity of the monk, Bede of Jarrow (c. 673–735), who entered the monastery at the age of seven and remained there for the rest of his life. As the proposed statement of value from the draft site nomination says:

> "Bede's exceptional abilities ... flourished in this environment. His prolific output ... on a great variety of ... subjects, including theology, astronomy, science, music and language ... still inspire active international scholarship, as they have done for more than thirteen centuries."