

LETTER ON TIMEKEEPING OF GERBERT OF AURILLAC TO BROTHER ADAM¹

Marek Otisk

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Abstract: OTISK, Marek. *Letter on Timekeeping of Gerbert of Aurillac to Brother Adam*. This paper focuses on the letter, written by Gerbert of Aurillac (Pope Sylvester II) in the late 980s, which was addressed to brother Adam who is otherwise unknown to us from other sources. Gerbert's text deals with the problems of timekeeping and it naturally uses professional astronomical and geographical terminology and concepts which were necessary for timekeeping during this period. Although our contemporary knowledge of brother Adam is lacking, this paper sets out to analyse the letter and to reconstruct the individual fragments of teachings which had to be available to the recipient of the letter (i.e. brother Adam). This paper thus focuses on some topics of the medieval (inspired by antiquity) geocentric view of the organization of the Cosmos together with the basic categories of geographical division of the Earth and, at the same time, the paper is trying to draw attention to the fact that such concepts could have been the part of elementary knowledge of an educated individual by the end of 10th century.

Keywords: *Gerbert of Aurillac, Brother Adam, medieval astronomy, medieval geography, timekeeping, horology*

Abstrakt: OTISK, Marek. *List Gerberta z Aurillacu bratovi Adamovi o meraní času*. Štúdia sa venuje listu Gerberta z Aurillacu (neskôr pápež Silvester II.) z konca 80. rokov 10. storočia, ktorý bol adresovaný nám dnes z iných zdrojov neznámemu bratovi Adamovi. Gerbertov list sa venuje problematike merania času a celkom samozrejme užíva odbornú astronomickú i geografickú terminológiu a zároveň odborné koncepcie, ktoré boli potrebné pre určovanie času v tomto období. Aj keď dnes o bratovi Adamovi nevieme nič, pokúša sa táto štúdia pomocou analýzy Gerbertovho listu rekonštruovať jednotlivé poznatky, ktorými disponoval adresát listu, t.j. brat Adam. Táto štúdia sa teda zameriava na určité témy stredovekého (antikou inšpirovaného) pohľadu na geocentrické usporiadanie vesmíru, na základné kategórie vtedajšieho geografického členenia Zeme a zároveň sa pokúša upozorniť, že predstavené znalosti museli byť bežnou výbavou vzdelaného jedinca už na konci 10. storočia.

Kľúčové slová: *Gerbert z Aurillacu, Brat Adam, stredoveká astronómia, stredoveká geografia, časomeračstvo, horologium*

In the spring of the year 989, Gerbert of Aurillac (also called Gerbert of Reims, of Bobbio, or of Ravenna, also known as Pope Sylvester II²) wrote a letter to his friend Adam. This not very

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² Gerbert's life is not the subject of this paper as well as the famous legend diabolized him since 11th century. Only some elementary information is listed here: he was born before 950 in the region of Auvergne, as a child he entered the monastery in Aurillac, between the years 967 – 970 he studied on the Iberian Peninsula; since 972 he pursued further education and, more importantly, he was a teacher in Reims,

long text discusses partial theoretical findings, which were fundamental for contemporary timekeeping. It specifically describes changes in the presence of daylight over the horizon during a year in relation to geographical latitude of that place, i.e. according to the length of solstitial day. The letter is accompanied by two tables by means of which Gerbert illustrates described changes. The text was obviously meant for a very educated recipient because Gerbert uses professional terms of contemporary timekeeping, astronomy and geography without any further explanation. He also does not hesitate to mention two different interpretations of the procedural alternations of the Sun's presence over horizon during a year and to explicitly defend one of these interpretations.

It can be assumed that Adam was fairly familiar with the contemporary astronomical theories belonging to the necessary intellectual equipment for timekeeping. This paper focuses on Adam's potential knowledge and its main goal is to provide detailed analysis in order to capture a probable basis of Adam's education which had been presupposed by Gerbert.

First, the contents of the letter are briefly introduced (section 1), then the individual contemporary conceptions, exhibited by Gerbert's terminology, are explained: i.e. the movement of the Sun across the sky and its importance for the timekeeping, respectively two different delimitations of an hour as the unit of time (section 2) and further the division of the Earth into time and climate zones (section 3). The method of recognizing the geographical latitude, available to people by the end of 10th century, is also explained in compliance with Gerbert's text.

The paper offers an explanation of basic theoretical concepts, which were crucial before the year 1000 for substantial orientation in time and its measurement with the help of the astronomical phenomena. The basic categories of contemporary geocentric model of the organization of the Cosmos and principles of geographical division of the Earth are presented in this way.

1. Content of the letter and Gerbert's astronomical tools

Gerbert's letter is apparently a response to Adam's prior request for clarifying some partial knowledge which are necessary for timekeeping. We know practically nothing about brother Adam.³ In the opening of the letter Gerbert mentions hardships brought onto him by the death of Adalberon, the Archbishop of Reims.⁴ His passing among the *intelligibilia*, which is how Gerbert refers, by the term borrowed from Boethius (*1 In Isag.* I, 3; CSEL 48, 8), to the death of his relatively close friend, practically prevented Gerbert from any intellectual work (*Epist.* 153; MGH BDK 2, 180). Since Adalberon died in January 989, we can without any doubts date the letter generally back to the spring 989 (see Gerbert 2008, 375 or Gerbert 2009, 113). The very next sentence of this letter provides a justified reason for a hypothesis that Gerbert and Adam were friends.

he shortly (apparently during the years 982 – 983, officially till 998) served as an abbot of Benedictine monastery in Bobbio, since 983 he operated in Reims again, where, since 989, he took part in a dragging controversy over the post of archbishop (he had been actually serving as an archbishop for several months but he was never officially approved for the office), since 998 he was an archbishop in Ravenna and several months later he became the pope till his death in 1003. Gerbert's very active career (both intellectual and political) has become the subject of many scholars, see e.g. Anna M. Flusche (2005), Nancy M. Brown (2010), Oscar G. Darlington (1936 and 1947), Uta Lindgren (1976), Pierre Riché (1987), etc. Massimo Oldoni (1977, 1980, 1983) is especially interested in Gerbert's legend.

³ Adam could have been a monk, or a priest or canon (cf. MGH BDK 2, 180 or Gerbert 1961, 190). There is no reason to doubt that he was Gerbert's student, who could have belonged to Gerbert's friends and disciples possibly during the seventies but more likely in the eighties of 10th century.

⁴ To Reims bishop Adalberon see, for example, Diane Reilly (2013, 13-18), Justin Lake (2013, 22-23), Jason Glenn (2004, 28-46) or Richer of Reims (*Hist.* III, 21-23; MGH SS 38, 181-183).

Gerbert states, that he wrote the letter in order to make the missing friend (*amicus absens*) present and, as a token of this friendship (*pignus amicitiae*), he chose several astronomical theses (*Epist.* 153; MGH BDK 2, 180). These theses describe ascend and descend of the Sun (*accessus et recessus solis*) according to the theory stating that the changes in duration of the presence of the Sun over the horizon are irregular (*inequales*) during a year and not according to the interpretation which supposes that every month the length of daily sunlight increases (or decreases) regularly at a specific place (*Epist.* 153; MGH BDK 2, 180).

Gerbert subsequently quotes the eighth book *De nuptiis Philologiae et Mercurii* of Martianus Capella (*De nupt.* VIII, 878; BTL, 333) and he reminds us that the increase of daylight, following the winter solstice, proceeds in this way: In the first month daylight increases by one-twelfth of the difference between the length of the day during winter and summer solstice; in the second month, the daylight increases by one-sixth of the same difference; during the third and fourth month, the increase is one-quarter of the difference between the length of the day during winter and summer solstice; in the fifth month the increase is one-sixth again and in the sixth month it is one-twelfth of the same difference (*Epist.* 153; MGH BDK 2, 180). Gerbert does not waste time to add that during the second half of the year the process is reversed – the length of the day shortens according to the same calculation.

According to this theory, as Gerbert states, he sketched horologies of two climates after he had admeasured specific length of the day for every month in both climates using accurate time intervals (hours). It concerns the climate of Hellespont (Dardanelles), where the longest day of the year is 15 hours long, and the second *horologium* is meant for the climate whose inhabitants can enjoy daylight during the longest day of the year for full 18 hours (*Epist.* 153; MGH BDK 2, 180).

Gerbert processed mentioned tables by this method in order to pose as an example (*exemplar*), which can be used by Adam to construct his own horologies (*propria horologia*) for any climate. It is enough for Adam to find out the length of solstitial day for specific place using clepsydra (*clepsidra*). It is comparatively easy (*facile*) to establish the length of solstitial day: During solstice, we must separately mark the amount of water which passed through clepsydra through the night and through the day and subsequently we must convert the sum of these values to twenty-four hours (*Epist.* 153; MGH BDK 2, 180). Both tables are added at the end of the letter (*Epist.* 153; MGH BDK 2, 181).

Gerbert's letter explicitly mentions two different theories concerning the changes in daylight during the year, however only one name is given – Martianus Capella. However, his encyclopedic introduction of the seven liberal arts certainly was not the only source of Gerbert's knowledge of astronomy and timekeeping. Thanks to his disciple Richer of Reims (after 940 – after 998) and his chronicle, we know that Gerbert (especially in the seventies of 10th century when he was a teacher in Reims) paid extensive attention to the teaching of astronomy. Richer dedicated his chronicle to Gerbert (*Hist.* I, prol; MGH SS 38, 35) and in the third book of this work he included also a long passage about this person while focusing on the teaching process practiced by Gerbert during the seventies in Reims. In the case of astronomy, he describes four astronomical tools, which were made by Gerbert for presentation of the art of astronomy: apart from popular celestial globe (Richer, *Hist.* III, 50; MGH SS 38, 195-196; cf. Gerbert, *Epist.* 134; MGH BDK 2, 162 or *Epist.* 148; MGH BDK 2, 175) he also describes two armillary spheres (Richer, *Hist.* III, 52-53; MGH SS 38, 197-198) and observation hemisphere, which was also the subject of Gerbert's construction letter to his other friend Constantine of Fleury (Richer, *Hist.* III, 51; MGH SS 38, 196; cf. Gerbert, *De sphaera; Gerberti Opera Mathematica*, 24-28).⁵

⁵ Therefore, Richer does not mention neither *horologium*, the subject of this paper, nor the astrolabe, whose introduction to Latin Christian West is often associated with Gerbert – for more details see Arno Borst (1989) or Wesley Stevens – Guy Beaujouan – Anthony Turner, eds. (1995).

The very fact that Gerbert during the last third of 10th century constructed and used these pedagogical, explanatory, and observational tools is rather untypical for Latin teachings of astronomy. Gerbert's own approach to astronomy was probably inspired by a similar practice to which he was introduced during his studies in Catalonia (967 – 970) where contemporary Christian centres of knowledge were influenced by Arabic astronomical teachings.

Besides, the letter to brother Adam and Richer's description of astronomical tools used by Gerbert in Reims are not the only evidence of Gerbert's interest in practically useful and empirically verifiable application of astronomical knowledge. The chronicler Thietmar of Merseburg wrote at the beginning of 11th century (*Chron.* VI, 100; MGH SS RG NS 9, 393) that Gerbert (as a person at Imperial court) in the second half of the nineties of 10th century constructed horologium in Magdeburg and he used astronomical observational tube (*fistula*)⁶ for its correct functional setting.

2. Definition of the day and the course of the Sun

The orbit of the Sun (or the course of stars at night sky) was fundamental for medieval timekeeping based on astronomical phenomena. The focus on time and its counting was dictated by many factors including the everyday practice or religious duties and needs, e.g. regular prayers at monasteries or date assessment of movable feasts, especially Easter, which led to the establishing of independent interdisciplinary science during the Middle Ages – the computus, i.e. the mainly so called *computus paschalis* or *computus ecclesiasticus* (see e.g. Borst 1990 or Germann 2006). Although Gerbert was not dealing with computus, he paid much attention to clock construction (cf. Poulle 1996, 365-367).

Medieval thinkers adopted antique theories about the movement of the Sun, to which two basic motions are ascribed. The Sun – as well as the whole world sphere (*sphaera mundi*) to which the stars (*stellae*) and constellations (*sidera*) are firmly embedded go around the Earth (from the east to the west) once per 24 hours and this shift is substantial for the definition of day and night. When the sun is over the horizon, we talk about the day, while the absence of daylight is characteristic for the night. The sun and its light distinguishes day from night in the same way as light separated day from night during the creation of the world (cf. *Gen.* 1, 3-5). At the same time, it holds that the day is 24 hours long and one day equals one orbit of the Sun around the Earth (Beda, *De temp. rat.* 5; CCSL 123B, l. 3-8).

However, the Sun is not firmly connected with the celestial sphere (contrary to stars) and it does possess even another movement: from the west to the east. This movement spans over yearly period during which the Sun follows its own circular orbit which is called ecliptic (*ecliptica*) and it passes twelve zodiacal constellations (see Isidore, *Etym.* III, 50-52; OCT, l. 19-2 or Martianus, *De nupt.* VIII, 834-835; BTL, 314-315). Ecliptic is thus the circular record of the yearly Sun orbit and it forms one of the basic circles which were used for describing, characterising, and dividing the celestial sphere (not only) during the Middle Ages. The other circles are so called parallel circles of the world sphere, i.e. celestial equator (*circulus aequinoctialis*), the northern and the southern tropic (*circulus solstitialis vel aestivus*, *circulus brumalis vel hiemalis*, i.e. the tropic of Cancer and the tropic of Capricorn), and the northern and the southern polar circle (*circulus septentrionalis vel arcticus*, *circulus australis vel antarcticus*) (Beda, *De nat. rer.* 9; CCSL 123A, l. 1-15). While these five imaginary circles are parallel to each other, the ecliptic is intersecting them because the orbit

⁶ There are even other (later) mentions of Gerbert's use of clocks, namely clepsydra, however, they are not conclusive because of larger time distance (see *Gerberti Opera Mathematica* 1899, 40, 393).

of the Sun, during its journey over a year, crosses the equator of celestial sphere twice and it forms an angle with it of approximately (according to medieval conception) $23,5^\circ$, or 24° .⁷

The yearly movement of the Sun and its retreat from the celestial equator causes the change of seasons and it, of course, causes the changes of daylight (the presence of the Sun over the horizon). We can thus divide the annual path of the Sun by four basic milestones: there are two so called equinoctial days (*aequinoctialis*, i.e. the days when the Sun crosses the equator and it is over the horizon for the same time as it is under the horizon – we speak of spring equinox in March and of autumn equinox in September) and two solstitial days (*solstitialis*), i.e. the days when the Sun reaches the tropics and its departure from the celestial equator changes its direction and the Sun starts its return back to the equator (Beda, *De temp. rat.* 16; CCSL 123B, l. 1-88). For the inhabitants of the northern hemisphere this means that in June we can speak of summer solstice since the Sun reaches the tropic of Cancer and we have the longest day and the shortest night in year, while in December, during the winter solstice, the Sun has departed to the tropic of Capricorn and we have the shortest day and the longest night.

Two various definitions, used by medieval thinkers, of an hour (*hora*) can be derived from these theories about the movements of the Sun. On the one hand, the so called equinoctial or equal (*aequinoctialis*, *aequalis*) hours were used and their name is derived from equinoctial days during which the Sun is located over the equator and the length of the day and night is the same (both are 12 hours). During its regular and basically identical daily journey the Sun describes a circle (360°) and since the day is 24 hours long, one hour equals the time the Sun needs to cover 15° during its daily movement (Gerbert [?], *De util. astrol.* 8, 2-3; *Gerberti Opera Mathematica*, 132). This time assessment is used also by Gerbert in his letter when he describes the climates by the term equinoctial (*aequinoctialis*) hour (Gerbert, *Epist.* 153; MGH BDK 2, 180).

However, more often the medieval concept of hour was understood as one-twelfth of the time during which the Sun is over the horizon. The day and night thus have the same length (12 hours) but the very length of the day and night hour is changing in relation to the actual place of the Sun at the ecliptic, that is in relation to the time that the Sun is over and under the horizon. These hours are called temporal or unequal (*temporalis*, *inaequalis*) because their length changes over the course of a year, depending on the specific date and geographical latitude (Gerbert [?], *De util. astrol.* 8, 3; *Gerberti Opera Mathematica*, 132).

Both systems of definition imply that a day was divided by medieval scholars according to four breaking points: noon and midnight (both systems are identical for these two points, because the Sun is at its highest point on the sky during the noon, i.e. today we would say that it is exactly 12:00, while during the midnight the stars are in the highest place of the sky and we would say that it is exactly 0:00); or the sunrise and the sunset, which are happening at different times during the year and this is the reason for different length of equal and unequal hours.⁸

Adam apparently had to know all of these theories because Gerbert is not speaking about the ecliptic or about the definitions of day and hour in his brief letter, despite the fact that Gerbert's statements would not have been comprehensible without this knowledge because he was using one definition of an hour while he is mentioning different interpretations of the yearly course of the Sun and its timekeeping consequences. Gerbert describes in greater detail the speed by which (on northern hemisphere) the day is prolonged and the night is shortened during the winter

⁷ The presently accepted value is around $23^\circ 26'$.

⁸ Time assessment according to equal and unequal hours was also discussed by contemporary authors of texts about astrolabes and astrolabe constructors, who marked, among others, the curves of unequal hours on their astronomical and timekeeping instrument, which were also modified according to the actual geographic latitude (see e.g. Burnett 1998, 348).

and spring months, or the daylight is declining and the night is increasing during the summer and autumn months. It is clear from Gerbert's text that at his time there were at least two different ways of characterising the chain of changes in the presence of the Sun over the horizon. Either the equal increase (or decline) of sunlight over a year was presupposed, or these changes were considered unequal (Pseudo-Beda, *De mundi coel.*; PL 90, 883D-884A).

For the geographical latitude where the length of day during the summer solstice is 16 hours, the first interpretation (the equal changes) would mean that since June till December the presence of daylight is shortened every day by 160 seconds, i.e. by 80 minutes per month, and during the winter solstice the length of the day reaches 8 hours. This theory, which could have been advocated by computists of the Carolingian or Ottonian era, fulfils the requirements of regularity, stability and invariableness of events at sky and their interpretation, however, it poorly corresponds to the empirical experience.

This could have been the main reason, why Gerbert himself leaned towards the second interpretation and in the support of this thesis he quotes Martianus Capella who in the eighth book of *The Marriage of Philology and Mercury* wrote that between both solstices the duration of Sun's presence over the horizon changes unequally. According to the aforementioned algorithm (see the first part of this paper), the day in the example of the longest solstitial day (16 hours in the second decade of July) would be shortened by 40 minutes compared to the same day in June; by other 80 minutes in August; by other 2 hours (120 minutes) in September and October (autumn equinox); then by other 80 minutes in November; and at winter solstice in December the day is shortened by 40 minutes.

This unequal course of changes in the length of day over a year is in Martianus' text accompanied by an interesting reasoning concerning this irregularity. The Sun is intersecting the equator of world sphere directly (*directum*), when it goes from the south to the north in March or when it travels in the opposite direction in September (Martianus, *De nupt.* VIII, 878; BTL, 333), while during the solstices it must change the direction of its movement, which causes the slowdown because the journey to the north changes into the journey to the south and vice versa. This necessity for the change of direction and the description of curve invokes the slowdown of movement of the Sun, therefore around the equinoctial days the faster changes occur while during the solstitial days the changes are slower. This reasoning could have been seen as plausible by Gerbert and its application would save the regularities in the movements of the Sun to certain extent which would also better correspond to the observations of the sky.

3. Earth and time climates

Since Gerbert prepared two horologies for Adam according to this theory – one for the climate of Hellespont (Dardanelles); the second for the geographical latitude where the longest day of the year reaches 18 hours – and even then, there is no explanation of what the climates (*climate*) are, we can assume that the author of the letter anticipated such geographical knowledge to be known to the addressee.

Adam, as well as his other educated contemporaries, evidently knew about (not exclusively) contemporary division of the Earth into five basic parts, which was done by five parallel circles of celestial sphere (polar circles, tropics and equator), although now it has been applied to the division of the Earth (cf. Macrobius, *In Som. Scip.* II, 5, 13-17; BTL, 112). The territories around Earth's poles, which are in direction towards the equator demarcated by polar circles, cover the northern and the southern polar areas which were, according to medieval theories, uninhabited because the climate is too cold and it does not provide conditions for human

population. Similar situation can be found also in another part of the Earth which is located between both tropics, i.e. enclosing the equator on the northern and even on the southern side, and life does not flourish there because of overly hot weather. There are two parts of the Earth left, delimited by two zones stretching between the tropics and polar circles.

The question whether the southern part of the Earth is inhabited or not was often tackled during the Early Middle Ages (cf. McCready 1996, 108-127), but in relation to the analysis of Gerbert's letter and to the estimation of Adam's knowledge we only need to focus on the northern hemisphere. The northern inhabited part of the Earth was further subdivided into three continents: the east was formed by Asia, the western part consisted of northern (Europe) and the southern areas (Africa). All three continents were divided by the Mediterranean Sea (cf. Isidore, *Etym.* XIV, 2; OCT, l. 21-11 or Hiatt 2007, 149-176).

The antiquity brought a detailed division into climatic (and time) zones into medieval geographic descriptions, i.e. parallel zones passing through the continents across the same geographical latitude and therefore they featured similar climatic conditions, occurrence of comparable fauna and flora, and resembling customs of its inhabitants (cf. Cassiodorus, *Inst.* II, 7, 3; Cassiodorus 2003, 442 or Isidore, *Etym.* III, 42, 4; OCT, l. 17-20). For timekeeping purposes, these climates were also delimited according to the length of the longest day and the shortest night during the year. Scholars usually distinguished between seven zones – that is: Meroë, Syene (Aswan), Alexandria (Lower Egypt), Rhodos, Hellespont (Dardanelles), Mesopotamus (Black Sea) and the mouth of river Dnieper, i.e. Borysthenes (see e.g. Eratosthenes, *Frag.* 3A.18-40; BTG, 188-210; Ptolemaios, *Alm.* II, 12; BTG, 174-187; Cassiodorus, *Inst.* II, 7, 3; Cassiodorus 2003, 442-444; Isidore, *Etym.* III, 42, 4; OCT, l. 20-23; cf. also Honigman 1929 or Stahl 1962), to which other climates were added according to the actual need for differentiation of certain areas or in order to include various extremes or curiosities (like the mythical Rhyphaean mountains or the island Thule in far north etc.). By this method, the northern inhabited part of the Earth was structured up to 12 zones stretching usually from the Atlantic to India and the Pacific and it included the areas from Africa up to the islands in the Arctic Ocean (for more detailed description see Plinius, *Nat. hist.* VI, 33-34(39), 211-220; BTL, 517-522 or Beda, *De temp. rat.* 33, CCSL 123B, l. 1-98).

In the compendious treatise of Martianus Capella, the traditional enumeration of seven zones is broadened to eight, while the Black Sea zone (Borysthenes) is omitted and the zones for Rome and the aforementioned Rhyphaean mountains are added (Martianus, *De nupt.* VIII, 876-877; BTL, 331-332), and two other marginal northern zones are also mentioned: Britain and the island Thule (Martianus, *De nupt.* VI, 595; BTL, 209). The zone of Hellespont, which was introduced by Gerbert in the overview table in his letter, was not usually absent from the basic enumeration of seven climates and was, among others, characterised by the fact that the longest day spans 15 hours. However, Capella's description and delimitation of individual geographical zones is rather confusing – e. g. in the case of Hellespont he states that the longest day is 15 hours long but the shortest night on the same day is only 8 hours (Martianus, *De nupt.* VIII, 877; BTL, 332). It can be expected that Gerbert (or Adam) was using more comprehensive and more precise tables and, among them, the highest clarity is reached by mentioned passages from Pliny or the parts of the text inspired by him of Venerable Bede.

However, the standard summaries of climates, available during Gerbert's time, do not bring out the climate where the longest day lasts 18 hours, which is approximated by one of Gerbert's horological table in the letter to Adam. There are only scarce references to such climate during the Early Middle Ages – for instance can be mentioned the chronicle of Venerable Bede (Beda, *Hist. eccl.* I, 1; 1962, LCL 246, 14) or Eriugena's commentary to Martianus' *The Marriage of Philology and Mercury* (Eriugena, *In Marc.* 296.5; MAA 34, 140), however, even then Gerbert's introduction of this climate can be surprising.

I consider the illustrative and explanatory character of Gerbert's schemes encompassing both climates to be the most probable reason for including this table. If he had wanted to introduce the theory of unequal change in the duration of sunlight over the course of a year by using specific examples, the most suitable climates for this pedagogical-didactic task would have been those climates where the difference of the length of both solstitial days reaches the value which can be easily divisible by number 12 because the monthly change can be measured as either one-twelfth, one-sixth or one-quarter of the difference between the length of both solstitial days. The climate with the longest day of 18 hours has the shortest day in the year 6 hours long, therefore the difference in their length is 18 hours, hence monthly changes can be easily described using the whole hours: i.e. 18 hours (= June) → 17 hours (= July) → 15 hours (= August) → 12 hours (= September) → 9 hours (= October) → 7 hours (= November) → 6 hours (= December). Similarly, as far as the climate of Hellespont is concerned the longest and the shortest day differs by 6 hours, therefore the table of this time zone can manage with only hours and half-hours, that is: 15 hours (= June) → 14.5 hours (= July) → 13.5 hours (= August) → 12 hours (= September) → 10.5 hours (= October) → 9.5 hours (= November) → 9 hours (= December).

Apparently, because of the illustrative power Gerbert created these exemplary *horologia* according to which Adam could make his own horologies, provided he considered the climate in which the given horology should be applied. The people of the 10th century had several possibilities how to recognize the climate (i.e. geographical latitude) in which they were located (for example astrolabe – cf. Gerbert [?], *De util. astrol.* 13, 1-2; *Gerberti Opera Mathematica*, 134-135). Gerbert offers one simple experimental method, as was mentioned before. During the solstitial days we can use clepsydra, mark the amount of water which passes since the sunrise till the sunset and in the same manner precisely capture the amount of water since the sunset till the next sunrise, and then the given ratio (i.e. the length of the day and night) convert to 24 hours (Gerbert, *Epist.* 153; MGH BDK 2, 180).⁹ By this easy conversion to hours and minutes any person interested in creating *horologium* can easily arrive at the length of the longest day or night.

Conclusion

Since we do not know Adam's request to which Gerbert answers, we are left only with speculations about the content of the original correspondence between Gerbert and Adam. The first obscurity resides in the very term *horologium*, which can mean a timekeeping instrument (clocks) but it can also refer to the tables concerning the changes in duration of sunlight over a year for specific geographical latitude. The diction of the letter itself implies that the second option is more probable, but we cannot fully refuse the first or any other interpretation.

Provided Gerbert really wrote about the tables, the question of why Adam was interested in creation of such a table still remains. There are several possible answers. The table concerning the changes in the duration of sunlight over a year can be a welcomed instrument for converting equal and unequal hours. The assessment of climate (a geographical latitude) is a necessary condition for the correct set-up of sundial and night clocks, and, at the same time, it is important for the validity of astronomical observation and the correct use of astronomical equipment, astrolabe included.

⁹ Similar method for the assessment of the place of observation (for night observation and time assessment) was also described by Macrobius or Eriugena – see Macrobius, *In Som. Scip.* I, 21, 12-21; BTL, 87-88 or Eriugena, *In Marc.* 295.5; MAA 34, 139.

Astrolabe, the most widely used astronomical instrument in Middle Ages, was a newcomer to Latin West in Gerbert's time and he was often mentioned as an important person in its initiation, although we lack substantial evidence for this claim.¹⁰ Astrolabes consisted of exchangeable disks on their front part, which allowed their use in different climates (cf. e.g. Gerbert [?], *De util. astrol.* 18, 1-3; 1899, 138-142) – it was enough for the user to know only the climate he was in and then he just needed to use the proper astrolabe's disk for the correct use. The oldest Latin texts about the usefulness of astrolabe often highlight the fact that the instrument can serve as a clock (cf. Gerbert [?], *De util. astrol.* 1, 1; 1899, 115-116). No matter which reason was the most important for Adam, we cannot doubt that the measuring of time played a fundamental role in his request for horological tables.

At the same time, it probably holds that Adam had to be well acquainted with contemporary astronomical and geographical theories and the minimal extent of these theories has been a subject of the paper. Adam's proficiency in geocentric astronomy, in grasping of spherical form of the universe, and in the particularity of the movement of the Sun is evidently presupposed by Gerbert, therefore he is able to tackle alternative interpretations of the changes in the day duration over a year without an elaborated introduction. Even the climatic zones are considered to be a commonplace conception in the letter and the importance of this concept for timekeeping purposes is not needlessly explained. Only the instructions for the climate assessment are provided.

Apparently, Adam and Gerbert were friends, as stated before, and we may extrapolate that Gerbert knew who he is writing to and what information is important for the addressee. On the other hand, it rather obviously shows what was the approximate standard theoretical and scientific background of an educated person by the end of the 10th century, since we do not have any further information concerning brother Adam (not even the possible response to this Gerbert's letter is preserved), therefore this can serve as an example of the contemporary level of astronomical and geographical knowledge in relation to timekeeping.

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¹⁰ For detailed analysis, see Wesley Stevens – Guy Beaujouan – Anthony Turner, eds. (1995), Werner Bergmann (1985), Uta Lindgren (1985, 619-644), David C. Lindberg (1978, 52-90); Burkhard Stautz, (1994, 315-328) or Stephen McCluskey (1998, 176).

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SUMMARY: LETTER ON TIMEKEEPING OF GERBERT OF AURILLAC TO BROTHER ADAM. This paper deals with the letter, written by Gerbert of Aurillac (called also Gerbert of Reims, among other abbot in Bobbio, illegitimate archbishop of Reims and archbishop of Ravenna, in 999 – 1003 Pope Sylvester II) in the 989. The addressee of the letter is brother Adam, probably Gerbert's disciple, perhaps monk or priest or canon. Adam is otherwise unknown to us from other sources. The Gerbert's letter is relatively brief and its content is quite concise. The text focus on the problems of timekeeping and it uses professional astronomical and geographical terminology and concepts which were necessary for timekeeping during this period. Because of it this paper aims through the analysis of the letter to reconstruct the individual findings which had to be well known for the recipient of the letter (i.e. brother Adam). Firstly, the content of Gerbert's letter is presented (section 1). Then this paper focuses on some topics of the medieval geocentric view of the organization of the Cosmos. Mainly the definition of a day (and an hour) is described and the importance of two basic movements of Sun for these definitions (section 2). Afterwards the basic categories of medieval (and ancient) geographical division of the Earth are explained (two polar areas, equator area and two areas stretching between the tropics and polar circles) and main attention is concentrated to the north inhabited area with the Mediterranean Sea in the centre and with three continents Asia, Europa, and Africa around this sea. The north area is then divided among numerous climatic and time zones (section 3). All these theories had to be known for Adam and the paper is trying to draw attention to the fact that such concepts could have been the part of elementary knowledge of an educated man by the end of 10th century.

MAREK OTISK

doc. Mgr. Marek Otisk, Ph.D.
University of Ostrava
Faculty of Arts
Department of Philosophy
Reální 5
702 00 Ostrava
Czech Republic
marek.otisk@osu.cz