MEDIEVAL ASTRONOMY IN CATALONIA AND THE SOUTH OF FRANCE: THE 'IMPROVED' LUNAR *KALENDARIUM* OF FRIAR RAYMOND (RAMON) BANCAL (CA. 1311) AND ITS PREDECESSORS

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Resumen

Durante la Baja Edad Media, una de las tareas más comunes de los astrónomos fue el cálculo de los datos lunares, como sicigias y eclipses, que fueron utilizados comúnmente por los practicantes de la astrología médica. Un ejemplo temprano poco conocido de este tipo de trabajo es el *Kalendarium* para los años 1311 a 1386 adscrito a Ramon Bancal, que fue ministro de los franciscanos en la provincia de Aragón en 1326/27. Su obra es un calendario lunar 'mejorado' de un tipo que se originó inicialmente alrededor de 1290 en respuesta a las deficiencias evidentes del cómputo lunar utilizado por la Iglesia medieval. Este artículo analiza, por primera vez, la estructura y el contenido de la obra de Bancal y la relaciona con otros calendarios de este período. También presenta evidencias de un origen francés meridional tanto de la obra como del autor. El trabajo se cierra con una mirada al *Tractat de Bahare*, un texto poco conocido catalán sobre el cálculo lunar según el calendario judío, demostrando su composición en el año 1300.

Abstract

During the late Middle Ages, one of the most common tasks of astronomers was the calculation of lunar data, such as syzygies and eclipses, which were commonly utilized by practitioners of medical astrology. A little-known early example for this type of work is the *Kalendarium* for the years 1311 to 1386 ascribed to Ramon Bancal, who served as the Franciscan minister for the province of Aragón in 1326/27. His work is an improved lunar calendar of a type that first took shape around 1290 in response to the obvious shortcomings of the lunar *computus* used by the medieval Church. This article will analyze the structure and content of Bancal's work and relate it to other calendars in use at the time. In addition, it will present evidence for a Southern French origin of both the work and its author. The article will close with a look at the *Tractat de Bahare*, an obscure Catalan text on lunar computation according to the Jewish calendar, which can be shown to date from the year AD 1300.

Palabras clave: Astronomía, Astrología, Calendarios, Computus, Medicina, Ciencia y sociedad, Cataluña, Francia, siglo XIV.

Keywords: Astronomy, Astrology, Calendars, Computus, Medicine, Science & Society, Catalonia, France, 14th Century.

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INTRODUCTION: A NEGLECTED SOURCE OF MEDIEVAL CATALONIAN ASTRONOMY?

Among the documents that shed light on the origins of the world-famous monastery of Santa María de Pedralbes —one of the undisputed highlights of Catalan Gothic architecture— is a letter dated 1 July 1326 [FITA, 1895, pp. 487-488], in which the Franciscan minister for the province of Aragón, a friar by the name of Ramon Bancal (Raymundus Bancalis), reports on his inspection of the construction site on the previous day. The chief initiator and financier of this building project was Elisenda de Montcada (1292-1364), fourth and last wife of King Jaume II (el Just) of Aragón, who had obtained a special permission from Pope John XXII to finalize her goal of erecting a magnificent new house for the Order of Saint Claire outside the gates of Barcelona. Since the Poor Claires were a branch of the Franciscans, Ramon Bancal had a duty to supervise the project, which involved discussing the building's layout and construction plans with Elisenda's treasurer Domènec Granyena and her chaplain Ferrer Peyró [CASTELLANO, 1998, pp. 25-41; 2014]. On 27 September 1326, he signed a letter confirming the election of Sancha de Conques as the new abbess of the already existing convent of Santa Clara in Barcelona [FITA, 1896, pp. 54-55], which later supplied Pedralbes with its first batch of nuns [CASTRO, 1968]. On 3 May 1327, he was among the many honorary guests at the new monastery's inauguration ceremony, which was also attended by the king, the royal family, and the archbishop of Toledo [GONZÁLEZ & RUBIÓ, 1982, p. 29]. His tenure as provincial minister cannot have lasted much longer, however, for by 2 December 1327 the pope had begun to exert pressure on the general of his order, the famous Michael of Cesena, to remove the provincial ministers for Aragón and the 'Province of St Francis' (Umbria) from office, claiming that their misrule had caused these provinces to suffer "detriment and serious dangers" (*detrimenta et pericula gravia*) [GÁL & FLOOD, 1996, p. 183].

Thus far the very few recorded details about the life and career of Friar Ramon Bancal, who would not even be a footnote in the annals of medieval science, were it not for the fact that the brief entry for his name in the *Diccionari d'història eclesiàstica de Catalunya* [BOADAS & MARTÍ, 1998] also ascribes to him a work on the mean conjunction of Sun and Moon, which can be found in a manuscript now in Madrid:

M Madrid, Biblioteca Nacional de España, 9288, fols. 93r-99v. Parchment, 230 × 150 mm, 105 fols., s. XIV.

Folios 93r-98v are taken up by a calendar, one month per page, which incorporates a lunar almanac with conjunction times for the years 1311-1386. On the following leaf, one finds an auxiliary table and a brief explanatory text (or 'canon'), which is headed "Regula de coniunctionibus mediis lune cum sole et eorum aspectuum secundum Bancalem" [fol. 99r]. At the end we read: "Explicit canon seu regula kalendarii fratris R^{i} Bancalis de ordine fratrum minorum" [fol. 99v]. To my knowledge, the plausible claim that the text's author, a Franciscan named R[aimundus] Bancalis, was identical to the aforementioned provincial minister of the years 1326/27, goes back to Martí de Barcelona, who published a descriptive note on MS M in 1933 [p. 380, n. 1]. This identification was later taken up and expanded upon by Manuel de Castro [1973, pp. 403-405, n. 2], who pointed out that the same work also exists in another copy:

P Paris, Bibliothèque nationale de France, lat. 7420A, fols. 57v-63r and 71r. Parchment, 155 fols., 245 × 175 mm, Southern France, ca. 1332/33[1].

The *Kalendarium*'s availability in two different manuscripts, one of which (MS P) probably still dates from the 1330s, would appear to make it a prime candidate for elucidating the history of astronomy in Catalonia and the Crown of Aragón during the reign of Jaume II (1291-1327), who has been almost completely overshadowed by his grandson Pere III el Cerimoniós (1336-1387). Among the medieval Christian rulers on the Iberian peninsula, Pere's influence as a patron of the science of the stars ranks second only to that of the Castilian king Alfonso X el Sabio (1252-1284), whose *Tablas alfonsíes* he appears to have sought to surpass when commissioning new astronomical Tables for Barcelona, completed ca. 1381[2]. Compared to the plethora of astronomical activity that unfolded under the aegis of these two monarchs, the decades that intervene between them look almost barren. One of the few documented cases of astronomical learning that can be straightforwardly related to the Aragonese court during these years is a book on solar and lunar eclipses once owned by King Jaume, which his son and successor Alfons III el Benigne (1327-1336) ordered to have translated into the romance vernacular in the year 1328[3]. As far as mathematical astronomy is concerned, the most important work to date from Jaume's reign is the 'Almanac of 1307' for the city of Tortosa, which goes back to an Arabic template, but only survives in Latin and various vernacular translations. Among them is a Catalan rendering of the accompanying text, which is preserved fragmentarily in a fifteenth-century codex in Valencia [MILLÀS & FARAUDO, 1948, pp. 143-150][4].

With the *Kalendarium* of Ramon Bancal, which was calculated for a start in 1311, we would seem to have another witness to astronomical activity in this otherwise poorly documented period—provided, of course, its Catalan-Aragonese origin can be maintained. In order to assess this question, section 1 will begin by outlining the work's historical and manuscript context, more specifically its place in a particular genre of astronomically enhanced lunar calendars, which first emerged in England and France in the late thirteenth century and went on to enjoy great popularity during the late Middle Ages. Next on is a brief analysis of the structure and content of Bancal's calendar, provided in section 2, which will also reproduce some of the relevant tables. In section 3, I shall turn to the use and reception of Bancal's work, which appears to have been mostly restricted to Southern France. Together with the internal evidence provided by the calendar itself, this forces the conclusion that Friar Ramon —or, rather, Raymond— was a man from the Languedoc, who made his calculations for a location in this region. Section (4) will make up for Bancal's removal from the list of Catalonian astronomers by offering a brief look at the *Tractat de Bahare*, an obscure Catalan treatise on Jewish lunar computation found in a manuscript in Andorra. As I intend to show, this text was written in AD 1300 and thus during the reign of Jaume II.

1. LUNAR COMPUTATION AT THE TURN OF THE FOURTEENTH CENTURY

Both of the manuscripts known to contain Bancal's *Kalendarium* offer some useful starting ground for contextualizing the work. While the codex kept in Madrid (MS M), to which we shall return below, is almost exclusively dedicated to calendrical and astronomical tables, the Parisian one (MS P) contains a more diverse anthology of computistical, astronomical-astrological, and mathematical writings. Oddly enough, the scribe responsible for the inclusion of Bancal's work chose to separate the calendrical tables (fols. 57v-63r) from the accompanying canons (fols. 71r) by interjecting another *Kalendarium*, which had been created in the 1290s by the Danish astronomer Petrus de Dacia, also known as Peter Nightingale [PEDERSEN, 1983, pp. 336-59][5]. This highly popular work, which still exists in well over sixty copies[6], is only the best-known representative of a whole tradition of astronomically enhanced calendars, which sought to improve upon the lunar data offered in more conventional tables, as they were typically found in works related to the Easter *computus*. In ecclesiastical usage, the phases of the Moon were of importance chiefly for the calculation of the movable feast days, due to the fact that the date of Easter Sunday was dependent on the first full moon in spring. Its annual occurrence was determined with the help of a 19-year lunar cycle, first adopted by the Church of Alexandria in the fourth century, which was founded upon the assumption that the dates of the new and full moons in the Julian calendar would return in a perpetual sequence after 19 years.

By the twelfth century, it had become common usage to furnish calendars with a column for the so-called 'Golden Number' (*aureus numerus*), which indicated the year within a 19-year cycle in which a given date became the seat of a new moon [VAN WIJK, 1936; BORST, 1998, pp. 704-708]. Convenient as this device certainly was, it lacked astronomical accuracy, resting as it did on an equation of 19 years in the Julian calendar (= 6939.75d) with 235 synodic months, whose implied average length was thus 6939.75 ÷ 19 = 29.530851d = 29d 12h 44m 25.53s. The result exceeded the actual length of the mean synodic month by several seconds, given that the latter is currently measured as 29.530589d or 29d 12h 44m 2.88s. Using this value, we find that the overestimation accrues to a complete day in slightly over three centuries (ca. 308.5y) and will continue to grow unless a correction is made. By the year 1200, the discrepancy between the actual conjunctions of Sun and Moon and the Golden Numbers had already reached about three days, compelling scholars to openly call for a reform of the ecclesiastical calendar [KALTENBRUNNER, 1876; North, 1983].

As is well known, such plans did not come to fruition until the Gregorian calendar reform of 1582, but in the meantime multiple generations of computists and astronomers had reacted to the problem at hand by creating and disseminating what I will hereafter call ‘improved’ lunar calendars, which effectively constituted a reform of lunar computation ‘from below’[7]. The distinguishing hallmark of such calendars was that they supplemented or replaced the old Golden Number with calculated mean conjunction times, which were most typically laid out in four parallel columns for a period of 76 years or 940 synodic months. The blueprint for this approach had already been created in the late eleventh century by the Lotharingian computist Gerland, whose calendar with 76-year lunar tables emended the ‘ecclesiastical’ moon by using as the new reference point a solar eclipse observed on 23 September 1093 [LOHR, 2013, pp. 212-228]. Gerland’s calculated conjunctions, which were timed to the nearest hour, enjoyed renewed popularity in the thirteenth century as part of the *Kalendarium Lincolniensis* [LINDHAGEN, 1916], a work attributed to Robert Grosseteste, the famed and learned Bishop of Lincoln (d. 1253). If this ascription is authentic, which one may seriously doubt, Grosseteste would have done little more than to take Gerland’s new moon data (via a twelfth-century intermediary created by Roger of Hereford) and insert them into a standard *kalendarium*, with a beginning of the year in January and entries for saint and feast days as well as computistical and astronomical data[8].

Although visibly closer to the phenomena than traditional calendars, the *Kalendarium Lincolniensis* was still founded on the mean synodic month of the 19-year cycle and thus grew out of touch with the actual lunar phases at the same alarming rate. Eventually, this persistent failure prompted astronomers to retain the basic layout of the *Kalendarium*, but to re-cast its new moons with the help of astronomical tables. During the late Middle Ages, such improved calendars, which frequently also included other types of astronomical information (e.g., zodiacal positions for Sun and/or Moon, the length of daylight, or the Sun’s noon altitude), could be found in a great variety of guises and contexts. A significant impetus for their creation was provided by the needs of physicians and other practitioners of medical astrology, who used the phases and the zodiacal position of the Moon as a criterion for administering cures and treatments such as phlebotomy [WALLIS, 1995; Carey, 2004]. The widespread interest in lunar computation was already commented upon by the influential French astronomer John of Murs, who created several tables for this purpose during the 1320s [CHABÁS & GOLDSTEIN, 2012]. According to John of Murs

> all people, whether men or women, study the celestial harmony to the point that they actually seem to interfere with the conjunctions and oppositions of the Sun and the Moon. Indeed, the common people are incapable of abstaining from interpretations concerning the condition of the air and of human bodies during new moon and full moon. ... and certainly, among the more learned, the very many who have taught how to issue judgements of past, present and future events by means of conjunctions and oppositions have a high reputation. It is no wonder, then, if the science of those conjunctions and oppositions is sought after by everybody [PORRES & CHABÁS, 2001, p. 67].

Ideally, such knowledge would have involved the moment of true as well as that of mean syzygy, but a look at the surviving specimens of improved calendars shows that most authors remained content with only listing mean conjunctions, as these were far easier to calculate. Before the Alfonsine Tables came into widespread use during the second quarter of the fourteenth century, the parameters for this kind of job were usually provided by the so-called Tables of Toledo [PEDERSEN, 2002], which had been created in the late eleventh century by a group of Andalusian astronomers, the most prominent among whom was Ibn al-Zarqālluh, known in the West as Azarchel or Azarquiel [MILLÀS, 1943-1950]. It is to Azarquiel that the Toledan Tables, and especially their accompanying canons, were usually attributed in the medieval manuscript tradition, which still comprises more than 160 Latin witnesses, a French adaptation [BOUDET & HUSSON, 2012], and a recently discovered Castilian fragment [CHABÁS, 2012], but not of a single Arabic original. A fairly common element of the Toledan Tables and their various Christian adaptations (e.g. for Toulouse or Novara) was a set of tables for mean syzygy, which reckoned with a mean synodic month of 29 days, 12 hours, 44 minutes, and 3 1/3 seconds [PEDERSEN, 2002, pp. 1327-1350]. This value is equivalent to the 29 days, 12 hours, and 793 'parts' (*ḥalaqim*) used in the Jewish calendar, but also to the 29;31,50,8,20d (in sexagesimal notation) employed by Claudius Ptolemy in the *Almagest*[9]. Ptolemy had received this parameter via Hipparchus, but it ultimately goes back to Babylonian sources [NEUGEBAUER, 1989; GOLDSTEIN, 2003]. In decimal notation, it corresponds to 29.530594d, which is an excellent value in terms of accuracy.

To my knowledge, the earliest example of a Christian improved calendar that demonstrably uses these Toledan parameters is a work of probable English origin, which survives in both Latin and Anglo-Norman versions. According to the attached explanation, it was made in the year 1289, but the contained lunar data clearly show that it was calculated for a 76-year period beginning in 1292. Its tables thus reach up to 1367, assigning to each new moon date the current hour of the day at which conjunction will occur[10]. The very same period from 1292 to 1367 is also covered by two other English calendars, which differ from the previous one by displaying both the (completed) hour and minute of the day. The first can be found in at least four manuscripts, two of which refer to it as the '*Kalendarium* of Roger Bacon'—but this ascription must be treated with great caution[11]. It appears to have originated in Lincoln, the cathedral town associated with Bishop Robert Grosseteste, which is identified as the latitude of reference (53°) used in a column that displays the Sun's noon altitude for each day of the year. The accompanying text explicitly states that the conjunctions were calculated for the longitude of Toledo, which "is not much different from the meridian of the middle of Ireland[12]". For the author of another English calendar, made at the University of Oxford in 1292, this was not close enough to home, seeing how he added 15 minutes to the conjunction times of the former work. In doing so, he accounted for an assumed longitude difference of 3;45° between Toledo and Oxford (correct: ca. 2;45°)[13].

Year	I	II	III	IV	V	VI
	TT (syz.)	TT (mean mot.)	R. Bacon	R. Bancal	P. of Dacia	A. of Diest
1311	20 Jan 22:35	20 Jan 22:36:30	19 Jan 22:35	19 Jan 22:37	20 Jan 11h 3q	19 Jan 23h
1312	10 Jan 07:24	10 Jan 07:25:09	09 Jan 07:24	09 Jan 07:25	09 Jan 20h 2q	09 Jan 8h
1313	28 Jan 04:57	28 Jan 04:57:53	27 Jan 04:57	27 Jan 04:58	27 Jan 17h 4q	27 Jan 5 ½h
1314	17 Jan 13:46	17 Jan 13:46:33	16 Jan 13:46	16 Jan 13:47	17 Jan 2h 4q	16 Jan 14 ½h
1315	06 Jan 22:34	06 Jan 22:35:13	05 Jan 22:34	05 Jan 22:35	06 Jan 11h 3q	05 Jan 23h
1316	25 Jan 20:07	25 Jan 20:07:56	24 Jan 20:07	24 Jan 20:08	25 Jan 9h 1q	24 Jan 21h
1317	14 Jan 04:56	14 Jan 04:56:36	13 Jan 04:56	13 Jan 04:57	13 Jan 17h 4q	13 Jan 5h
1318	03 Jan 13:44	03 Jan 13:45:16	02 Jan 13:44	02 Jan 13:45	03 Jan 2h 4q	02 Jan 14h
1319	22 Jan 11:17	22 Jan 11:17:59	21 Jan 11:17	21 Jan 11:18	21 Jan 24h 2q	21 Jan 12h
1320	11 Jan 20:06	11 Jan 20:06:39	10 Jan 20:06	10 Jan 20:07	11 Jan 9h 1q	10 Jan 20 ½h
1321	29 Jan 17:39	29 Jan 17:39:23	28 Jan 17:39	28 Jan 17:40	29 Jan 6h 3q	28 Jan 18 ½h
1322	19 Jan 02:28	19 Jan 02:28:03	18 Jan 02:28	18 Jan 02:28	18 Jan 15h 2q	18 Jan 3h
1323	08 Jan 11:17	08 Jan 11:16:43	07 Jan 11:17	07 Jan 11:17	07 Jan 24h 2q	07 Jan 12h
1324	27 Jan 08:49	27 Jan 08:49:26	26 Jan 08:49	26 Jan 08:50	26 Jan 21h 4q	26 Jan 9h
1325	15 Jan 17:38	15 Jan 17:38:06	14 Jan 17:38	14 Jan 17:38	15 Jan 6h 3q	14 Jan 18h
1326	05 Jan 02:26	05 Jan 2:26:46	04 Jan 02:26	04 Jan 02:27	04 Jan 15h 2q	04 Jan 3 ½h
1327	23 Jan 23:59	23 Jan 23:59:29	22 Jan 23:59	23 Jan 00:00	23 Jan 13h 1q	23 Jan 0 h
1328	13 Jan 08:48	13 Jan 08:48:09	12 Jan 08:48	12 Jan 08:48	12 Jan 21h 4q	12 Jan 9 ½h
1329	31 Jan 06:20	31 Jan 06:20:53	30 Jan 06:20	30 Jan 06:21	30 Jan 19h 2q	30 Jan 7h

Tab. 1: The January conjunctions from 1311-1329 in early improved calendars[14]

The *Kalendarium* of R. Bancal happens to be closely related to both these English calendars in that it, too, uses Toledan parameters to calculate the time of mean conjunction down to the nearest minute. As seen from a comparison of columns I and III in Tab. 1 below, the times in the *Kalendarium* of (pseudo-)Roger Bacon are practically identical to those obtainable from the syzygy tables that standardly accompany the Toledan Tables. The only difference concerns the date, which is consistently one day lower compared to the Toledan Tables, where the day always begins at noon, 12 hours ahead of the current civil date. In the calendar, by contrast, the noon-epoch appears to lie 24 hours later, which may reflect conscious choice or indicate a failure to include the first day of the Arabic era (Hijra) in the calculation[15]. R. Bancal's conjunction dates (in column IV) exhibit the same shift in the numbering of days, but the times are generally one minute ahead of those in the *Kalendarium* of (pseudo-)Roger Bacon. From a comparison with column II, one can see that this increase brings his results very close to the conjunctions actually predicted by the parameters in the Toledan mean motion tables for Sun and Moon—although it remains unclear if Bancal really used this cumbersome method for finding the time of mean syzygy[16].

In addition to the examples just mentioned, Tab. 1 also includes data from two other contemporary calendars, which take a somewhat rougher approach to displaying new moon times. One is the aforementioned *Kalendarium* of Peter Nightingale (column V), which begins a year later than the English calendars, covering the period from 1293 to 1368. In terms of layout and presentation, this work was very closely modelled on the old *Kalendarium Lincolniensis*, the main difference being that the entries for the hour of conjunction were supplemented by dots indicating the current quarter-hour. As seen from the table above, the times in Nightingale's calendar follow neatly from the Toledan mean conjunctions, if one bears in mind that Peter begins the day at midnight and always counts the current rather than the complete hour [PEDERSEN, 1983, pp. 59-62, 289-90]. The other calendar was created ca. 1301 by the little-known Flemish astronomer and physician Alard of Diest (column VI), who tabulated new moons for the years 1301 to 1376, timing them to the nearest half-hour. According to the accompanying text, Alard made these calculations for his hometown Diest in Brabant, whose latitude he measured very accurately as 50;58° (correct: 50;59°) and whose meridian he claims to 'precede' (*precedit*) the meridian of Paris by about half an hour, as revealed by observation of eclipses[17]. The actual distance between Paris (2;21° East) and Diest (5;03° East) is only about 2;42° or 10:48 in minutes of time. Upon analysis, however, the times listed in Alard's calendar closely track those of the Toledan Tables, without any noticeable longitude correction. Scribal errors aside, most of the remaning deviations seem explicable if Alard always added rounded months of either 29 days 12 ½ hours or 12 days 13 hours to the conjunction on 10 January 1301. The latter occurred at 03:33 pm according to the Toledan Tables and is listed as 4 ½ h in the calendar, which should be interpreted as the current hour.

Two further improved calendars from this period deserve a brief mention, especially because they both had influential addressees. One of them was created by the otherwise unknown Dominican friar Pierre Vidal, who in 1318 sent the result to Pope John XXII, eager to convince the pontiff that a reform of the ecclesiastical calendar was urgently needed. His letter of dedication is preserved, uniquely it seems, in MS P (fol. 101r), from which we learn that Vidal made his calculations for the city of Montpellier, listing the hour and minute of mean conjunction for a period of 3 × 19 = 57 years, starting in 1311[18]. The following *kalendarium valde bonum* (fols. 102r-7v) does not fully conform to this description, however, as it instead covers four 19-year cycles from 1311 to 1386, using the same date-range and 'Toledan' algorithm as the calendar ascribed to Bancal. The main difference is that Vidal's times are, on average, 7h 7m ahead of those in Bancal's *Kalendarium*. Most of this addition is due to the fact that Vidal began the day from equinoctial sunrise, whereas Bancal used the following noon. The remaining 67 minutes indicate a longitudinal difference of 16;45°, which is more than twice the actual distance between Toledo (4;1° West) and Montpellier (3;53°).

Much better known than Vidal's calendar is the *Kalendarium regine*, which the astronomer William of Saint-Cloud created in 1296 in honour of Marie of Brabant, widow of the French king Philip III[19]. This work offered a more extended range of astronomical data than usual, even though it only tabulated the new moons for one 19-year cycle, starting in 1292. Another peculiarity is that William gave the time to the nearest current hour, but consistently increased the result by a day in an effort to push the calculated new moons closer towards the evening of first visibility. Even so, the technical basis was evidently provided by the Toledan Tables (or, perhaps, the Tables of Toulouse adapted from them). This is noteworthy given William's critical attitude towards these tables, whose precession model he considered to be defective. Such criticism is documented in his *Almanach planetarum* of 1292 [PEDERSEN, 2014], in which he also proposed several corrections to the planetary longitudes, including a subtraction of 40m from all lunisolar conjunctions.

William of Saint-Cloud's misgivings foreshadow the fact that one generation later the Toledan Tables were abandoned in favour of the Alfonsine Tables, which originated in the previous century at the court of Alfonso el Sabio. The main hub of this revolution in computational astronomy was the University of Paris [CHABÁS & GOLDSTEIN, 2003, pp. 243-290; POULLE, 2005], where a modified Latin version of the Alfonsine Tables became the centre of astronomical interest around 1320. This is evident, *inter alia*, from the remarks that preface a *Kalendarium* made in that year by the prominent astrologer Geoffrey of Meaux, who was associated with the Collège de Sorbonne. His 'calendar', which is found at the very start of MS M (fols. 1r-9v), is a somewhat more sophisticated affair than the works discussed so far, tabulating solar and lunar mean motions as well as other parameters necessary for predicting eclipses[20]. As Geoffrey himself states in the introduction (fol. 1rb), these parameters were all given in accordance with the old Toledan Tables, which he found to be more trustworthy than the 'new' Alfonsine Tables. As if to counter these allegations, his work is immediately followed by the canon to another set of lunar tables (fols. 10v-14v), this time attributed to John of Lignères, who was active in Paris during the

1320s and 1330s [POULLE, 1973; 2005, pp. 36-45]. John was one of the pioneers in the use of Alfonsine parameters, as reflected, for instance, in his astronomical tables of 1322, from which the tables in MS M appear to have been excerpted. They list the times of all mean conjunctions from 1321 to 1396, with values that can be recomputed with the Alfonsine Tables if an addition of 48 minutes is made. This suggests that the author worked for a location 12° East of Toledo, which was a frequently used (albeit exaggerated) estimate for the longitude of Paris[21].

That MS M is a codex primarily dedicated to early-fourteenth century French astronomy is further underscored by the tables that take up fols. 15r-88v. These belong to a previously unnoticed copy of the influential *Almanach perpetuum* by Jacob ben Machir ibn Tibbon of Montpellier (d. ca. 1304), better known as Profatius Judaeus [BOFFITO & MELZI D'ERIL, 1908], which did much to popularize the genre of the perpetual planetary almanac in the Latin West[22]. Profatius's canons, which are found on fols. 89r-92v, confirm that the almanac was computed for the coordinates of Montpellier. In line with its early starting date (1300), the Toledan Tables are still at the root of all the data presented [TOOMER, 1973; BOUDET, 1994, pp. 52-54].

2. BANCAL'S 'PERPETUAL' LUNAR CALENDAR

With these preliminaries in mind, we can now turn to the structure and layout of Bancal's calendar, as it is reproduced in Tab. 2 below, displaying the conjunctions of the month of January for a period of 76 years. Basic orientation is provided by the column to the very right ('D.M.' = dies mensis), which indicates the day of the month from 1 to 31. Further left is a column for the traditional Golden Number ('A.N.' = aureus numerus), which makes it possible to compare the new moons tabulated in the calendar with the 'ecclesiastical new moon'. Between these two, I have omitted a few columns that belong to the standard repertoire of medieval liturgical *kalendaria*, including the ferial letters (from A to G) used to identify the weekday, and the designation of the day according to the Roman system (numbering backwards from Kalends, Ides, and Nones). A zone for entering saint and feast days as well as some seasonal data (like the Sun's entry into the zodiacal signs) is also provided for in both copies, but only properly used in MS M. The column to the very left ('N.C'. = numerus cycli) shows the year of the 19-year cycle in which the day in question becomes the seat of a conjunction. To the right of this number, the calendar displays the corresponding time, in hours and minutes, for each of the four 19-year cycles covered.

As Bancal himself explained in the accompanying canon, the conjunction times pertaining to a particular year of the 19-year cycle can sometimes be found on two consecutive dates and thus in two adjacent rows. In order to indicate which dates belong to the same year, his original design was supposed to include short dashes to connect numbers in different rows. They are indeed featured in MS M, but omitted

N.	1st cycle		2nd cycle		3rd cycle		4th cycle		A.		D.
C.	h.	m.	h.	m.	h.	m.	h.	m.	N.		M.
19			10	10	2	43			3		1
8	13	45	6	18	22	52	15	25			2
									11		3
16	2	27	19	0	11	33	4	6			4
5	22	35	15	8	7	42			19		5
					20	23	0	15	8		6
13	11	17	3	50			12	56			7
			23	58	16	31	9	5	16		8
2	7	25					21	46	5		9
10	20	7	12	40	5	13					10
					17	55	10	28	13		11
18	8	48	1	21					2		12
7	4	57	21	30	14	3	6	36			13
15	17	38					19	18	10		14
			10	11	2	44					15
4	13	47	6	20	22	53	15	26	18		16
			19	1					7		17
12	2	28			11	34	4	7			18
1	22	37	15	10	7	43			15		19
					20	24	0	16	4		20
9	11	18	3	51			12	57			21
			16	33	9	6	1	39	12		22
17	0	0					21	47	1		23
6	20	8	12	41	5	14					24
					17	56	10	29	9		25
14	8	50	1	23							26
3	4	58	21	31	14	4	6	37	17		27
11	17	40					19	19	6		28
			10	13	2	46					29
19	6	21	22	54	15	27	8	0	14		30
8			19	3					3		31

Tab. 2: The new moons of January in Bancal's calendar

from MS P. For Tab. 2, I have replaced this method with one based on alternate shading, such that the hours and minutes belonging to a particular year of the 19-year cycle are always printed on the same kind of background, either white or grey. If the entries in any such sequence are compared with each other, it becomes readily apparent that the conjunction times usually drop by 7h 27m (in some cases by 7h

26m) from one 19-year cycle to the next. This pattern is due to the fact that 19 years in the Julian calendar exceed the length of 235 'Toledan' synodic months by 1h 26m 56;40s. The remaining 6h accrue because 19 Julian years last 6939.75d on average, which is 6h short of a complete number of days. Only after 4 iterations of the 19-year cycle, i.e., after 27,759 days, will there be no remainder left —hence the popularity of the 76-year period among medieval calendar-makers.

In order to properly work with this sort of *kalendarium*, users had to know how to determine the position of their targeted year in one the four 19-year cycles on display. As Bancal himself explained, this was no more difficult than to subtract 1310 from the current year of the incarnation. If the number remaining was 76 or less, the corresponding year could be located straightforwardly in the calendar: years 1-19 in the first cycle, 20-38 in the second cycle, 39-57 in the third cycle, and 58-76 in the fourth cycle. Clearly, however, this rule was limited to the years 1311-1386, which is the range of dates for which the tabulated conjunction times were valid. If they could not be straightforwardly applied to earlier or later periods, this was due to the fact that 940 synodic months were 5 hours, 47 minutes, and 46;40 seconds (i.e. 4 × 1h 26m 56;40s) short of 76 years in the Julian calendar. In order to extend the calendar's use beyond these boundaries, it was hence necessary to apply a correction, which was based on the number of 76-periods by which the targeted date was removed from one of the conjunctions on display. Rather than just describing this correction in general terms, as other authors had done before him, Bancal supplied his work with an auxiliary table, which minutely tabulates the value that needs to be added or subtracted in order to adapt the calendar to any period between AD 18 and AD 2602.

The result is presented in Tab. 3 below, a version of which precedes the canons to Bancal's *Kalendarium* in both preserved copies. It is on account of its function as a corrective to the main calendar that the scribe of MS P (fol. 71r) refers to the canon by the title *Correctio kalendarii*. In the table that provides for this *correctio*, the number of years ('N.A.' = numerus annorum) always designates the largest number that can be subtracted from the current year while still leaving a remainder between 1 and 76. For the present 76-year period from 1311 to 1386, this is 1310, which is why the correction for '1310' is given as 0 hours and 0 minutes. The previous entry, for '1234', instructs an addition of 0d 5h 48m, meaning that for all years between 1235 and 1310, the conjunction times fell 5 hours and 48 minutes later than shown in the present calendar. Similarly, for conjunctions in 1387-1462, the same amount of time has to be subtracted. The aforementioned 5h 47m 46;40s have here obviously been rounded to the nearest minute, but the difference is taken into account in subsequent entries, which tabulate the increment for successive 76-year periods. For instance, the final entry on the right side (for 'subtractions') shows that in the years 2603-2678, the conjunctions will fall 4d 2h 32m later than indicated in the calendar. This value is equivalent to 17 × 5h 47m 46;40s (= 4d 2h 32m 13;20s), if seconds are omitted.

N. A.	Diff. added			N. A.	Diff. subtracted		
	d.	h.	m.		d.	h.	m.
18	4	2	32	1386	0	5	48
94	3	20	44	1462	0	11	36
170	3	14	57	1538	0	17	23
246	3	9	9	1614	0	23	11
322	3	3	21	1690	1	4	59
398	2	21	33	1766	1	10	47
474	2	15	46	1842	1	16	34
550	2	9	58	1918	1	22	22
626	2	4	10	1994	2	4	10
702	1	22	22	2070	2	9	58
778	1	16	34	2146	2	15	46
854	1	10	47	2222	2	21	33
930	1	4	59	2298	3	3	21
1006	0	23	11	2374	3	9	9
1082	0	17	23	2450	3	14	57
1158	0	11	36	2526	3	20	44
1234	0	5	48	2602	4	2	32
1310	0	0	0	*****			

Tab. 3

The fact that Bancal conceived of his work as a 'perpetual' lunar calendar, valid for more than just one 76-year period, makes it very difficult to reliably determine the time of writing. After all, it means that there was no pressure on him to calculate conjunction times only for the future, as had been done by the English author of the calendar made in 1289. Most of the improved calendars mentioned so far (with the exception of Peter Nightingale and Alard of Diest) took as their starting point the first year of a 19-year cycle, be it 1292 or 1311. This was an expedient choice, as it made sure the count of lunar years went in lockstep with the old method of determining the Golden Number, but it is not necessarily indicative of the exact time of composition, as can be seen from the dates assigned to the works of William of

Saint-Cloud (1296) and Pierre Vidal (1318)[23]. While it remains likely that Bancal's time of writing was close to 1311, no certainty can be reached in this matter. In principle, any year within the first 19-year cycle from 1311 to 1329 is a feasible candidate, as would be a composition in 1309 or 1310.

3. THE FRENCH CONNECTION

In both manuscripts, the table for the *correctio* of the lunar calendar is supplemented by an additional column, which tabulates the value users need to add to a given conjunction in order to infer the time of other moments within a synodic month, here designated as 'aspects' (*aspectus*). Although Friar Bancal was by no means the only calendar-maker to include such information[24], the degree to which he focused on the Moon's 'aspects' seems exceptional and makes for the most distinguishing trait of his work. Besides the time of the opposition or full moon, he also identifies the time at the end of the first sixth of a given lunation (*sextilis vel hexagonus*), the end of the first quarter (*tetragonus*), the end of the first third (*trigonus*) as well as the beginnings of the final third, quarter and sixth (*trigonus secundus* etc.). As one may expect, these are all derived from the standard value of the synodic month by simple divisions. Hence, the value to be added to arrive at the time of mean opposition is 14d 18h 22m, i.e., one half of 29d 12d 44;3,20m. For the *sextilis primus* it is one sixth (4d 22h 7m), for the *tetragonus primus* it is one fourth (7d 9h 11m), for the *trigonus primus* it is one third (9d 20h 15m). Similarly, the remaining three 'aspects' are two thirds (19d 16h 29m), three quarters (22d 3h 33m), and five sixths (24d 14h 37m) of a synodic month[25].

At first glance, this treatment of 'aspects' may seem slightly gratuitous, especially if we consider that the precise time of the Moon's opposition, let alone its *sextilis* or *trigonus*, plays no particular role in a lunar calendar as traditionally conceived, in which days are simply counted from new moon to new moon. Bancal's insistence on tabulating them anyway suggests that for him the correction of the ecclesiastical calendar was less important than the provision of a lunar almanac for medical-astrological purposes, which users might consult to regulate their choice of diet or determine the right time for bloodletting. The medical utility of his work is indeed underlined very strongly in a brief text uniquely contained in the fourteenth-century manuscript Paris, Bibliothèque de l'Arsenal, 2872, which is a massive anthology of astrological and alchemical texts in French translation. One of these texts, found on fols. 61va-64rb (beginning "Car science medicinal la disposicion de l'aeir..."), happens to be the commentary on a lost work by a certain *maistre* Étienne Arblant, who was the creator of a complex astronomical wheel-diagram, entitled *La Roe a savoir la conionction et la distance du soleil et de la lune et les lieux de euls avecques les aspectus des autres planetes, pour ce que le mire se puisse adresser a ses oeuvres* ("The Wheel for knowing the conjunction and distance of Sun and Moon as well as their locations, together with the aspects of the other planets, so that the physician can use them in his works"). Its one-time existence was already noted by Antoine Thomas, who included brief entries for the names 'Raymond Bancal' and 'Étienne Arblant' in volume 35 of the illustrious *Histoire littéraire de la France* [THOMAS, 1921b; 1921c], but the French text appears to have received no attention in the meantime.

From the preserved commentary it appears that Arblant's *Roe* consisted of three different sections, the first of which was a calendar featuring the hour and minute of each conjunction from 1311 to 1386, to be accompanied by an auxiliary table for time corrections. The commentator leaves no doubt that this material was taken wholesale from the *Kalendarium* of R. Bancal, whom he calls *frère Raymon Bancal de l'Ordre des Meneurs*[26]. No traces of the *Roe* itself remain in the present manuscript, with the result that the scribe instead refers readers to the new moons in the *Kalendier la Royne*, found at the very beginning of the same codex (fols. 1r-6v). This is none other than the French version of William of Saint-Cloud's *Kalendarium regine*, which the author himself made for Jeanne de Navarre, the wife of Philip IV of France[27]. Contrary to what has been suggested [HARPER, 1966, p. 19], however, it can hardly have been the copy presented to the Queen, as Jeanne already died in 1305, whereas the commentary on fols. 61va-64rb, which is in the same hand as the rest of the codex, identifies the present year as 1335[28]. This is thus the definite *terminus ad quem* for Arblant's work (and a fortiori for Bancal's).

But the French text not only offers us a date, it also gives us a location, in so far as the commentator mentions another auxiliary table in the shape of a 'small wheel' (*roe petite*), which noted the length of the 'artificial day' (i.e., the period of daylight) for the tenth, twentieth, and final day of each month. According to his remark, the data contained in this small wheel were "true at Toulouse," which might indicate either the commentator's or Étienne Arblant's place of origin[29]. Now, the likelihood seems strong that this 'small wheel', too, was in some way excerpted from Raymond Bancal's *Kalendarium*. As it happens, both copies of the latter work contain a separate column recording the length of daylight at the end of the first, second, and final third of each month, similar to what is described in the commentary. In addition to listing these times as part of the calendar proper, MS P also adds another part to the auxiliary tables on fol. 71r, which provides all 3 × 12 = 36 day-lengths at a single glance.

This restriction to only 36 dates contrasts strongly with other improved calendars made at the time, like those by Peter Nightingale and William of Saint-Cloud, where day- and night-time lengths were provided for each day of the year, supplemented by other solar data such as noon altitudes and tropical longitudes. The omission of such material from Bancal's calendar suggests that the course of the Sun—unlike that of the Moon—was of no particular interest to *frère Raymon*. Even so, the data provided allow us to conclude that in his scheme the longest day of the year was meant to last exactly 15 ½ hours[30]. This value far exceeds the maximum day-length normally associated with Toledo in medieval sources, which is 14h 51m, with a corresponding latitude of 39;54° [PEDERSEN, 2002, pp. 1125-27, 1516; CHABÁS & GOLDSTEIN, 2003, pp. 211-13]. Instead, it is identical to the length that medieval astronomers, like William of Saint-Cloud [HARPER, 1966, p. 87], generally associated with the longest day in the middle of the sixth of seven 'climes' or climate zones. According to the authoritative *Liber de sphaera* by John of Sacrobosco, the sixth clime stretches from 43 ½ to 47 ¼ degrees northern latitude [THORNDIKE, 1949, p. 112; WRIGHT, 1925, pp. 454-55], which would have still included the latitude of Toulouse (43;36°), but not that of Catalonian locations like Barcelona (41;23°) or Girona (41;59°).

As so often, there is more than one way to account for this surprising state of affairs. One solution, perhaps the least attractive one, would be to suppose that it was really Arblant or some other author from his region who created the solar table in MS P and that the daytime lengths were only inserted into the calendar after the fact. Alternatively, and more plausibly, we may suppose that Friar Bancal stayed north of the Pyrenees —and within the sixth clime— when he composed his calendar. Given the lack of information about his career before 1326, this is entirely possible and would help us explain why the initial transmission and reception of his work went mainly, if not exclusively, through Southern French channels. Aside from Arblant's *Roe* and MS M, in which all texts apart from Bancal's *Kalendarium* share an obvious French provenance, this is particularly clear from MS P, a codex noted for its metrical Provençal texts on astrology and geomancy [MEYER, 1897, pp. 257-275; Contini, 1940; Ebneter, 1955]. Other items included that were obviously written in the Pais d'Òc are the aforementioned calendar by Pierre Vidal, which was made for Montpellier in or before 1318, and a lecture (*lectura*) on the *Compotus manualis* of John of Pulchro Rivo (fols. 38ra-46va), which is stated at the end to have been 'edited' in Toulouse in 1332. This may give us an indication of when the bulk of the codex was approximately written, although it must be pointed out that the text of the lecture itself repeatedly identifies the present year as 1322 (fols. 39rb, 41vb)[31].

One more piece of evidence remains to be considered and that is *frère Raymon*'s family name, which is unusual enough to shed light on his place of origin. As it happens, the name *Bancal*, latinized as *Bancalis*, is associated not with Catalonia, but with the County of Rouergue, which is largely coextensive with the modern Département Aveyron. Famous among the Rouergat gentry is the family *de Bancalis*, who rose to nobility in the early modern period, but various forms of the name Bancal are already attested in thirteenth-century charters and documents from Bonnecombe Abbey, located about 15 km south of the departmental capital Rodez. Examples include a certain Ugo Bancal(s), who served as subprior in 1231 and as the monastery's cellarer in about 1234-1254 [VERLAGUET, 1918-1925, pp. 381-382, 391, 397, 399, 402, 579, 588, 591, 594]. Better still, there was a 'Ramundus Bancalis' among the monks of Bonnecombe in 1299, who reappears as 'Ramond Bancal' in a document signed in 1320, where he is referred to as *cellérier moyen* [VERLAGUET, 1918-1925, pp. 280, 287][32]. Were it not for the different monastic order (Bonnecombe was a Cistercian foundation, not a Franciscan one), it would be very tempting indeed to identify him with our calendar-maker. At any rate, the abbey is at 44;15° northern latitude and thus relatively close to the ca. 45;30° that are required for the maximum day-length indicated in the *Kalendarium*. We are thus in a position to conclude with confidence that Raymond Bancal's lunar calendar was created and disseminated in the Languedoc, although one may still speculate that he brought a copy of the work with him when he moved to Barcelona later in his life to become Franciscan minister for Aragon. Oddly enough, the present-day descendants of his family call themselves *de Bancalis de Maurel d'Aragon*, although this is in reference to a town in the Département Aude, not the Iberian kingdom.

4. CODA: LUNAR RECKONING IN CATALONIA, A.D. 1300

The negative insight that Bancal's *Kalendarium* is not an Aragonese production after all should not distract us from the fact that medieval Catalonia possessed an important tradition of lunar computation, which is best exemplified by the sophisticated tables for true syzygy created ca. 1361 by the Jewish astronomer Jacob ben David Bonjorn for the meridian of Perpignan [CHABÁS, ROCA & RODRÍGUEZ, 1992]. They later served as the basis for the *lunari* devised by the Barcelonese citizen Bernat de Granollachs ca. 1485, which spawned 90 printed editions and a total print-run of about 50,000 copies [CHABÁS & ROCA, 1998][33]. As José Chabás [2000] has pointed out, there are also other types of *lunarios* extant in medieval Iberian manuscripts, which take recourse to much simpler devices such as the 19-year Metonic cycle and a uniform mean synodic month of 29 days, 12 hours, and 793 'parts' (where 1 hour = 1080 'parts'). The latter value, which is equivalent to the one implicit in the Toledan Tables, is a characteristic feature of the Jewish calendar, whose system of calculating *moladot* (mean conjunctions) was appreciated by many Christian scholars in medieval Europe as an efficient resource for an improved lunar computation [NOTHAFT, 2014b]. That this attitude also existed in Catalonia is evident from the Còdex Miscel·lani of the Arxiu de les Set Claus in Andorra [SANTANACH, 2003], which is our only witness to an obscure *Tractat de Bahare o ensenyament segons Iherusalem* [VELA, 1997, pp. 70-74]. In essence, this 'treatise' is a brief set of notes on how to calculate the new moon according to the principles of the Jewish calendar. These notes were originally meant to accompany a set of tables, as is evident from a reference to "que per la taula de la quint appar" [VELA, 1997, p. 73], but these are no longer extant.

As the author is well aware, the nominal meridian of reference for the Jewish calendar is the city of Jerusalem, which is why he recommends the subtraction of 648 'parts' (= 36 minutes) from the Jewish conjunction times to arrive at the corresponding times for Barcelona or Mallorca. This correction implies a difference of only 9° longitude (the text itself even only speaks of 8°), which is excessively small. Another important feature of the Jewish calendar discussed is the time of the first conjunction at the epoch of creation, which provides the foundation for all other conjunctions in history. According to the standard convention, this conjunction occurred on a Monday (7 October 3761 BC) at 5h and 204p, but this is often simply written as 2.5.204. Transcribing this numerical value into Hebrew notation yields the word בהר״ד, which is why the epoch date of the Jewish calendar is also known as *molad baharad*. Indeed, the final paragraph of the *Tractat de Bahare* refers to the *molad baharad* as "la *primera* Luna de Bara qui fou en la creacio del mon, ço es, dilluns a 5 e 204 punts" [VELA, 1997, p. 74]. It is thus very likely that the word *Bahare* in the title was derived from this Hebrew mnemonic word rather than from an Arabic root, as has previously been suggested [VELA, 1997, p. 163].

Now, in the aforementioned Còdex Miscel·lani the *Tractat de Bahare* belongs to an astrological fascicle of 16 pages (fols. 70r-80v) [SANTANACH, 2003, pp. 439-441], which Susanna Vela [1997, p. 28] has dated to ca. 1430–40 on palaeographic grounds. It is worth pointing out, however, that the text itself contains numerical information that indicates a much earlier date of composition. The key datum to be considered is the conjunction the author selects as his reckoning example for the aforementioned longitude conversion:

> Posem que aquest ensenyament d.aquesta obra es fet sobra Iherusalem, atrombam lo girament de la Luna dimecres a 20 dies de abril a 6 hores e 431 punt [VELA, 1997, p. 72].

His words suggest that he wrote at a time when 20 April fell on a Wednesday, with a calculated mean conjunction at 6h 431p. This perfectly matches the situation in the year AD 1300, when this was the date and time of the *molad* of the month of Iyyar in the Jewish calendar. The same conclusion can indeed be drawn from the conjunctions that the author identifies as the 'first' and 'second' of the year, i.e. the new moons of January (Friday, 16h 212p), and (Sunday, 4h 1005p) [VELA, 1997, p. 73]. According to the standard Jewish reckoning, these were the *moladot* of Adar and Adar II in AD 1300. We can thus conclude that the *Tractat de Bahare*, or at least the work it was based on, originated at the turn of the thirteenth into the fourteenth century. It appears to offer us what Ramon/ Raymond Bancal's calendar cannot: a genuine piece of evidence for the astronomical activities during the reign of Jaume II.

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NOTES

1. The calendar is here separated from the canon by 15 pages. On fol. 71r we read: "Incipit correctio kalendarii facta a fratre R^{o} Bancalis, ordinis minorum, et hoc est canon primi kalendarii magistri Bancalis, ut patet in prima tabula et in scripto sequenti". For a detailed description of this manuscript, see MEYER [1897, pp. 227–243].
2. The best and most comprehensive account of the astronomical activities during Pere's reign is CHABÁS [2004], who writes that "gairebé tota l'activitat astronòmica a la Corona d'Aragó al segle XIV sembla vinculada d'una manera o altra a la cort reial" [p. 506]. See, in addition, SAMSÓ [1994, pp. 572–574], CIFUENTES [2002, pp. 189–196], VERNET & SAMSÓ [2004, pp. 261–267]. The astronomical tables produced for Pere el Ceremoniós are studied by MILLÀS [1962], LAGUARDA [1964], POULLE [1966], SAMSÓ [1987] and CHABÁS [1996a]. Specifically on the astrological interests of Pere and his son Joan I, see now also RYAN [2011, pp. 105–123].
3. This is known from household records published by RUBIÓ [1908, pp. 91–92]. The idea that Jaume II sponsored astronomical observations similar to Pere III, as put forward by MILLÀS [1962, pp. 68–69], rests solely on a footnote in THORNDIKE [1934, p. 295, n. 6], who misread a note in MS Paris, BnF, lat. 7324, fol. 50v, as referring to the year 1302. In reality, the text belongs to a star catalogue made by Pere's court astrologer Dalmau Ses Planes in the year 1362. The correct reading is provided by BOUDET [1994, p. 65] and by CHABÁS [2004, p. 493].
4. There are also Castilian, Portuguese, and Hebrew translations. See MILLÀS [1935, pp. 285–89; 1949, pp. 387–397; 1943–1950, pp. 395–405], CHABÁS [1996b, pp. 263–265; 2004, pp. 506–508] and CIFUENTES [2002, pp. 197–198]. The Portuguese version was edited by ALBUQUERQUE [1961, pp. 68–150].
5. Next to the *Kalendarium* itself (fols. 63v–69r), MS P also intersperses the canons and two versions of Peter's *Tabula lunae* for the Moon's sidereal position (fols. 69va and 70r), a piece on time-measurement by shadow length (fol. 69va), a brief text on the effects of the planets addressed to a certain Friar Vincent (fol. 70ra–va), and two lists of solar and lunar eclipses in the years 1324–1344 (fol. 70vb). The quire is completed by four astronomical and prognostic wheel diagrams, some with accompanying explanations (fol. 71rb–v). For descriptions and transcriptions of most of this material, see PEDERSEN [1983, pp. 267, 360, 369, 376, 384, 388–389, 397, 452–453].
6. See the list of manuscripts in PEDERSEN [1983, pp. 206–302], to which one may add those recorded by CORDOLIANI [1955, pp. 178–179, 200], for Madrid. The work was also incorporated wholesale into the *Tratado de Astrología* (ca. 1438/39), edited by CÁTEDRA [1983, pp. 159–191], where it is identified as "[el] *Martilogio nuevo* de maestro Pedro" [CÁTEDRA, 1983, p. 161].
7. Most of these works would be more accurately referred to as a new moon almanacs grafted onto the Julian calendar, but I shall speak of lunar calendars in what follows for the sake of convenience. The mass of late medieval (para-)textual objects fitting this description is far too great to be done justice in this brief article, which is why I shall limit myself to only a few specimens produced up to 1321. Of fundamental importance for their study is the edition of Peter Nightingale's calendar and related material in PEDERSEN [1983, pp. 203–456], and the great wealth of manuscripts recorded in ZINNER [1925].
8. See the discussions in KALTENBRUNNER [1876, pp. 305–307, 411–412], VAN WIJK [1936, pp. 38–45], Pedersen [1983, pp. 365–366, 418–419], MORETON [1995, pp. 580–581; 2003, pp. 172, 177–179], BORST [1998, pp. 74–75, 152–153; 2001, pp. 302–306] and LOHR [2013, pp. 435–437]. An incomplete list of manuscripts is provided by THOMSON [1940, pp. 106–107]. For copies in Spanish libraries, see CORDOLIANI [1952, p. 351; 1954, p. 137; 1955, p. 187].
9. Following a widespread convention, I shall distinguish sexagesimal (base 60) from decimal fractions by using a semicolon in place of a period, with commas separating the individual sexagesimal 'digits'. In Jewish calendrical tradition, the hour is divided into 1080 *ḥalaqim* (חלקים), such that one *ḥeleq* is equivalent to 3 1/3 seconds.

10. MSS Cambridge, Gonville and Caius College, 512 (543), fols. 179vb–182v (Latin); London, British Library, Arundel 220, fols. 308r–314v (Anglo-Norman). The first few lines of the canon (without any of the calendar) also appear in MS Oxford, Bodleian Library, Digby 149, fol. 125v.
11. MSS London, British Library, Cotton Vespasian A.II, fols. 2r–8v (ascribed to Roger Bacon); Oxford, Bodleian Library, Bodley 464, 58r–71r (ascribed to Roger Bacon); Oxford, Corpus Christi College, 221, fols. 2r–8v; Erfurt, Bibliotheca Amploniana, 4° 351, fols. 73r–78v. See also the notes on this calendar in LITTLE [1914, pp. 417–418], WORDSWORTH [1904, p. 137], and PEDERSEN [1983, pp. 258, 419; 2002, p. 761].
12. MS London, British Library, Cotton Vespasian A.II, fol. 2r: "Kalendarium sequens extractum est a tabulis Tholetanis anno domini 1292 factus ad meridiem civitatis Tholeti, que in Hispania sita est, cuius meridianus non multum distat a meridiano medii puncti Hibernie." LITTLE [1892, p. 209] suggested "a Minorite in Toledo 1297 [sic!]" as the actual author, but this obviously rests on a misinterpretation of the passage. He is followed by CASTRO [1973, p. 404], who wrongly regards this calendar as an earlier work by Ramon Bancal.
13. MS Oxford, Bodleian Library, Digby 149, fols. 124r–25v, 128r–33v.
14. The data contained in columns I–VI are derived from the following sources: (I) edition of the Toledan syzygy tables in PEDERSEN [2002, pp. 1332, 1338, 1340]; (II) simulation of the Toledan Tables in Raymond Mercier's programme 'devplo' (http://www.raymondm.co.uk); (III) MS London, British Library, Cotton Vespasian A.II, fol. 3r; (IV) MS M, fol. 93r; (V) PEDERSEN [1983, p. 336]; (VI) MS Erfurt, Bibliotheca Amploniana, 4° 370, fol. 2r. Both for this table and for Tabs 2 and 3 below, I have silently emended obvious scribal errors in the manuscripts.
15. An error seems likely if we consider that the canons explicit state "quod dies incipiat a meridie preteriti diei et terminetur in medio sui" (MS London, British Library, Cotton Vespasian A.II, fol. 2ra).
16. The tables in question are edited by PEDERSEN [2002, pp. 1147–48, 1154–55]. The slight differences that exist between them and the syzygy tables are explained in TOOMER [1968, pp. 80–81].
17. MS Erfurt, Bibliotheca Amploniana, 4° 370, fol. 1v: "Hoc kalendarium est factum <in> Dist in Brabantia, cuius latitudo est 50 graduum et 58 minutorum. Meridies autem eius precedit meridiem Parisiensem fere per dimidiam horam, sicut per eclipses ibidem et Parisius observantes inveni." The calendar follows on fols. 2r–7v. For what little is known about Alard of Diest, see ZINNER [1951] and VERCAUTEREN [1951, pp. 87, 90].
18. Parts of this letter were transcribed by MEYER [1897, pp. 236–237] and THOMAS [1921a, pp. 625–626], but the work still awaits proper study.
19. See the study and edition in HARPER [1966]. Further MSS are noted in PEDERSEN [1983, pp. 325, 419]. The new moon data were excerpted separately into the calendar contained in MS Utrecht, Universiteitsbibliotheek, 722, fols. 37r–42v, which is the one mentioned by VAN WIJK [1936, p. 41]. On William of Saint-Cloud, see also MILLÀS [1943–1950, pp. 392–394], POULLE [1976].
20. Other copies are found in MSS Erfurt, Bibliotheca Amponiana, 4° 369, fols. 6r–14v; 4° 381, fols. 40v–41r (canons only, incomplete); Los Angeles, J. Paul Getty Museum, Ludwig XII.6, fols. 1r-11r; Paris, Bibliothèque nationale de France, lat. 7281, fols. 160v–63r (without calendar part); lat. 15118, fols. 67r–75v; Toledo, Archivo y Biblioteca Capítulares, 99–5, fols. 13v–25v; Uppsala, Universitetsbibliotek, C 653, fols. 189r–97r. On Geoffrey of Meaux, see THORNDIKE [1934, pp. 281–293].
21. See the list of Alfonsine meridians in KREMER & DOBRZYCKI [1998, p. 194], and the specimen of John of Lignères's syzygy tables printed in PEDERSEN [2002, p. 1349]. The final leaves of MS M (fols. 100r–5v) contain John's explanatory canons on how to use the universal astrolabe or *saphea Arzachelis*, an instrument first described by Azarquiel in the eleventh century.
22. The presence of this work in MS M was overlooked by DE BARCELONA [1933], CORDOLIANI [1955, p. 193], and DE CASTRO [1973], who all treat fols. 15r–88v as part of the earlier tables by Geoffrey of Meaux and John of Lignères.

23. Another example worth mentioning is the calendar for 1311–1386 found in MS Erfurt, Bibliotheca Amploniana, 4° 362, fols. 63r–69v, which was made in 1313 by an anonymous Premonstratensian monk. See ZINNER [1925, pp. 172 (no. 5331), 445] and PEDERSEN [1983, pp. 225, 420].
24. See, e.g., the calendar by Alard of Diest, in MS Erfurt, Bibliotheca Amploniana, 4° 370, fol. 1r: "Adde super diem et horam coniunctionis 7 dies et horas 9 et habebis primam quadraturam lune. Adde super dictum diem et horam 14 dies et horas 18 et habebis oppositionem solis et lune. Adde 22 dies et duas horas et invenies secundam quadraturam."
25. The table in MS P, fol. 71r, omits the first line for the *sextilis primus*.
26. MS Paris, Bibliothèque de l'Arsenal, 2872, fols. 62ra–b: "Et entre les autres auctors le quel soufisamment et non superflue, legierement et exemplairement traicta du soleil et de la lune, tant quant a mire en appartient, fu maistre Estienne Arblant, le quel fu compilaire de ceste *Roe*, de la quelle exposicion, en l'aide de Dieu devant mise, de chascune entend a bailler en lettres. Et di bien 'compilaire', quar il ne fit pas le kalendrier, mais le fit frere Raymon Bancal, de l'Ordre des Meneurs. Et le remanent fist le devant dit maistre Estienne en son *Quadran*. Et en ceste figure le compila." A colour PDF of the entire manuscript is available online: http://gallica.bnf.fr/ark:/12148/btv1b60002894.r=arsenal+2872.
27. Ibid., fol. 64rb: "Ci deffaut le kalendier susdit; ci recourez au kalendier la Royne." See ibid., fols. 1r–6v (calendar), 7r–21v (canons). The canons on fols. 7r–21v were transcribed by HARPER [1966, pp. 182–239]. Another copy is found in MS Rennes, Bibliothèque Municipale, 593, fols. 1r–8v (marked for the year 1304). See BOUDET [2011].
28. MS Paris, Bibl. de l'Arsenal, 2872, fols. 62vb: "En l'an present se compte par la incarnacion Mil CCCXXXV, des quiuels se on oste mil CCCX, demoureront XXV, pour quoy sera le VI^e an du secont cercle."
29. Ibid., fol. 63ra: "Et aussi devons savoir que l'acteur de ce kalendrier fait une Roe petite la quelle se compte a savoir en ceste Roe la quantite du iour artificial. Et est tout mis en ceste Roue de chascun mois XXX iours, c'est assavoir le X^e, le XX^e et le dernier de puis trouveras le compte des heures et des minus de ce iour. Et se est vray a Toulouze."
30. This length can be inferred from the entry for 11 June, which has 15h 29m. According to the Toledan Tables, the summer solstice in 1311 fell on 15 June. Given the slow change around the solstices, the day-length would not have increased by more than a minute over these four days.
31. MS P, fol. 46va: "Explicit lectura compoti manualis edita Toloze Anno Domini M° CCC° XXXII." See MEYER [1897, p. 227], THORNDIKE [1949, p. 75; 1954, p. 234], and NOTHAFT [2014a, pp. 231, 241, n. 41].
32. Other relevant names are 'D. Bancal(s)', documented in 1237, 1246, 1253 [VERLAGUET, 1918–1925, pp. 403, 584, 589], a 'dompnus G. Bancals, major cellerarius dicte domus', documented in 1267 [VERLAGUET, 1918–1925, p. 603], and the sacristan 'Guillermus Bancals', documented in 1280 [VERLAGUET, 1918–1925, p. 260].
33. One may also refer to the 19-year calendar using 'true' new moons that prefaces the *Catalan Atlas* of Abraham Cresques (1375). It is discussed by SAMSÓ & CASANOVAS [1975, pp. 31–34], and SAMSÓ [2005].

BIBLIOGRAPHY

ALBUQUERQUE, L.M. de (1961) *Os almanaques portugueses de Madrid*. Coimbra, Junta de Investigações do Ultramar.

BARCELONA, M. de (1933) "Notes descriptives dels manuscrits franciscans medievals de la Biblioteca Nacional de Madrid". *Estudis franciscans*, *45*, 337-398.

BOADAS I LLEVAT, A. & MARTÍ I MAJOR, J. (1998) "Bancal, Ramon". En: *Diccionari d'història eclesiàstica de Catalunya*. Vol. 1. [Barcelona], Generalitat de Catalunya, 190.

BOFFITO, G. & MELZI D'ERIL, C. (eds.) (1908) *Almanach Dantis Aligherii sive Profhacii Judaei Montispessulani Almanach perpetuum ad annum 1300 inchoatum, nunc primum editum ad fidem Codicis Laurentiani (Pl. XVIII sin. N. 1)*. Florence, Olschki.

BORST, A. (1998) *Die karolingische Kalenderreform*. Hannover, Hahn.

BORST, A. (2001) *Der karolingische Reichskalender und seine Überlieferung bis ins 12. Jahrhundert*. Hannover, Hahn, 3 vols.

BOUDET, J.-P. (1994) *Lire dans le ciel: la bibliothèque de Simon de Phares, astrologue du XV^e^ siècle*. Brussels, Centre d'Études des Manuscrits.

BOUDET, J.-P. (2011) "Guillaume de Saint-Cloud, *Kalendarium regine*, XIII^e^ s." En: C. Galderisi (ed.) *Translations médiévales: cinq siècles de traductions en français au Moyen Âge (XI^e^-XV^e^ siècles)*. Vol. 2.1. Turnhout, Brepols, 524-525.

BOUDET, J.-P. & HUSSON, M. (2012) "The Earliest Astronomical Tables in French (*c.* 1271)". *Journal for the History of Astronomy*, *43*, 287-298.

CAREY, H.M. (2004) "Astrological Medicine and the Medieval English Folded Almanac". *Social History of Medicine*, *17*, 345-363.

CASTELLANO I TRESSERRA, A. (1998) *Pedralbes a l'edat mitjana: història d'un monestir femení*. Barcelona, Publicacions de l'Abadia de Montserrat.

CASTELLANO I TRESSERRA, A. (2014) "El projecte fundacional del monestir de Santa Maria de Pedralbes i el palau de la Reina Elisenda de Montcada a través de dos inventaris del 1364". *Anuario de estudios medievales*, *44(1)*, 103-139.

CASTRO, M. de (1968) "Necrologio del monasterio de Sta. M.ª de Pedralbes (s. XIV)". *Hispania sacra*, *21*, 391-427.

CASTRO, M. de (1973) *Manuscritos franciscanos de la Biblioteca Nacional de Madrid*. Valencia, Soler.

CÁTEDRA, P.M. (ed.) (1983) *Tratado de astrología atribuido a Enrique de Villena*. Barcelona, Editorial Humanitas.

CHABÁS, J. & GOLDSTEIN, B.R. (2003) *The Alfonsine Tables of Toledo*. Dordrecht, Kluwer.

CHABÁS, J. & GOLDSTEIN, B.R. (2012) "John of Murs Revisited: The *Kalendarium Solis et Lune* for 1321". *Journal for the History of Astronomy*, *43*, 411-437.

CHABÁS, J.; Roca, A & Rodríguez, X. (1992) *L'astronomia de Jacob ben David Bonjorn*. Barcelona, Institut d'Estudis Catalans.

CHABÀS, J. & Roca, A. (1998) "Early Printing of Astronomy: The *Lunari* of Bernat de Granollachs". *Centaurus*, *40*, 124-134.

CHABÁS, J. (1996a) "Astronomía andalusí en Cataluña: las Tablas de Barcelona". En: J. Casulleras y J. Samsó (eds.) *From Baghdad to Barcelona*. Vol. 1. Barcelona, Instituto "Millás Vallicrosa" de Historia de la Ciencia Arabe, 477-525.

CHABÁS, J. (1996b) "El almanaque perpetuo de Ferrand Martines (1391)". *Archives internationales d'histoire des sciences*, *46*, 261-308.

CHABÁS, J. (2000) "'Lo compta de la Luna': lunarios medievales". En: J. Batlló Ortiz, P. de la Fuente Collell y R. Puig Aguillar (eds.) *Actes de les V Trobades d'història de la ciència i de la tècnica (Roquetes, 11-13 desembre 1998)*. Barcelona, Societat Catalana d'Història de la Ciència i de la Tècnica, 335-341.

CHABÁS, J. (2004) "L'activitat astronòmica a l'època del rei Pere (segle XIV)". En: J. Vernet y R. Parés (eds.) *La ciència en la història dels Països Catalans*, vol. 1, *Dels Àrabs al Renaixement*. Valencia, Institut d'Estudis Catalans, 483-514.

CHABÁS, J. (2012) "The Toledan Tables in Castilian: Excerpts of the Planetary Equations". *Suhayl*, *11*, 179-188.

CIFUENTES I COMAMALA, L. (2002) *La ciència en català a l'Edat Mitjana i el Renaixement*. Barcelona, Publicacions de la Universitat.

CONTINI, G. (ed.) (1940) *Un poemetto provenzale di argomento geomantico*. Fribourg, Libraire de l'Université.

CORDOLIANI, A. (1952) "Les manuscrits de comput ecclésiastique de la Bibliothèque Capitulaire de Tolède". *Revista de Archivos, Bibliotecas y Museos*, *58*, 323-352.

CORDOLIANI, A. (1954) "Inventaire des manuscrits de comput ecclésiastique conservés dans les bibliothèques de Madrid (1^{e} série)". *Hispania Sacra*, *7*, 111-143.

CORDOLIANI, A. (1955) "Les manuscrits de comput ecclésiastique des bibliothèques de Madrid (2ème série)". *Hispania sacra*, *8*, 177-208.

EBNETER, T. (ed.) (1955) *Poème sur les signes géomantiques en ancien provençal: publié d'après le manuscrit unique de la Bibliothèque Nationale de Paris*. Olten, Graf.

FITA, F. (1895) "El monasterio de Santa Clara en Barcelona: Bulas inéditas de Alejandro IV, Urbano IV, Clemente IV, Bonifacio VIII y Juan XXII". *Boletín de la Real Academia de la Historia*, *27*, 436-489.

FITA, F. (1896) "El monasterio de Santa Clara en Barcelona". *Boletín de la Real Academia de la Historia*, *28*, 54-62.

GÁL, G. & FLOOD, D. (eds.) (1996) *Nicolaus Minorita: Chronica*; *Documentation on Pope John XXII, Michael of Cesena and the Poverty of Christ with Summaries in English: A Source Book*. St. Bonaventure (NY), Franciscan Institute Publications,

GOLDSTEIN, B.R. (2003) "Ancient and Medieval Values for the Mean Synodic Month". *Journal for the History of Astronomy*, *34*, 65-74.

GONZÁLEZ I BETLINSKI, M. & RUBIÓ I RODON, A. (1982) "La Regla de L'Orde de Santa Clara de 1263, un cas concret de la seva aplicació: el monestir de Pedralbes de Barcelona". *Acta historica et archaeologica mediaevalia*, *3*, 9-46.

HARPER, R.I. (1966) *The* Kalendarium Regine *of Guillaume de St.-Cloud*. PhD Diss., Emory University.

KALTENBRUNNER, F. (1876) "Die Vorgeschichte der gregorianischen Kalenderreform". *Sitzungsberichte der philosophisch-historischen Classe der kaiserlichen Akademie der Wissenschaften*, *82*, 289-414.

KREMER, R.L. & Dobrzycki, J. (1998) "Alfonsine Meridians: Tradition versus Experience in Astronomical Practice c. 1500". *Journal for the History of Astronomy*, *29*, 187-199.

LAGUARDA TRÍAS, R.A. (1964) "La declinación solar en las tablas astronómicas de don Pedro el Ceremoniso". *Sefarad*, *24*, 111-120.

LINDHAGEN, A. (1916) "Die Neumondtafel des Robertus Lincolniensis". *Arkiv för Matematik, Astronomi och Fysik*, *11(2)*, 1-41.

LITTLE, A.G. (1892) *The Grey Friars in Oxford*. Oxford, Clarendon Press.

LITTLE, A.G. (1914) "Roger Bacon's Works: With References to the MSS. and Printed Editions." En: A.G. Little (ed.) *Roger Bacon*. Oxford, Clarendon Press, 375-425.

LOHR, A. (ed.) (2013) *Der Computus Gerlandi: Edition, Übersetzung und Erläuterungen*. Stuttgart, Steiner.

MEYER, P. (1897) "Traités en vers provençaux sur l'astrologie et la géomancie". *Romania*, *26*, 225-275.

Millàs i Vallicrosa, J.M. & Faraudo de Saint-Germain, L. (1948) “Textos astronòmics en un manuscrit català medieval”. *Boletín de la Real Academia de Buenas Letras de Barcelona*, *21*, 143-162.

Millàs i Vallicrosa, J.M. (1935) “Manuscrits catalans de caràcter astronòmic a la Biblioteca Nacional de Madrid”. *Analecta Sacra Tarraconensia*, *11*, 279-289.

Millàs i Vallicrosa, J.M. (1943-50) *Estudios sobre Azarquiel*. Madrid, CSIC.

Millàs i Vallicrosa, J.M. (1949) *Estudios sobre historia de la ciencia española*. Barcelona, CSIC.

Millàs i Vallicrosa, J.M. (1962) *Las Tablas astronómicas del Rey Don Pedro el Ceremonioso*. Barcelona, CSIC.

Moreton, J. (1995) “Before Grosseteste: Roger of Hereford and Calendar Reform in Eleventh- and Twelfth-Century England”. *Isis*, *86*, 562-586.

Moreton, J. (2003) “On Not Editing Grosseteste”. En: E.A. Mackie y J. Goering (eds.) *Editing Robert Grosseteste*. Toronto, University of Toronto Press, 167-184.

Neugebauer, O. (1989) “From Assyriology to Renaissance Art”. *Proceedings of the American Philosophical Society*, *133*, 391-403.

North, J. D. (1983) “The Western Calendar—‘Intolerabilis, Horribilis, et Derisibilis’: Four Centuries of Discontent”. En: G. V. Coyne, M. A. Hoskin y O. Pedersen (eds.) *Gregorian Reform of the Calendar.* Vatican City, Specola Vaticana, 75-113.

Nothaft, C.P.E. (2014a) “John of Pulchro Rivo and John of Saxony: A *Mise au point*”. *Journal for the History of Astronomy*, *45(2)*, 227-42.

Nothaft, C.P.E. (2014b) *Medieval Latin Christian Texts on the Jewish Calendar*. Leiden, Brill.

Pedersen, F.S. (ed.) (1983) *Petri Philomenae de Dacia et Petri de S. Audomaro Opera quadrivialia*. Vol. 1. Copenhagen, Gad.

Pedersen, F.S. (ed.) (2002) *The Toledan Tables: A Review of the Manuscripts and the Textual Versions with an Edition*. Copenhagen, Reitzel, 4 vols.

Pedersen, F.S. (2014) “William of Saint-Cloud: *Almanach Planetarum*”. *Cahiers de l’Institut du Moyen-Âge Grec et Latin*, *83*, 1-133.

Porres, B. & Chabás, J. (2001) “John of Murs’s *Tabulae permanentes* for Finding True Syzygies”. *Journal for the History of Astronomy*, *32*, 63-72.

Poulle, E. (1966) “À propos des tables astronomiques de Pierre d’Aragon”. *Revista da Faculdade de Ciências (Coimbra)*, *39*, 5-15.

Poulle, E. (1973) “John of Lignères”. En: C.C. Gillispie (ed.) *Dictionary of Scientific Biography*. Vol. 7. New York, Charles Scribner’s Sons, 122-128.

Poulle, E. (1976) “William of Saint-Cloud”. En: C C. Gillispie (ed.) *Dictionary of Scientific Biography*. Vol. 14. New York, Charles Scribner’s Sons, 389-391.

Poulle, E. (2005) “Les astronomes parisiens au XIV^{e} siècle et l’astronomie alphonsine”. En: *Histoire littéraire de la France*. Vol. 43.1. Paris, Diffusion de Boccard.

Rubió i Lluch, A. (1908) *Documents per l’història de la cultura mig-eval*. Vol. 1. Barcelona, Institut d’Estudis Catalans.

Ryan, M.A. (2011) *A Kingdom of Stargazers: Astrology and Authority in the Late Medieval Crown of Aragon*. Ithaca (NY), Cornell University Press.

Samsó, J. (1987) “Al-Zarqāl, Alfonso X and Peter of Aragon on the Solar Equation”. En: D.A. King y G. Saliba (eds.) *From Deferent to Equant*. New York, The New York Academy of Sciences, 467-476.

SAMSÓ, J. (1994) "Las ciencias exactas y físico-naturales". En: J.Á. García de Cortázar (ed.) *La época del gótico en la cultura española (c. 1220-c. 1480)*. Madrid, Espasa Calpe, 555-593.

SAMSÓ, J. (2005) "Una concepció de l'Univers". En: *El món i els dies: l'atles català, 1375*. Barcelona, Enciclopèdia Catalana, 44-56.

SAMSÓ, J. & CASANOVAS, J. (1975) "Cosmografia, astrologia i calendari". En: *L'Atlas Català de Cresques Abraham: primera edició en el sis-cents aniversari de la seva realització 1375-1975*. Barcelona: Diàfora, 23-36.

SANTANACH I SUÑOL, J. (2003) "El *Còdex Miscel·lani* de l'Arxiu de les Set Claus (Andorra la Vella, Arxiu Històric Nacional)". *Anuario de estudios medievales*, *33*, 417-462.

THOMAS, A. (1921a) "Pierre Vidal, frère prècheur, astronome". En: *Histoire littéraire de la France*. Vol. 35. Paris, Imprimerie Nationale, 624-627.

THOMAS, A. (1921b) "Raimond Bancal, frère mineur, astronome". En: *Histoire littéraire de la France*. Vol. 35. Paris, Imprimerie Nationale, 627-628.

THOMAS, A. (1921c) "Maître Étienne Arblant, astronome". En: *Histoire littéraire de la France*. Vol. 35. Paris, Imprimerie Nationale, 628-629.

THOMSON, S.H. (1940) *The Writings of Robert Grosseteste, Bishop of Lincoln 1235-1253*. Cambridge, University Press.

THORNDIKE, L. (1934) *A History of Magic and Experimental Science*. Vol. 3. New York, Columbia University Press.

THORNDIKE, L. (1949) *The* Sphere *of Sacrobosco and Its Commentators*. Chicago, The University of Chicago Press.

THORNDIKE, L. (1954) "Computus". *Speculum*, *29*, 223-238.

TOOMER, G.J. (1968) "A Survey of the Toledan Tables". *Osiris*, *15*, 5-174.

TOOMER, G.J. (1973) "Prophatius Judaeus and the Toledan Tables". *Isis*, *64*, 351-355.

VAN WIJK, W.É. (1936) *Le Nombre d'Or: étude de chronologie technique suivie du texte de la Massa compoti d'Alexandre de Villedieu*. The Hague, Nijhoff.

VELA PALOMARES, S. (1997) *Tencar: una miscellània d'astrologia del s. XV, a Andorra*. Andorra la Vella, Consell General d'Andorra.

VERCAUTEREN, F. (1951) "Les médecins dans les principautés de la Belgique et du nord de la France, du VIII^{e} au XIII^{e} siècle". *Le Moyen Âge*, *57*, 61-92.

VERLAGUET, P.A. (1918-1925) *Cartulaire de l'Abbaye de Bonnecombe*. Vol. 1. Rodez, Carrère.

VERNET, J. & SAMSÓ, J. (2004) "La ciència i la tècnica als Països Catalans durant la baixa edat mitjana." En: J. Vernet y R. Parés (eds.) *La ciència en la història dels Països Catalans*. Vol. 1. Valencia, Institut d'Estudis Catalans, 251-267.

WALLIS, F. (1995) "Medicine in Medieval Calendar Manuscripts". En: M.R. Schleissner (ed.) *Manuscript Sources of Medieval Medicine: A Book of Essays*. New York, Garland, 105-143.

WORDSWORTH, C. (1904) *The Ancient Kalendar of the University of Oxford*. Oxford, Clarendon Press.

WRIGHT, J.K. (1925) *The Geographical Lore of the Times of the Crusades*. New York, American Geographical Society.

ZINNER, E. (1925) *Verzeichnis der astronomischen Handschriften des deutschen Kulturgebietes*. Munich, Beck.

ZINNER, E. (1951) "Magister Alard von Diest und die Pariser Beobachtungen von 1312-15". *Isis*, *42*, 38-40.