

## “Reiterative Calendars in Medieval and Early Modern Jewish Manuscripts”<sup>1</sup>

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By the early 10th century, a system of calendar reckoning had emerged in the Rabbinic Jewish centres of the Near East that became diffused very widely among the Jewish communities and is now universally accepted as the basis of the Jewish calendar. This system is based on a complex arithmetic calculation that must be performed regularly and requires knowledge and numerical expertise. An alternative way of setting the Jewish calendar existed alongside the standard calculation until the end of the Middle Ages and into the early-modern period. This system assumes that the Jewish calendar fully repeats itself every 247 years, so that a calendar can be calculated once and re-used indefinitely. This cycle is not fully compatible with the standard Rabbinic calendar but diverges in a small number of years every century.

The use of two incompatible systems of calendar reckoning could lead to calendar differences between Jewish communities, and is significant for the study of the standardisation of the Jewish calendar. Although various aspects of the 247-year cycle have received attention in the works of historians of the Jewish calendar,<sup>2</sup> no comprehensive study exists that would take into account the calendrical as well as the social aspects of using this calendar. The present article is an outcome of my research on 247-year Jewish calendar cycles in the framework of the ERC Advanced Grant project “Calendars in Late Antiquity and the Middle Ages: Standardization and Fixation” that ran at UCL between 2013–2018.<sup>3</sup> In this project, I collected and analysed a corpus of over two hundred medieval and early-modern sources in Hebrew, Judaeo-Arabic, Latin and Samaritan Hebrew that either contain or discuss 247-year calendars (see Appendix 2). This corpus includes prayer books, Bibles, halakhic works, self-standing calendar treatises and scientific compendia.

The compiled corpus sheds light on the following research questions related to the cycle and its effects on the standardization of calendars in the Middle Ages:

- What are the origins of the 247-year cycle?
- How were 247-year calendars produced: were they copied by scribes from master copies, or each time freshly calculated and designed? How different were they from one another? How different were they from calculated calendars?
- What were the attitudes of scholars and rabbinic leaders towards the use of the 247-year

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2 On the 247-year cycle see Yosef Tobi, *The Jews of Yemen. Studies in Their History and Culture* (Leiden: Brill, 1999), 211–26. Hayyim Yehiel Bornstein, “Divre yeme ha-ibbur ha-aharonim, heleq aleph” (Hebrew), *Ha-Tequfah* 14–15 (1934, 3rd edition): 321–72, esp. 354–58. Hayyim Yehiel Bornstein, *Mahloqet Rav Saadia Gaon and Ben Meir* (Hebrew) (Warsaw, 1904), 141–44. Nadia Vidro, “The origins of the 247-year calendar cycle,” *Aleph* 17, no. 1 (2017): 95–137. Eran Raviv, *Mathematical Studies in the Hebrew Calendar* (unpublished PhD thesis, Bar Ilan University, 2015), 53–111.

3 On this project see <https://www.ucl.ac.uk/hebrew-jewish/research/research-projects/calendars-late-antiquity-and-middle-ages-standardization-and-fixation-0>, consulted on 28/02/2018.

cycle and its potential for calendar diversity?

- Were 247-year cycles used in practice? Did the use of these cycles lead to calendar diversity between different Jews or Jewish communities?
- Did calendar disputes occur due to the use of the 247-year cycle? Were they settled in favour of the 247-year cycle or the normative calculation?

The present article is structured as follows. In the main body of the article I attempt to answer the outlined questions on the basis of the full corpus of assembled sources. In Appendix 1, I describe 247-year cycles as they are found in manuscripts and printed sources from different geo-cultural areas. Appendix 2 lists manuscript sources used in the project.

#### The 247-year calendar cycle, its origins and history

In the Rabbinic calendar years can be of fourteen different types. The type of a year depends on three variables: the day of the week of Rosh Hashanah, the length of the variable months Marḥeshvan and Kislev, and the number of months in that year.<sup>4</sup> Rosh Hashanah may fall on a Monday, Tuesday, Thursday or Saturday. The pair of months Marḥeshvan and Kislev can be ‘defective’ (both have 29 days), ‘regular’ (Marḥeshvan has 29 days and Kislev 30 days) or ‘full’ (both have 30 days). A Jewish year can have 12 months and be ‘plain’ or can have 13 months and be ‘intercalated’. The inclusion or not of this additional 30-day intercalary month is a function of the 19-year cycle of intercalations in which 12 years have 12 months and seven years have 13 months. The permutations of these three variables fully determine the course of a Jewish year. Only 14 such combinations are permitted, and to set a calendar for a particular year ultimately means to establish which of the 14 types will apply to it.

In the standard calendar the type of a year is established by calculating *moladot* (mean conjunctions) of a number of years and applying various other rules, a cumbersome procedure that requires knowledge and significant numerical abilities. It would ease the setting of the calendar if the calculation could be replaced by a calendar cycle, established once and used forever. In the standard calendar, different types of year occur in a sequence which does not repeat itself exactly until it has run for 689,472 years. This period is obviously too long to serve as a cycle in practice. Of more practical value is the period of 247 years, after which the Rabbinic calendar repeats itself almost exactly: if a sequence of year types for 247 years is re-used for the following 247 years, it will deviate from a calendar calculated for these next 247 years in two to seventeen years only.<sup>5</sup> If the sequence is reused again, such “reiteration errors” accumulate widening the gap between the standard calendar and the 247-year cycle. The approximate nature of the 247-year cycle was known already in the 12th century.<sup>6</sup> Nonetheless, many medieval and early-modern Jewish sources

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4 For a detailed explanation of the workings of the Jewish calendar see Rahamim Sar-Shalom, *Gates to the Hebrew Calendar* (Hebrew) (Netanyah: R. Sar-Shalom, 1984), esp. 52, 131–40.

5 On the accuracy of the 247-year cycle see Raviv, *Mathematical Studies*, 57–62.

6 See, for example, Abraham Ibn Ezra’s critique of the 247-year cycle in *Shalosh She’elot* (Moritz Steinschneider, *Sefer Shene ha-Me’orot* (Berlin: Zaretsanski, 1846), 1). For another 12th century critique see Vidro, “Origins,” 124–26.

include 247-year calendars that claim to accurately repeat themselves forever (*hozer halilah*) with no mistakes.

The 247-year cycle is best known in research literature under the title *'Iggul* of R. Naḥshon Gaon, attributed to Naḥshon ben Zadok, head of the Academy of Sura in the second half of the ninth century, ca. 865–873.<sup>7</sup> However, studies of extensive corpora of calendar literature demonstrate that the cycle was unknown in the 9th century.<sup>8</sup> The 247-year cycle is not mentioned in in-depth discussions of calendar procedures in the correspondence relating to the Saadia–Ben Meir dispute (921–922),<sup>9</sup> and is equally absent from Abū Rayḥān al-Bīrūnī's comprehensive and well-informed section on the Jewish calendar in his work *The Chronology of the Ancient Nations* completed in 1000.<sup>10</sup> The earliest traceable 247-year cycles appear to have been put together in the middle of the 10th century, between mid 920s and early 980s.<sup>11</sup> The cycle may have been devised in the aftermath of the Saadia–Ben Meir dispute. In this dispute small differences in the calendar calculation traditions of Babylonia and Palestine caused a major rift between the two communities. It became clear that following a calculated calendar did not guarantee calendar unanimity. Under these circumstances, the 247-year calendar cycle may have been proposed as an alternative for the standard calendar that was capable of preventing future calendar dissidence by establishing an unchangeable sequence of year types and eliminating the need for calculation.<sup>12</sup> Had it been accepted, it would have been a relatively accurate luni-solar calendar that could have served the Jewish community almost as well as the *molad* calculation: the cycle is only slightly less astronomically accurate than the normative calculation,<sup>13</sup> and does not violate any of the basic Rabbinic calendation principles.<sup>14</sup> Instead, the 247-year cycle came to be regarded not as a replacement for the standard calendar but as an easy means of setting it, used alongside the more demanding calculation.

The earliest 247-year calendars, in Oriental manuscripts, are attributed to Josiah b. Mevorakh (ibn) al-ʿĀqūlī, a scholar of Babylonian descent. He is best known in connection

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7 The precise dates of Naḥshon Gaon's incumbency are controversial, the above given dates follow Robert Brody, *The Geonim of Babylonia and the Shaping of Medieval Jewish Culture* (New Haven, London: Yale University Press, 1998), 344.

8 Raviv, *Mathematical Studies*, 63, 86; Vidro, "Origins".

9 Here and in the following, all dates are CE unless otherwise specified.

10 On the Saadia–Ben Meir calendar dispute see Stern, *Calendar and Community*, 264–75. Bornstein, *Dispute*. Marina Rustow, Sacha Stern, "The Jewish Calendar Controversy of 921–22: Reconstructing the Manuscripts and their Transmission History," in *Time, Astronomy, and Calendars in the Jewish Tradition*, eds Sacha Stern, Charles Burnett (Leiden: Brill, 2014), 79–95. For Al-Bīrūnī, see Abū Rayḥān al-Bīrūnī, *The Chronology of Ancient Nations* 7; trans. C. Edward Sachau (London: published for the Oriental Translation Fund of Great Britain & Ireland by W.H. Allen & Co., 1879), 141–175. I thank Sacha Stern and François de Blois for drawing my attention to these sources' silence on the 247-year cycle.

11 See Appendix 1, *Oriental* and Vidro, "Origins," 120–22.

12 We can find a parallel for this concept in the Christian calendar, where the establishing of an Easter cycle not only permitted Easter to be determined for many years in advance, but also diminished the possibility of conflicts over the correct date and allowed communities in different parts of the world to celebrate Easter at the same time. See Wallis, F., *Bede: The Reckoning of Time* (Liverpool: Liverpool University Press, 1999), xx.

13 The normative Rabbanic calendar assumes a slightly excessive lunation, i.e. the *molad* occurs slightly later than the mean conjunction. As a result, the *molad* calculation falls behind the moon by about 25 minutes in 247 years. The 247-year cycle falls behind the moon by about 1 hour and 15 minutes (Sacha Stern, personal communication; see also Bornstein, "Divre yeme ha-ibbur", 356).

14 Such as the rule *lo ADU Rosh* that specifies that Rosh Hashanah may not fall on Sunday, Wednesday and Saturday and similar rules.

with the calendar cycle but may have also authored Bible commentaries, one of them preserved in a 1009 Genizah manuscript, at which time he was still alive.<sup>15</sup> The attribution of the cycle to Naḥshon Gaon first appears in late 12th century Ashkenazi sources and is attested in only about one third of the examined corpus.<sup>16</sup> It is predominantly Ashkenazi but is also relatively frequent in Italian manuscripts; it is rare in Sefardi, Provencal and Oriental manuscripts, and does not occur in Byzantine, Samaritan and Latin sources known to me. Clearly pseudo-epigraphical, the attribution of the 247-year cycle to Naḥshon Gaon, a high-ranking Rabbinic leader, must have been introduced as a means of adding authority to a deviant but convenient way of setting the calendar. It is for the same reason that in some Ashkenazi manuscripts Hayye Gaon and Sherira Gaon are said to have verified the 247-year calendar's cyclicity.<sup>17</sup> In contrast, Josiah b. Mevorakh's authorship of the reiterative calendar appears to be historical because his name would not add weight to the scheme.

The reiterative calendar is most commonly found in primary sources under the titles *Thirteen Cycles* (*maḥzorim*), *Thirteen Rows* (*shurot*) or *The 247(-year) Cycle* (*maḥzor remez*).<sup>18</sup> In Oriental manuscripts, titles like *The Big Cycle* (*maḥzor gadol* in Hebrew or *maḥzor kabīr* in Judaeo-Arabic), *The Revolving 247* (*al-remez al-dā'ir*) and *The Big Waterwheel-like Cycle* (*maḥzor gadol dūlābī*) are also found. The title 'iggul (lit. 'circle'), which is regularly used in secondary literature, is found in some sources that ascribe the cycle to Naḥshon, but is never given to reiterative calendars that are not attributed to the gaon.<sup>19</sup> For these reasons, the 247-year cycle is not referred to in this article as the 'iggul of R. Naḥshon.

Although calendrical and historical considerations indicate that the 247-year cycle was first put together in the middle of the 10th century, no 10th- and 11th-centuries copies of reiterative calendars survive.<sup>20</sup> In contrast, a number of early and mid 12th century cycles and discussions of the reiterative calendar exist, some in contemporary manuscripts, others in later copies. These sources are from many different geographical areas: Egypt and Maghreb, Byzantium, Provence, Ashkenaz.<sup>21</sup> This demonstrates that by the middle of the 12th century the cycle spread and became widely known. The cycle's later dissemination is reflected in the large number of preserved sources that either contain or discuss 247-year calendars. In my corpus of medieval and early-modern Jewish manuscripts on the 247-year

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15 Vidro, "Origins," 122–24.

16 See Nadia Vidro, "Naḥshon Gaon: Calendar scholar or pseudo-author," *Jewish Studies Quarterly* (forthcoming in 2018).

17 Oxford, Bodl. Opp. 614, fol. 50v (14th century, Ashkenazi), Cincinnati, HUC 436, fol. 191r (1435, Ashkenazi). See Vidro, 'Origins', 132–33.

18 The former two designations reflect the fact that 247 years can be represented as thirteen 19-year cycles of intercalations. See below, "The format of 247-year cycles", p. XXX.

19 A cognate term 'iggulot remez is used by Abraham Ibn Ezra who does not ascribe the cycle to Naḥshon Gaon (Steinschneider, *Sefer Shene ha-Me'orot*, 1).

20 A possible exception is a discussion of the reiterative calendar preserved in T-S Ar.29.135 and T-S Ar.29.3r, which are paleographically datable to the 11th–12th century.

21 For the Orient, see an early 12th century critique of the 247-year cycle (Vidro, "Origins," 124–26) and Oxford, Bodl. e.45/45-56, with a calendar starting in 1142; for Byzantium see Vatican, Biblioteca Apostolica ebr. 303, fol. 190v, with a calendar starting in 1142; for Provence see Abraham Ibn Ezra's critique of the 247-year cycle composed in Narbonne in ca. 1148 (Steinschneider, *Sefer Shene ha-Me'orot*, 1). For Ashkenaz, see Moscow, Guenzburg 481, fol. 102r, with a calendar starting in 1123 and Parma, Biblioteca Palatina Cod. Parm. 2295, fols 101v–103r, with a calendar starting in 1161.

cycle, there are 81 texts<sup>22</sup> in Ashkenazi hands, 61 in Oriental hands, 32 in Italian hands, 29 in Sefardi and Provençal hands and 4 in Byzantine hands. 247-year cycles are also included in many printed works on the Jewish calendar and law between the 15th–19th centuries. Apart from the Jews, the 247-year cycle was also known to Samaritans and to Christian scholars, which latter viewed it as a *vade mecum* of the calendar of the Old Testament and of Scriptural chronology.<sup>23</sup>

#### *Attitudes towards the cycle*

A range of opinions about the 247-year cycle are attested in the sources. About a fifth of the sources contain a calendar for 247 years but say nothing about its cyclicity or suitability for setting the Jewish calendar. Another fifth oppose the cycle. The remaining sources support the cycle and advocate its use.

The earliest known refutations of the 247-year cycle were written already in the first half of the 12th century, the same time when the cycle first became wide-spread.<sup>24</sup> Among well-known medieval scholars who criticised the cycle are Abraham ibn Ezra,<sup>25</sup> Isaac Israeli,<sup>26</sup> Profiat Duran<sup>27</sup> and Obadiah b. David, the author of the standard commentary on Maimonides' *Mishneh Torah, Sanctification of the Moon*.<sup>28</sup> In addition, anonymous refutations are found in medieval and early-modern manuscripts. All refutations are based on the following scientific argument: For a calendar cycle to work *molad* Tishri must recur exactly at the same time and on the same day of the week at the end of its cyclicity period. However, in the Rabbinic calculation *molad* Tishri of year  $n+247$  does not equal that of year  $n$  but is 905 parts smaller. This small difference has implications for *moladot* approaching calendrical limits. Take, for example, the limit of *molad zaqen* (i.e. 18 hours counted from 6pm). According to the rules of Rabbinic calendar, if *molad* of year  $n$  exceeds the limit of *molad zaqen*, this year will not start on the day of its *molad* but will be postponed. If, however, the excess is less than 905 parts, *molad* of year  $n+247$  being 905 parts less will fall below the limit of *molad zaqen*, the year will not be postponed, and the type of year  $n+247$  will not be the same as that of year  $n$  (in some years, the limit of the *molad* is earlier; an excess over the limit leads either to postponement or to other effects on the calendar type of the forthcoming year; this kind of limit can similarly lead to differences between years  $n$  and  $n+247$ ). The cycle's critics argued that if outdated calendar information is used in such years, it will differ from data determined by the *molad* calculation and will result in a violation of commandments, eating leavened bread on Passover and not fasting on the day

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22 A manuscript can contain more than one text on the reiterative calendar.

23 See Appendix 1, *Oriental* and *Latin* respectively.

24 See footnote 6.

25 Abraham ibn Ezra, *Shalosh She'elot* (1148, Narbonne), question 1 (Steinschneider, *Sefer Shene ha-Me'orot*, 1).

26 Isaac Israeli, *Yesod 'Olam* (1310, Toledo), book 4, section 10 (B. Goldberg and L. Rosenkranz, *Liber Jesod Olam* (Hebrew) (Berlin: Sumtibus editorum, 1848), 2 vols, 2:23).

27 Profiat Duran, *Heshev ha-Efod* (1395), chapter 22. On this unpublished work see M. Kozodoy, *The Secret Faith of Maestre Honoratus: Profayt Duran and Jewish Identity in Late Medieval Iberia* (Philadelphia, Pa.: University of Pennsylvania Press, 2015), 104–14.

28 Obadiah b. David, Commentary on *Sanctification of the Moon* (ca. 1340), chapter 8, halacha 10 (first printed in the the Amsterdam, 1702 edition of *Mishneh Torah*).

of Atonement. This line of argument very clearly shows that the 247-year cycle was opposed by scholars not because it was an astronomically bad calendar but because it deviated from the standard calculated calendar and was liable to disturb calendar unanimity, an important principle of Rabbanic calendar reckoning.<sup>29</sup>

The scientific critique of the cycle could not sway the public's opinion: 60% of the sources in my corpus consider the cycle a perfectly acceptable way of setting the calendar and advocate its use. The support for the 247-year cycle can be indicated through a simple *hozer ḥalilah* ("it repeats itself forever") or can be put more persuasively: "all Israel in all generations should follow this order (of year types), until a priest stands to Urim and Tummim (Neh 7:65)" (i.e. until the messianic times when empirical calendar will be used),<sup>30</sup> "one will find it correct without a shadow of a doubt,"<sup>31</sup> "until the earth endures, it will not cease (cf. Gen 8:22) and will not leave off from the mouth of the holy seed because it repeats itself forever."<sup>32</sup> Some people appear to have been aware that the 247-year cycle was not completely accurate but still considered it a good calendar since the few mistakes that it produces could be easily corrected.<sup>33</sup> Others erroneously assumed that the 247-year cycle deviated so rarely from the standard calculation that this would not happen before messianic times, when any kind of fixed calendar would be abolished and the empirical calendar restored.<sup>34</sup> One author went so far as to suggest that the 247-year cycle should be used in place of the empirical calendar even in messianic times "because the Almighty agrees with it".<sup>35</sup>

#### *The format of 247-year cycles*

In the sources, the cycle exists in two different formats: a calendar for a particular 247-year period and a cycle of remainders for any consecutive 247 years. 247-year cycles of both formats embody the same idea of a Jewish calendar that is reckoned once and reused forever with no mistakes. A classification of calendars according to their format helps to identify separate stages in the cycle's history and to uncover regional calendar writing trends.

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29 See Stern, *Calendar and community*, 241–244.

30 Moscow, RSL, Guenzburg 746, fol. 193r (Byzantine, 15th century): ועל הסדר הזה יתנהגו כל ישראל לדורי דורים עד: עמוד כהן באורים ותומים

31 T-S Ar.2.12r (Oriental, ca. 1181): יגדה צחיה בלא שך ולא ריב:

32 Oxford, Bodl. Canon Or. 1, fol. 81r (Ashkenazi, 14th century): עוד כל ימי הארץ לא ישבות ולא ישוב מפי זרע הקד[ש]: בגלל כי הוא חוזר חלילה

33 Paris, BnF heb. 642, fols 183v-184r (Sefardi or Provençal, 15th century): והוא מנה וקבע י"ג מחזורי' מי"ט שנים (He (R. Naḥshon) counted and fixed 13 cycles of 19 years that repeat themselves forever without many changes and those changes are easy to correct.)

34 Moscow, RSL, Guenzburg 481, fol. 102r (Ashkenazi, 15th century): והם חוזרין כן חלילה לעולם עד עמוד כהן לאורים (They repeat themselves forever until a priest stands to Urim and Tummim but with a small discrepancy. However, before this discrepancy occurs we will eat in Messianic times by the mercy of our Creator.)

35 Oxford, Bodl. 330, fol. 11r (Ashkenazi, 1559): ואפילו עמוד הכהן הגדול לאורים ותומים אין צריך לעדים על חידוש הלבנה: (Even when a priest stands to Urim and Tummim, there is no need for witnesses of the new moon because one should rely on the 'Iggul' of R. Naḥshon, peace be upon him, all the time that the sun and the moon are in existence, forever, because the Almighty agrees with it.)

### *Calendars for a particular 247-year period (dated tables)*

The most common format of the 247-year cycle is a table of nineteen columns over thirteen rows (or vice versa).<sup>36</sup> In such tables, each row represents one 19-year cycle of intercalations and each cell represents one year of that cycle and is filled with the calendrical type of the year it stands for. The tables are dated by numbering 19-year cycles, where cycle 1 stands for years 1–19 Anno Mundi (henceforth AM), cycle 2 for years 20–38 AM, and so on.<sup>37</sup> Individual years' dates are also occasionally given, by original scribes or by later users. Numbered 19-year cycles and dates clearly indicate which 247 years are covered by the table. Such dated calendars are attested in all Jewish geo-cultural areas and in Latin manuscripts.<sup>38</sup> They are sometimes anachronistically associated with R. Naḥshon Gaon.

Tables for a particular stretch of 247 years cannot be assumed cyclical unless explicitly stated. Their intended reiterativeness can be indicated by saying that the table repeats itself forever (*ḥozer ḥalilah*) or by giving instructions to go back to the first line and start using the table all over again.<sup>39</sup> In some tables, reiterativeness is signaled by noting 19-year cycle numbers for more than one iteration of the 247-year cycle.<sup>40</sup> To use a reiterative 247-year table in any given year, one must take that year's date and calculate its 19-year cycle and its number within that cycle. The cell that corresponds to the established 19-year cycle and year number contains the year type for the sought year. If the required 19-year cycle is not explicitly covered by the table, one must look for a cycle thirteen or a multiple of thirteen 19-year cycles earlier and take the data from there.

### *Cycles of remainders (undated calendars)*

Another attested format of the reiterative calendar are sequences of 247 year types that are not dated to specific years. In these calendars years are counted not from an established era (such as the era of Creation or the Seleucid era) but from an arbitrarily chosen epoch and are referred to by their position within the cycle, from 1 to 247. To calculate the position of a year in a 247-year cycle counted from any epoch, one must take that year's date according to the era with which the cycle operates and subtract from it the years of the epoch minus one. One must then calculate the remainder from casting out 247s from the obtained number. This remainder determines the position of the year in the 247-year cycle. For example, years 1 AM, 248 AM and 495 AM all correspond to year 1 of a 247-year cycle that takes the year of Creation as its epoch. Years 1006 SE, 1253 SE and 1500 SE are year 6 of the 247-year cycle with an epoch in 1001 SE. A reiterative calendar in the shape of a cycle of remainders specifies to which year type each remainder is assigned. In order to use this

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36 13x19=247.

37 Despite this dating system, tables never begin at 1 AM and only rarely at 1 AM *modulo* 247 (see Appendix 1, Latin).

38 Dated calendars for a particular 247-year period are not always tabular and can have a variety of other less common formats. Since the exact details of their layout are less important for the present article than the fact that they cover a particular set of thirteen 19-year cycles, I will refer to all such calendars as tables.

39 E.g., Oxford, Bodl., Opp. 59, fol. 164r (Ashkenazi, ca. 1308).

40 See, for example, Paris, BnF heb. 263, fol. 57v (Italian, 1480/1–1481/2), Cesena, Biblioteca Malatestiana Pluteo sinistro XXIX 4, fol. 3v (Sefardi, 14th century), Frankfurt, SUB Oct. 31, fols 38v–39r (Ashkenazi, 1662/3), Nicholas Trevet, *Comptus Hebreorum* (C.P.E. Nothaft, *Medieval Latin Christian Texts on the Jewish calendar: A study with five editions and translations* (Brill: Leiden, 2014), 363).

cycle in any given year, one must follow the algorithm described above, find the calculated remainder in the cycle of remainders and see to which of the fourteen year types this year is assigned.

The simplest cycle of remainders operates with dates from Creation and takes 1 AM as its epoch; the position of a year in this cycle equals its AM date *modulo* 247. Only descriptions of the algorithm associated with this cycle survive but no actual calendars.<sup>41</sup> Cycles of remainders that start from other epochs are common in Oriental and Italian manuscripts and are described in Appendix 1, *Oriental* and *Italian*.

It appears that cycles of remainders are the original format of the reiterative calendar, and tables for a particular set of thirteen 19-year cycles represent a later development. The earliest cycle of remainders was devised by Josiah b. Mevorakh (ibn) al-‘Āqūlī in the middle of the 10th century. In contrast, the earliest surviving dated table starts in 1123/4<sup>42</sup> and the earliest such table implied by the sources must have started in 1104/5.<sup>43</sup> This is not merely a corollary of the surviving manuscripts – calendar data in 247-year tables indicates that such tables did not exist before the 11th century. As can be seen in Table 1 below, the 247-year cycle deviates from the standard *molad* calculation in a number of years, so that using a reiterative calendar in these years will create mistakes. Significantly, reiteration errors in years between 984/5–1252/3 are never attested in the tables. Between 1252/3 and 1354/5 there are no errors either, but that is because in these years the cycle does not differ from the standard calculation.<sup>44</sup> But in 1354/5–1355/6 and later, reiteration errors are very common in the tables. This indicates that calendar data for years prior to and including 1005/6 (247 years earlier than 1252/3) was never incorporated in 247-year tables. Had there been 247-year tables that covered years before 1005/6, they would have left a trace in later tables in the form of reiteration errors reflecting the early year types. This leads to the conclusion that the first dated 247-year calendars must have been put together between 1006/7 and 1107/8 (which is 247 years earlier than 1354/5) or possibly 1104/5 (which is the estimated starting date of the earliest table implied by the sources). Cycles of remainders may have been re-formatted into dated tables for the sake of convenience, since an undated calendar is clearly less intuitive than a dated one. Parallels for this conjectured development may be found in some copies of the Oriental cycle of remainders, where pre-calculated remainders for a number of years are noted down in order to help

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41 I am aware of three sources, from different geo-cultural areas: T-S Ar.29.135 and T-S Ar.29.3r (Oriental, ca. 11th–12th century), Cambridge, Trinity College F 12 22, fol. 6v (Ashkenazi, 14th century) and Moscow, RSL, Guenzburg 365, fol. 163v (Provençal, 15th century).

42 Moscow, RSL, Guenzburg 481, fol. 102r (Ashkenazi, 15th century). The earliest fragmentary table of a similar format (Manchester, Rylands B 4471), which may or may not have covered the entire 247 years, takes 1048/9 as its starting point.

43 This is inferred from a marginal note in Munich, Cod. Hebr. 128, fol. 28r (Provençal, 15th century) that speaks of 19-year cycle 270 as the beginning of a next iteration of the 247-year cycle, indicating that its previous iteration started thirteen cycles earlier in the beginning of the 19-year cycle 257, i.e. 1104/5.

44 Reiteration errors would have been possible in 1276/7–1277/8 if year types for 782/3–783/4 (two 247-year periods earlier) were used in 1029/30–1030/31 (one 247-year period earlier) and then again in 1276/7–1277/8. This, however, is not attested in any surviving tables.



users find their position within the cycle,<sup>45</sup> and in an Italian manuscript where a part of a cycle of remainders has been converted into a dated calendar for years close to the time of copying.<sup>46</sup>

*The production of 247-year cycles*

A calendar for 247 years can be copied from an earlier *Vorlage* or can be freshly calculated. To determine how a calendar was produced, one must look at particular years that in the standard *molad* calculation are fixed differently from corresponding years 247 years earlier. A calendar copied from an earlier *Vorlage* will contain outdated year types, correct for 247 or a multiple of 247 years earlier, in years susceptible to reiteration errors; a calendar produced by a fresh calculation will have no such mistakes. Needless to say, all calendars, either copied or calculated, can have mistakes unrelated to the use of the 247-year cycle. These mistakes can be easily distinguished from reiteration errors since they usually apply to single years and generate random results that are incorrect in any iteration of a 247-year cycle. On the contrary, reiteration errors occur in groups of two to three consecutive years and produce year types that are incorrect in one iteration of the cycle but correct in another.

The earliest identifiable 247-year cycle, put together by Josiah b. Mevorakh, correctly represents the standard calendar for years 689/90–935/6.<sup>47</sup> In its further iterations the cycle deviates from the standard *molad* calculation in years specified in Table 1 (years in which the 247-year cycle is identical with the standard calculation are not included in the table). In this table, the first column shows how a year is fixed in Josiah b. Mevorakh’s 247-year cycle of remainders, which is identical with the standard calculation in the cycle’s first iteration. Columns 2–5 show how years 247 or a multiple of 247 years later are fixed in the standard calculation. Where the year types in columns 2–5 differ from those in column 1, reiteration errors can occur if data is copied from an earlier *Vorlage*.

*Table 1: Years when the 247-year cycle deviates from the standard calculation, given here up to the first quarter of the 20th century. Temporary colour-coding: coloured – reiteration errors. Red – reiteration errors attested in dated 247-year tables. Green – reiteration errors not attested in dated 247-year tables. (to be replaced with Bold – reiteration errors. Grey background – reiteration errors not attested in dated 247-year tables.)*

earliest 247-year cycle			standard calculation							
remainder	CE date	year type <sup>48</sup>	CE date	year type	CE date	year type	CE date	year type	CE date	year type

45 T-S AS 144.111 and the folio formed by T-S AS 203.216, T-S AS 144.286, T-S AS 144.228.

46 Frankfurt, SUB Oct. 142, fols 80r–81v (Italian, 15th century).

47 The starting date of 689/90 is not indicative of the time when this cycle was conceived. See Appendix 1, *Oriental*.

48 The type of a year is commonly presented in the form of a shorthand notation consisting of three letters. The first letter of a year type stands for Rosh Hashanah and can be ב for Monday, ג for Tuesday, ה for Thursday and ז for Saturday. The second letter of a year type stands for the length of the variable months and can be ה for חסרים ‘defective’, כ for כסדרן ‘regular’; and ש for שלמים ‘full’. The third letter represents Passover and can be א for Sunday, ג for Tuesday, ה for

6	694/5	זשג	941/2	זשג	1188/9	זשג	1435/6	זחא	1682/3	זחא
7	695/6	הכז	942/3	הכז	1189/90	הכז	1436/7	גכה	1683/4	גכה
8	696/7	בחה	943/4	בחה	1190/1	בחה	1437/8	זשה	1684/5	זשה
49	737/8	זשה	984/5	זחג	1231/2	זחג	1478/9	זחג	1725/6	זחג
50	738/9	זחא	985/6	השא	1232/3	השא	1479/80	השא	1726/7	השא
53	741/2	זשג	988/9	זחא	1235/6	זחא	1482/3	זחא	1729/30	זחא
54	742/3	החא	989/90	גכז	1236/7	גכז	1483/4	גכז	1730/1	גכז
55	743/4	גכה	990/1	בשה	1237/8	בשה	1484/5	בשה	1731/2	בשה
65	753/4	בשז	1000/1	בשז	1247/8	בחה	1494/5	בחה	1741/2	בחה
66	754/5	בחג	1001/2	בחג	1248/9	זשג	1495/6	זשג	1742/3	זשג
69	757/8	בשה	1004/5	בשה	1251/2	בחג	1498/9	בחג	1745/6	בחג
70	758/9	זחא	1005/6	זחא	1252/3	השא	1499/1500	השא	1746/7	השא
84	772/3	השג	1019/20	השג	1266/7	השג	1513/4	השג	1760/1	החא
85	773/4	הכז	1020/1	הכז	1267/8	הכז	1514/5	הכז	1761/2	גכה
86	774/5	בחג	1021/2	בחג	1268/9	בחג	1515/6	בחג	1762/3	זשג
89	777/8	בשה	1024/5	בשה	1271/2	בשה	1518/9	בשה	1765/6	בחג
90	778/9	זחג	1025/6	זחג	1272/3	זחג	1519/20	זחג	1766/7	השג
94	782/3	השא	1029/30	הכז	1276/7	הכז	1523/4	הכז	1770/1	הכז
95	783/4	גכז	1030/1	בשז	1277/8	בשז	1524/5	בשז	1771/2	בשז
147	835/6	זשה	1082/3	זשה	1329/30	זשה	1576/7	זחג	1823/4	זחג
148	836/7	זחא	1083/4	זחא	1330/1	זחא	1577/8	השא	1824/5	השא
151	839/40	זשג	1086/7	זשג	1333/4	זשג	1580/1	זחא	1827/8	זחא
152	840/1	החא	1087/8	החא	1334/5	החא	1581/2	גכז	1828/9	גכז
153	841/2	גכה	1088/9	גכה	1335/6	גכה	1582/3	בשה	1829/30	בשה
172	860/1	השא	1107/8	השא	1354/5	הכז	1601/2	הכז	1848/9	הכז
173	861/2	גכה	1108/9	גכה	1355/6	בשה	1602/3	בשה	1849/50	בשה
192	880/1	השא	1127/8	השא	1374/5	השא	1621/2	הכז	1868/9	הכז
193	881/2	גכז	1128/9	גכז	1375/6	גכז	1622/3	בשז	1869/70	בשז
225	913/4	זשה	1160/1	זשה	1407/8	זשה	1654/5	זשה	1901/2	זחג
226	914/5	זחא	1161/2	זחא	1408/9	זחא	1655/6	זחא	1902/3	השא
233	921/2	השג	1168/9	החא	1415/6	החא	1662/3	החא	1909/10	החא
234	922/3	הכז	1169/70	גכה	1416/7	גכה	1663/4	גכה	1910/1	גכה
235	923/4	בחג	1170/1	זשג	1417/8	זשג	1664/5	זשג	1911/2	זשג
238	926/7	בשה	1173/4	בחג	1420/1	בחג	1667/8	בחג	1914/5	בחג
239	927/8	זחג	1174/5	השג	1421/2	השג	1668/9	השג	1915/6	השג

Reiteration errors in a dated calendar for a particular stretch of 247 years can be detected by collating it with a standard calculated calendar for the same years. The procedure is more complicated with cycles of remainders, which are undated. In such cycles one must

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Thursday and t for Saturday. Alternatively ways of representing year types can be found in medieval manuscripts.

determine whether a given sequence of year types corresponds to the standard calendar for any single 247-year period counted from the cycle's epoch. If year types assigned to remainders fit a 247-year period that ended before the time of copying or do not all fit the same 247-year period, the cycle of remainders can be said to have been copied from an earlier *Vorlage*.<sup>49</sup>

Among surviving copies of Josiah b. Mevorakh's cycle, only few contain a version of the calendar in which all year types pertain to one and the same iteration of the 247-year cycle. In most copies, year types for lower remainders fit a later iteration of the cycle than those for higher remainders.<sup>50</sup> This indicates that Josiah b. Mevorakh's calendar was commonly copied from earlier *Vorlagen* and was gradually updated in order to bring it in line with the standard calendar.

Two different cycles of remainders are attested in Italian manuscripts. The first cycle correctly represents the standard calendar for years 1237/8–1483/4 (19-year cycles 264–276); the second one correctly covers years 1256/7–1502/3 (19-year cycles 265–277). All copies of the cycles known to me are found in manuscripts produced in the 14th–15th centuries, within the first iteration of the sequences and too early for reiteration errors to occur.

The 247-year calendars most susceptible to reiteration errors are dated calendar tables. Scribes often strove to start such tables from the 19-year cycle in which they worked. To do this they could either produce or copy a table that started in the desired cycle, or they could take a reiterative table that started in an earlier 19-year cycle and move all 19-year cycles that have already passed to the end of the table, renumbering them but not updating the year types. Although reusing a calendar table in the described way inevitably creates reiteration errors, this method of creating calendar tables appears to have been popular in the Middle Ages and early-modern times.

In the overall corpus of manuscript tables for 247-years ca. 70% have reiteration errors. The percentages are highest in Ashkenazi and Italian tables (80% and 100% respectively) and lowest in tables from the Orient (24%, with just 13% of Yemenite tables having reiteration errors). In tables starting before the end of the 15th century, 66% have reiteration errors. In tables starting in the beginning of the 16th century and later, the percentages rise to 85%. It is evident that with the exception of the Orient, dated tables for thirteen 19-year cycles were most commonly produced by reusing old tables. Some *Vorlage* tables have been iterated more than once. Thus, year types given in many tables for 1601/2–1602/3 were last correct in 1107/8–1108/9, two iterations of the 247-year cycle earlier.

The state of reiterative tables did not improve in the age of printing: a 247-year calendar printed in Guadalajara (ca. 1482) as well as those included in *She'erit Yosef* by Joseph ben Shem Tov (Salonika, 1521), in printed *Tur Oraḥ Ḥayyim* by Jacob ben Asher (first printed in Constantinople, 1540) and in many *Sifre Evronot* (first printed in Riva di Trento, 1561) have reiteration errors and must have been based on earlier calendars. Despite the errors, these

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49 See Vidro, "Origins," 110, 124–28.

50 Vidro, "Origins," 112–19, 126–28.

printed tables did not remain tucked away in books but were displayed, a fact that highlights their authoritative status. Thus, a visiting scholar in Salonika in 1538/9 described seeing a faulty reiterative calendar on a wall of a synagogue and published a list of its mistakes.<sup>51</sup>

Copying calendars from earlier *Vorlagen* was so widespread that outdated year types are often found in tables that are not otherwise recognisable as produced by reiteration – they cover less than thirteen 19-year cycles, do not have cyclicity statements and are not associated with R. Naḥshon. For example, Toronto, MS Friedberg 3-016, fol. 91r (Ashkenazi, 14th century) has a calendar for three 19-year cycles 268–270 (1313/4–1369/70) with a reiteration error in 1354/5–1355/6. Munich, BSB Cod. hebr. 109, fols 36r–36v (Sefardi, 15th century) has a calendar for six 19-year cycles 274–279 (1427/8–1540/1) with a reiteration error in 1435/6–1437/8. A striking example is Zurich, Jeselsohn 16, fol. 146r (Ashkenazi, 16th century) where a calendar for five 19-year cycles 281–285 (1560/1–1654/5) has reiteration errors in all but one cycle, and includes year types that were last correct in the early 12th century. It is clear that these and similar tables effectively represent truncated 247-year cycles. Of tables for up to ca. 100 years that cover years susceptible to reiteration errors, every third contains outdated year types; of shorter tables for up to ca. 60 years, it is every fourth. If calendars of any length are considered, almost two thirds of those that can have reiteration errors do so. This means that Jews relying on ready-made calendars were more likely to use one with reiteration errors than without them.

Outdated year types can be found in tables that provide *moladot* – a hallmark of calculated calendar.<sup>52</sup> In such cases, it appears that year types have not been calculated on the basis of *moladot*, but that the two kinds of calendrical data have been uncritically put together for the sake of completeness. Even more surprising is the presence of outdated calendar information in scientific works on calendar that explicitly refute the 247-year cycle. Examples include *Yesod 'Olam*, a comprehensive monograph on mathematics, astronomy and calendar by Isaac Israeli composed in 1310 and *Ḥeshev ha-Efod*, a calendar monograph by Profiat Duran composed in 1395. Tables in all surviving copies of *Yesod 'Olam* and *Ḥeshev ha-Efod* have mistakes linked to reusing old calendrical information from thirteen or a multiple of thirteen 19-year cycles earlier.<sup>53</sup> At the same time, both authors explicitly state that the Jewish calendar does not recur after 247 years and warn that relying on calendrical information for thirteen 19-year cycles earlier leads to mistakes.<sup>54</sup> As I have suggested

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51 Issachar Ibn Susan, *Tiqqun Issachar* (Venice, 1578/9, fols 10v–11v). The described calendar was most probably a copy of the table in *She'erit Yosef* by Joseph ben Shem Ṭov, as is demonstrated by the identicalness of reiteration and printing mistakes in this table with those discussed in *Tiqqun Issachar* and is further corroborated by Ibn Susan's statement that the described calendar was printed in Salonika.

52 See e.g. Oxford, Bodl., Poc. 262, fols 249r–251v (Oriental, 1202), 12 cycles; London, BL Or 2674, fols 131v–135r (Italian, 15th century), 8 cycles; Frankfurt, SUB, Oct. 142, fols 80r–81v (Italian, 15th century), ca. 5 cycles, New York, JTS 2435, fols 50v–54r (Byzantine, 15th century), ca. 8 cycles.

53 The table in *Yesod 'Olam* covers 19-year cycles 268–300 and has generic mistakes linked to using outdated year types in cycles 274, 281, 282, and 287 but not in cycles 284, 291, 294, 295, 298, 299, and 300, where such mistakes are also possible (see, for example, London, BL Add 15977, fol. 178r). The table in *Ḥeshev ha-Efod* covers cycles 272–281 and has generic mistakes linked to using outdated year types in cycle 281 (see, for example, Parma, Biblioteca Palatina Cod. Parm. 2776, fol. 130v).

54 See below, footnotes 26 and 27.

elsewhere, these tables may have been put together by the scholars' less skilled amanuenses.<sup>55</sup>

#### Corrections and use

Evidence from different parts of the Jewish world indicates that 247-year calendars were widely used in practice. Some sources explicitly state the cycle's popularity "because it is simple and easy to grasp".<sup>56</sup> Elsewhere there is evidence of people warning others about imminent mistakes, which implies that 247-year tables were expected to be used and cause trouble.<sup>57</sup> We also find practical advice on how to keep track of the position of a sought year in a 247-year table by adding the AM date to the relevant cell at the start of each year.<sup>58</sup>

AM dates in secondary hands are found in many tables suggesting that the tables have been consulted in those years. Especially interesting are cases when secondary hand dates and 19-year cycle numbers are marked not for the initial iteration of the cycle as it is found in a manuscript but for a later period. For example, Vatican, BAV, ebr. 318, fol. 259v (Ashkenazi, end 13th century?) contains a 247-year calendar table for 19-year cycles 261–273 (1180/1–1426/7). In this table some original cycle numbers are crossed out and new cycle numbers, thirteen 19-year cycles later, are written instead, e.g. 277 for 264, 278 for 265, etc. In addition, AM dates for years 1458/9–1619/20, in the next iteration of the calendar, are added in at least two secondary hands. Such marks clearly indicate that users of the manuscript believed in the reiterative nature of the 247-year cycle and implemented it in practice.<sup>59</sup>

Cycles of remainders, too, have user marks that indicate their being used in years beyond the 247-year period that they correctly cover. 16th-century dates are marked in Italian cycles of remainders that correctly cover 1237/8–1483/4.<sup>60</sup> Similarly, a user of the Judaeo-Persian manuscript London, BL Or. 2451, fol. 369v (1482/3–1483/4) determined year types for 18th-century dates on the basis of a cycle that correctly covers 1183/4–1429/30. However, since cycles of remainders are not inherently dated, their users cannot be said to

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55 Nadia Vidro, "Calendar tables in manuscript and printed *Arba'ah Turim: Tur Oraḥ Hayyim*, chapter 428", *Journal of Jewish Studies*, 69/1 (2018), 58–85, esp. 74.

56 T-S NS 98.2 (Oriental, 13th–14th century): ונצרא כתרה אעתמאד אלנאס עלי עבור לרבינו יאשיהו בן מבורך זל לאנה (We saw that people often rely on the calendar of R. Josiah b. Mevorakh of blessed memory because it is simple and easy to grasp.)

57 Moscow, RSL, Guenzburg 365, fol. 147r (Provençal, 15th century): זאת התעייה ... לא שנת קצו וקצו לבד כמו שהעירוך טארשקון אבל גם שנת קצו you, but in the year 1437/8, too.)

58 *Sefer Minhage Maharil*, cited here according to Frankfurt, SUB Oct. 94, fol. 219v (Ashkenazi, 1460): בכל תחילת השנה (In the beginning of each year write down its date in the table and you will not make mistakes.)

59 Additional examples can be found in Zurich, Jesselsohn 17, fols 263v–264r (Ashkenazi, end 12th–end 13th century), Cincinnati, HUC 436, fol. 191v (Ashkenazi, 1435), Cambridge, Trinity College F 12 21, fol. 10v (Ashkenazi, 14th century), Oxford, Bodl. Heb. e.60, fol. 462r (Persian, 1485), Oxford, Bodl. Laud Or. 166, fol. 147r (Ashkenazi, 1470), Paris, BnF heb. 1032, fol. 1v (Ashkenazi, 14th century), London, BL Or 2389, fols 141v–142r (Yemenite, 1635), Vatican, BAV ebr. 423, fol. 30r (Italian, 15th century), Jerusalem, Kapah 16, fol. 12v (Yemenite), London, BL Or. 4104, fol. 21v (Yemenite, 15th century).

60 See, e.g., Jerusalem, NLI Heb. 38°4281, fol. 298v (Italian, 1391), Paris, BnF heb. 620, fol. 281v (Italian, 14th–15th century), Vatican, BAV Ross 437, fol. 395v (Italian, 1448), Parma, Palatina Cod. Parm. 2467, fols 46v–49v (Italian, ca. 1410).

have consciously reiterated the calendar.

As demonstrated above, a large proportion of 247-year calendars in medieval and early-modern Jewish sources were produced by copying from earlier *Vorlagen*. This affected the accuracy of the cycles in more than one way since in addition to reiteration errors, such calendars were more likely to have scribal mistakes.<sup>61</sup> Manuscript readers occasionally attempted to update outdated year types and correct scribal mistakes. Such corrections rarely cover whole tables, but apply to separate years or to relatively short stretches of years, presumably close to the time when a reader consulted the cycle. While some corrections are based on a calculation, sometimes performed in a manuscript's margins,<sup>62</sup> others are a result of collating different calendar tables. When collating, scribes and readers often noted divergent year types as alternative versions, without making a final decision which ones to follow.<sup>63</sup>

Corrections do not always improve a table's readings. Whether calculating or collating different calendars, readers were as likely to correct mistakes as to replace originally correct data with year types that were either outdated or wrong for other reasons. In a secondary note in Zurich, Jesselsohn 17, fol. 264r (Ashkenazi, end 12th–end 13th century), a user calculated *moladot* and incorrectly inferred from them years types for years 1462/3 and 1463/4, suggesting them instead of the correct data in the table. The table in Jerusalem, JNUL Heb. 8°1997, fol. 73r (Italian, late 15th century) underwent two sets of interventions. One reader collated it with a much earlier calendar and glossed it with year types that were last correct two 247-year periods earlier. Another reader acted to update the table and crossed out all outdated year types, both those in the main body of the table and in the glosses.

Despite the evidence of the 247-year cycle's use in practice, only one document has so far been discovered which has a date that is wrong in the standard calendar but is compatible with the cycle.<sup>64</sup> A number of reasons can be suggested for a lack of other such dates. Firstly, the cycle produces only few characteristic errors per iteration. With prolonged use reiteration errors multiply and are more likely to be detected, but since 247-year calendars other than the earliest Oriental cycles of remainders do not deviate from the standard calendar before the middle of the 14th century, reiteration errors do not begin to accumulate before the last third of the 16th century, when year types of nine out of the 46 years 1576–1622 differ from those 247 or a multiple of 247 years earlier (see Table 1).

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61 Scribes were aware of this danger and insisted that a copied calendar should be checked and rechecked. See Paris, BNF, Heb. 646, fol. 139v (Ashkenazi, 14th century): מאד יש לו לאדם ליזהר שלא יטעה כי יכול לבא לידי קילקול גדול לקלקל כל המועדים ולאכאול חמץ בפסח ולחילול יום הכיפורים על כן כל המעתיק יש לו לקרות בי פעמים או ג' פעמי' ולדקדק שלא יטעה אחרי שיעתיק (One should be very careful in order not to make mistakes because one can bring about a big distortion and distort all the festivals, eat leavened bread on Passover and profane the day of Atonement. This is why a copyist must read (what he copied) twice and three times and examine carefully after he had copied that he made no mistakes).

62 See, e.g. Zurich, Jesselsohn 17, fols 263v–264r (Ashkenazi, end 12th–end 13th century).

63 See, e.g., New York, JTS Rab. 689, fol. 122r (Ashkenazi, 1437), Jerusalem, The Israel Museum, 180/051, fol. 471r (Italian, 14th century).

64 New York, JTS Rab. 689 (Ashkenazi), dated in the colophon on fol. 194r Thursday, 23 Marḥeshvan 5198 AM (1437 CE). In 5198, 23 Marḥeshvan fell on a Tuesday. In contrast, in 4951 AM (1190 CE), 247-years earlier, 23 Marḥeshvan fell on a Thursday.

However, in this period printed wall calendars for a single year began to be produced and gain popularity and the use of manuscript calendar tables may have lessened.<sup>65</sup> Secondly, reiteration errors can be detected only in documents with a full date that includes the day of the week, the day of the month and the year. Given the rarity of fully dated documents, and the paucity of affected years, the chances of finding a date with a reiteration error are slim. Thirdly, there may have been some awareness among users of the 247-year cycle when it was unsafe to rely on it. Some theoretical discussions of the 247-year cycle give isolated examples of years or 19-year cycles when using an outdated calendar produces erroneous results.<sup>66</sup> This information may have been available to some of the cycle's users. A small number of reiterative tables themselves are provided with a full or partial list of errors that a table produces, either in its initial or its second iteration.<sup>67</sup> Another small group of tables alerts users to potential problems by not supplying AM dates in some years with reiteration errors when all other years are provided with a date.<sup>68</sup> Significantly, there is never a comprehensive list of all potential reiteration errors so that users could only receive a patchy idea of when it was unsafe to rely on a 247-year cycle.<sup>69</sup> Finally, corrections found in the calendars and public enquiries into the validity of the cycle, which were occasionally initiated in years leading up to possible years of calendar divergence, may have prevented mistakes in particular years.

#### *Public Enquiries*

The wide-spread use of the 247-year cycle led to a number of public enquiries into the adequacy of the 247-year cycle as a means of fixing the Jewish calendar. These enquiries

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65 Elisheva Carlebach, *Palaces of Time: Jewish Calendar and Culture in Early Modern Europe* (Cambridge, Mass., London: Belknap, 2011), 59–66. I have not analysed printed wall calendars for this article.

66 See Isaac Israeli, *Yesod 'Olam*, book 4, chapter 10, where the author explicitly writes that years 9–11 of the 19-year cycle 274 (1435/6–1437/8) are not identical to corresponding years in the 19-year cycle 261 (Goldberg, Rosenkranz, *Liber Jesod Olam*, 2:23). One reiteration error in the year 10 of the 19-year cycle 274 (1436/7) is pointed out in Obadiah b. David's commentary on Maimonides' *Sanctification of the Moon*, chapter 8, halacha 1. Surprisingly, neither work mentions possible reiteration errors in 1354/5–1355/6 (years 4–5 of the 19-year cycle 270) closer to their composition times in 1310 and 1340 respectively. Paris, BnF, heb. 642, fol. 184r (15th cent, Sefardi or Provençal), includes a calculation of *moladot* that demonstrates that some types of years in the 19-year cycle 282 differ from corresponding years in the cycle 269.

67 Munich, BSB Cod. hebr. 343, fol. 167v (Sefardi, 15th century) includes an accurate 247-year table and comments on all reiteration errors that the table included in the manuscripts will produce in its second iteration. The same can be observed in a 14th-century Yemenite work *Ner Israel* by Yosef ben Yefet ha-Levi (*Ner Israel*, chapter 13, see, e.g., London, BL, Or. 4104, fol. 11r). Zurich, ZB Heid. 145, fol. 45v (Ashkenazi, 1340/1) has a calendar with reiteration errors in 1354/5–1355/6 and 1435/6–1437/8 accompanied by a reader's gloss that points out the former set of mistakes but not the latter ones. In Parma 3266, fols 19r–19v (Ashkenazi, 14th century) different notations are used for year types in 19-year cycles that can and cannot have reiteration errors.

68 In Cincinnati, HUC 436, fol. 191v (Ashkenazi, 1435) AM dates are supplied by the scribe in all years starting from 1239/40, except in years 1435/6–1437/8, which are fixed incorrectly in the included table. Years 1354/5–1355/6, which also have reiteration errors but have already passed at the time of copying in 1435, are not marked in this way. In Moscow, RSL, Guenzburg 1068, fol. 47r (Italian, 16th century) and Oxford, Bodl., Mich. 484, fol. 169r (Italian, 16th century) an identical table is included, in which AM dates are missing in years 1601/2–1602/3 and 1681/2–1683/4 where reiteration mistakes are possible. Interestingly, the table has correct data in these years, but makes reiteration errors in other places without indicating them. It seems clear that the table was collated with a different table with reiteration errors in 1601/2–1602/3 and 1681/2–1683/4 and dates were not added in those years in which the tables differed.

69 Thus, the reiteration error in year 10 of the 19-year cycle 274 (1436/7) pointed out by Obadiah b. David (see footnote 64) appears to have been the only mistake known to a 19th-century maskil Reuven Joseph Wunderbar (see Reuven Joseph Wunderbar, *Immerwährender Kalender der Juden. Deutsch und Hebräisch. Nach den Quellen bearbeitet und herausgegeben* (Dessau: Baumgarten und Co, 1854), 5.)

never settled the matter of the reiterative calendar in a final way but may have prevented mistakes in the years involved. Three such cases are known to me: in fourteenth-century Yemen, in fifteenth-century Avignon and in early twentieth-century Russian empire.<sup>70</sup>

The earliest enquiry and dispute took place in Yemen and was reported in a calendar treatise by Ma'ūda al-Lidānī, otherwise unknown, composed in the first half of the 14th century.<sup>71</sup> Ma'ūda al-Lidānī reported that for a long time the Jews of Yemen relied on ready-made calendars, including the reiterative calendar by Josiah ben Mevorakh. In 1336 the reiterative calendar was checked against the standard calculation as it was laid out in Maimonides' *The Sanctification of the Moon* and was found to produce mistakes in years 1354/5–1355/6 and in various other years. Mistakes in years 1354/5–1355/6 described by Ma'ūda al-Lidānī were reiteration errors grounded in the fact that their year types differ from those 247 years earlier but must not have been updated in the calendar in circulation, a state of affairs observed in most surviving copies of Josiah ben Mevorakh's calendar.<sup>72</sup> A confrontation ensued between those who checked the cycle by calculation, established its faultiness and pushed for relying on the standard calculation and those who supported the 247-year cycle even though, in the words of Ma'ūda al-Lidānī, they had no arguments for it<sup>73</sup> and could only put forth an old claim that it was not appropriate to fix the calendar outside of Palestine.<sup>74</sup> It is unknown how the years 1354/5–1355/6 were fixed by the communities involved, but later sources indicate that a pre-occupation with the cycle continued in Yemen for centuries to come. Whereas most surviving Yemenite sources refute the cycle and emphasize that once a calendar for 247 years is finished, one must prepare a new one by calculation,<sup>75</sup> at least one treatise, composed in 1397 and still copied in the 18th and 19th centuries, advocates using it reiteratively.<sup>76</sup>

The second enquiry is linked to the next stretch of years when the 247-year cycle deviated from the normative calculation, viz., 1435/6–1437/8. We learn about it from a letter by a

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70 Abraham Ibn Ezra's critique of the 247-year cycle can be seen as an outcome of another such enquiry, initiated by David b. Joseph Narboni who found mistakes (דברים שאינם הגונים) in reiterative tables. See Steinschneider, *Sefer Shene ha-Me'orot*, 1.

71 On this dispute see Yosef Tobi, *The Jews of Yemen*, 211–26; Yosef Tobi, "The dispute over the 247-year cycle in Yemen," in *Studies in Judaism and Islam presented to Shelomo Dov Goitein on the occasion of his eightieth birthday by his students, colleagues and friends*, eds Shelomo Morag, Issachar Ben-Ami and Norman A. Stillman (Jerusalem: Magnes Press, 1981) (Hebrew), 193–228 (an edition and Hebrew translation of Ma'ūda al-Lidānī's account are on pp. 210–21).

72 See Vidro, "Origins," 118–119 (remainders 172 and 173). No Yemenite copies of Josiah b. Mevorakh's calendar are known to me.

73 מן גיר ביאן (Tobi, "The Dispute," 211).

74 Tobi, "The Dispute," 199–201, 210–11.

75 For example, Paris, BnF heb. 1331, fol. 123r (Yemenite, a 17th-century copy of a 15th-century text): ומתי מא פרג' אלמחזור אלכביר עמל דור מתלה עלי אלחסאב (When the big cycle is used up, make a similar cycle by calculation). Cincinnati, HUC 765, fol. 139v (Yemenite, a 17th-century copy of a 15th-century text): ומתי פרגת פאנצם לך מחאזיר גירה ואעתמד עלי (When it is used up, arrange for yourself further 19-years cycles. Rely on the rules that I explained to you above and do not at all let it come to your mind what they said about there being a cycle of years, not of 247 (years) and not any other!).

76 New York, JTS 5543, fol. 37v (Yemenite, 15th century): פאדי בלגת אכרה עדת אלי אולה בלא תעב ולא ענא דאיר ידור (If you reach its end, go back to the beginning without difficulty and without anguish, it repeats itself forever for all eternity.). On this work see Tobi, *The Jews of Yemen*, 213, 221–22. Tobi, "The Dispute," 202–203, 222–25. Tzvi Langermann, "What does *Sefer Yesira* have to do with the Jewish calendar? The place of *Sefer Yesira* in an introduction of a work on the 247-year cycle," (Hebrew) *Ale Sefer*, 26–27 (2017), 9–16.



15th-century Avignon physician Mordecai Nathan<sup>77</sup> to his uncle Don Boniac Astruc Nasi, composed between 1427/8–1435/6 and preserved in a later copy.<sup>78</sup> Mordecai Nathan's letter is a reply to an earlier letter from Don Boniac Astruc, which is not preserved but some of its contents can be reconstructed. Don Boniac Astruc was warned by Tarasconians that years 1435/6–1436/7 are fixed incorrectly in the 247-year table.<sup>79</sup> Alarmed and presumably unable to check and correct the calendar by himself, Don Boniac Astruc asked his nephew for a correct 247-year calendar, considering it “impossible to be without it”.<sup>80</sup> Instead, Mordecai Nathan wrote an epistle on reiterative calendar, pointing out a third imminent mistake in 1437/8 and explaining why the 247-year calendar is inaccurate. He reported that the faultiness of the reiterative calendar had been sensed in their community already some eighty years earlier but was since forgotten because the table produced no more mistakes until the time of the letter. Anticipating the disturbance in 1435/6–1437/8 Mordecai Nathan did all he could to alert people around him and prevent them from being “lead astray by the table”.<sup>81</sup> Realising that one man's efforts were not enough, Mordecai Nathan proposed an ingenious solution for preventing reiteration errors while not giving up 247-year tables completely. He formulated criteria when it was safe to carry over year types from an earlier table and suggested that every scholar should write these criteria under every 247-year table that he encounters. He urged Don Boniac Astruc to use his authority to encourage this course of action. Mordecai Nathan did not fulfill his uncle's request for a correct 247-year calendar. Instead, he recommended using a different, non-reiterative, table that provided *moladot* alongside year types, which at the time has been in circulation for about 70 years but contained calendar data for another century and a half.

The last of the three public enquiries known to me happened in 1902, when Jews in the Russian empire suspected their almanacs of containing incorrect year types for years 1901/2 and 1902/3.<sup>82</sup> Their main concern was that the almanacs disagreed with the table in *Ṭur Oraḥ Ḥayyim*, the first part of a highly influential legal code *Arba'ah Ṭurim* ('The Four Pillars') by Jacob ben Asher (Cologne, ca. 1270–Toledo, after 1340). In all printed editions of *Ṭur Oraḥ Ḥayyim* the calendar is presented as a cycle of 247 years that repeats itself four times.<sup>83</sup> This table provides correct year types for 1541/2–1787/8<sup>84</sup> but produces errors in other iterations of the cycle, including in years 1901/2–1902/3. Its deficiency has been

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77 On Mordecai Nathan see Isidore Simon and Abraham David, “Nathan, Mordecai,” *Encyclopaedia Judaica*, edited by Michael Berenbaum and Fred Skolnik, 2nd ed., vol. 15, Macmillan Reference USA, 2007, 10–11. Accessed on Gale Virtual Library on 23 March 2018.

78 Moscow, RSL, Guenzburg 365, fols 147r–148r (Provençal, ca. 1487).

79 See, e.g., Munich, BSB, Cod. hebr. 128, fol. 28r (late 15th century) for a surviving Provençal table with these mistakes.

80 Moscow, RSL, Guenzburg 365, fol. 148r: כי אי אפשר בלעדיו.

81 Moscow, RSL, Guenzburg 365, fol. 147v: ואני כבר נתעוררתי בתעיייה המשלשת הזאת זה כמה והעירורתי הני הנבונים אחי וגבירי קרשקש נתן ואחיו בונגואש יא' בדרוש ושחרתי להעיר כה וכה לבל יתעו בלוח (I have become alert to this triple error some time ago and alerted the ? the wise ones, my brother and lord Crescas Nathan and his brother Bonjudas of(?) Béziers. And I sought to comment on it this way and that way so that people are not lead astray by the table.)

82 On this dispute see also Raviv, *Mathematical Studies*, 105–107. Z.H. Yaffe, *Qorot Heshbon ha-'Ibbur* (Hebrew) (Jerusalem: Darom, 1930), 163–64.

83 On this calendar and its history see Vidro, “Calendar tables.”

84 In some editions, mistakes are found in this period, too (Vidro, “Calendar tables,” 81).

exposed already in the 17th century,<sup>85</sup> but many Rabbis in the Russian empire still considered the *Ṭur* table authoritative two hundred years later.<sup>86</sup> In a bid to clarify the matter, calendar experts Zvi Hirsch Yaffe and Rafael Gordon published articles in the pages of the periodical *Ha-Melits*,<sup>87</sup> confirming the year types given in the almanacs, refuting the 247-year cycle and dissuading people from relying on the table in *Ṭur Oraḥ Ḥayyim*.

*The place of the 247-year cycle among other schemes for setting the Jewish calendar*

Ample evidence confirms that the 247-year cycle, although incompatible with the standard *molad* calculation, was not regarded as an alternative Jewish calendar but as a means of setting the standard calendar. 247-year cycles are often found in treatises on the standard calendar, in close proximity with an explanation of the *molad* calculation. All identified refutations of the cycle oppose it for inaccurately representing the standard calendar, and 247-year calendars themselves are relatively frequently corrected in the manuscripts to bring them in line with the standard calculation.

Why did Jews use a calendar scheme that was known to yield erroneous calendrical information and in some years lead to celebrating festivals on wrong days, eating leavened bread on Passover and profaning the day of Atonement? The answer appears to be linked to the general level of knowledge in the field of calendar reckoning. An introduction to a work on calendar preserved in T-S Ar.54.7b distinguishes between people who have mastered the science of calendar reckoning and can calculate the calendar from first principles; those who studied less but can use pre-calculated data to set the calendar; and those whose knowledge is so insufficient that they must use a ready-made calendar.<sup>88</sup> It appears that most medieval and early-modern Jews belonged to the latter group of people and did not know how to construct or correct a calendar.<sup>89</sup> This included the educated elites: in the Avignon correspondence described above, Don Boniac Astruc, who bore the title “the prince” (heb. *nasi*) and must have been a high-standing member of the community, found himself unable to verify calendar data. In another episode the elders of Toledo struggled to fend off an accusation that they had celebrated Passover on a wrong date and turned to a calendar expert, Isaac Israeli, for justifying their date.<sup>90</sup>

A long-term ready-made calendar ensured that a community without calendar experts would not find itself without a means of setting the calendar. A 247-year cycle, which could be reused and only rarely produced mistakes, must have been especially attractive for those lacking calendar expertise. The sources frequently connect between using the reiterative

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85 H̄ezekiah da Silva (ca. 1656–1695), *Peri Ḥadash*, first published in Amsterdam 1706, fols 5r–6v.

86 Raphael Gordon, “Further on the matter of year types” (Hebrew), *Ha-Melits* (27 March (9 April), 1902), 3–4, esp. 3. Available online at <http://www.jpress.nli.org.il/Olive/APA/NLI/?action=tab&tab=browse&pub=HMZ#panel=browse>, accessed 23 March 2018. In *Ha-Melits*, Julian dates were used, and Gregorian dates were given in brackets; I have followed the same system when referring to the periodical. The online archive is organised by Gregorian date.

87 See Zvi Hirsch Yaffe, “Intercalation in its correct time” (Hebrew), *Ha-Melits* (4 (17) March 1902), 3–4 and Gordon, “Further on the matter of year types”.

88 T-S Ar.54.7b recto: ויכון בתא הדא עלי ג' טבקא[ת] פמן אכתר יתעלם אלעבור פיקף עלי אלפצול ומן לם יכתאר יתעב פי דלך פיהסב מא אשתהא מן אלגדאול אלמנצובה ומן צעב עליה דלך איצא פיעלם אלסנה או אלשהר מן אלסנין אלמנצובה עלי אלנסק

89 See also Carlebach, *Palaces of Time*, 6.

90 Isaac Israeli, *Sefer Yesod 'Olam*, book 4, section 18 (Goldberg, Rosenkranz, *Liber Jesod Olam*, 2:36).

calendar and a lack of knowledge:

... and the degradation and the lack of knowledge and the deficiency of learning. And we saw that people often rely on the calendar of R. Josiah b. Mevorakh of blessed memory because it is simple and easy to grasp<sup>91</sup>

Blessed be our Rock who poured out his spirit from on high (cf. Isa 23:15) on the enlightener of the Diaspora, R. Nahshon. Were it not for him, our feet would collapse in our long exile and through our lack of knowledge, but he counted and fixed thirteen cycles of nineteen years that repeat themselves forever without many changes and the few changes are easy to correct.<sup>92</sup>

The popular nature of the 247-year cycle is also further highlighted by the fact that hardly any attempts have been made to prove the cycle's validity, and those that are attested are scientifically weak. In Paris, BnF, heb. 646 it is erroneously stated that the 247-year calendar recurs because *moladot* "go in sevens" after 247 years, i.e. the molad of year N+247 equals that of year N *modulo* 7, a feature that is not found in shorter calendars.<sup>93</sup> In Oxford, Bodl. Heb. e.45/45-56 (Oriental, 1151/2) year types for fifteen 19-year cycles 259–273 (1142/3–1426/7) are listed in order to show repetition after the first thirteen, a method that worked only due to a lucky choice of years covered by the cycle. Had the table covered just one more 19-year cycle it would have produced mistakes in 1435/6–1437/8. In addition, some manuscripts state that whereas *moladot* do not repeat themselves after 247 years, year types do,<sup>94</sup> a claim that cannot be sustained in the framework of the standard calendar.

#### Conclusions

This article has analysed a large corpus of medieval and early-modern sources on the 247-year calendar cycle, a system of calendar reckoning that gained considerable popularity in all corners of the Jewish world despite being incompatible with the standard Rabbinic calendar. The corpus demonstrates that the 247-year cycle was put together in the middle of the 10th century by a Babylonian scholar Josiah b. Mevorakh (ibn) al-Āqūlī. The cycle may have been proposed in the aftermath of the Saadia–Ben Meir dispute of 921–922 as an alternative for the standard calendar that was capable of preventing future calendar

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91 T-S NS 98.2 recto (Oriental, 13th–14th century): עבוד לרבינו יאשיהו בן מבורך ז"ל לאנה סהל קריב אלמאכד

92 Paris, BnF, heb. 642 (15th cent, Sefardi or Provençal), fols 183v-184r: ברוך צורינו אשר הערה רוחו ממרום על מאור גלותינו רב נחשון שאלמלא הוא נתמוטטו רגלינו באורך גלותינו והסרון ידיעתינו והוא מנה וקבע י"ג מחזורי' מי"ט שנים וחוזרים חלילה (מאוד גלותינו) (the manuscript erroneously reads גלותינו).

93 Paris, BnF, heb. 646, fol. 139v (Ashkenazi, 14th century): והנה לך הטעם למה חוזרים לרמז שנים כשתמצה המולדות: מרמז שנים ילכו כולם שביעיות לא יבואו לשביעיות עד רמז שנים. Interestingly, this statement is followed by what appears to be a later gloss incorporated into the main text that explains that the cycle is inaccurate but is not harmful up to a certain point in the calendar.

94 NY JTS Rab 689, fol. 121v (Ashkenazi, 1437): זה הלוח שלפנינו תקן רב נחשון גאון והקבועים חזורי' חלילה אבל המולדות: (This table here was fixed by R. Nahshon Gaon. The year types repeat themselves forever, but the moladot do not repeat themselves because there is a difference of 905 parts.)

dissidence caused by differences in the calendar calculation procedures practiced in Babylonia and Palestine. Later, the 247-year cycle came to be regarded not as a replacement for the standard calendar but as an easy means of setting it, used alongside the more demanding calculation. By the middle of the 12th century the cycle spread to different geo-cultural areas and became widely known, often under the title *Thirteen Cycles*. In contrast, the title *'Iggul* and the attribution of the 247-year calendar cycle to R. Naḥshon Gaon were predominantly Ashkenazi and did not appear before the late 12th century. This attribution was probably introduced in order to give authority to a way of setting the Jewish calendar that had already become popular.

Although scholars regularly refuted the 247-year cycle on scientific grounds, demonstrating its inaccuracy as a means of setting the standard calendar, the cycle enjoyed considerable support throughout the studied period. A large proportion of calendar tables in medieval and early-modern Jewish sources were produced by copying from master copies for 247 years earlier, with many shorter calendars effectively being truncated 247-year cycles. This caused reiteration errors and scribal mistakes and undermined the accuracy of the tables. As a result many conflicting and partially erroneous calendars were in circulation. Evidence from users' glosses and public disputes indicates that at least some Jewish communities relied on 247-year cycles. Reiterative tables continued to be used even after mistakes in them were discovered and their imprecise nature exposed, due to the relative rarity of the errors. The generally low level of calendar knowledge even among educated elites meant that it was difficult for non-specialists to fix or check the calendar by calculation and created a demand for long-term ready-made calendars. In this situation, the 247-year cycle filled the niche of a non-technical way of setting the Jewish calendar that was not limited to a set range of years. Some of the cycle's users may not have been aware of its deficiency, while others may have known that it is not entirely accurate but found themselves unable to set the calendar in a more scientific way. The present analysis suggests that the important principle of calendar unanimity, although widely accepted in theory, could not have been always implemented in practice.

#### *Appendix 1: 247-year cycles in different geo-cultural areas*

##### *1. Oriental*

My corpus includes 61 Oriental manuscripts, penned between the 11th and the 19th century, that contain or discuss 247-year calendars. These include Genizah fragments and complete manuscripts, the latter mostly from Persia and Yemen. In Persian manuscripts 247-year calendars are usually found in Bible codices; in Yemenite manuscripts they are often discussed in calendar treatises within prayer books. The popularity of the 247-year cycle in the Orient is highlighted by a reference to it in a poem on the Samaritan calendar.<sup>95</sup>

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95 Sylvia Powels, *Der Kalender der Samaritaner anhand des Kitāb hisāb as-sinīn und anderer Handschriften* (Berlin

Since the 247-year cycle plays no role in the Samaritan calendar calculation, its mention must reflect a tradition picked up from local Jews.

The earliest identifiable 247-year cycle was put together in the Orient in the middle of the 10th century and has the shape of a cycle of remainders. Attributed to Josiah b. Mevorakh al-‘Āqūlī, it is known from Genizah fragments and Judaeo-Persian manuscripts.<sup>96</sup> This cycle operates with Seleucid dates (SE), has the epoch of 1001 SE (689/90) and is not synchronised with the 19-year cycle of intercalations (it starts in year 4 of the cycle). The epoch of 689/90 CE is not indicative of the time when the cycle of remainders was conceived. Indeed, data for Josiah b. Mevorakh’s cycle must have been originally put together using the standard *molad* calculation,<sup>97</sup> which in all likelihood has been known since the 9th century but not before.<sup>98</sup> This makes a construction date in the 7th century very unlikely. More probable is that the cycle was constructed around the end of the 247-year period from 689/90–935/6 or the beginning of the next one using calendrical records for the near past in combination with data calculated retrojectively for more remote years, or by retrojective calculation alone. The most likely *terminus post quem* for the creation of Josiah b. Mevorakh’s calendar is the Saadia–Ben Meir dispute of 921–922, when methods of calendation were discussed in fine detail but the 247-year cycle was not mentioned. The decade of 980s may be suggested as the cycle’s *terminus ante quem*. Josiah b. Mevorakh’s cycle was based on calendar data for years 689/90–935/6. In its second iteration it did not deviate from the calculated calendar until 980s, when the two calendars disagreed first in 984/5–985/6 and then 988/9–990/1 (see Table 1). If the cycle were put together in the 980s, it would have been apparent that it differed from the standard calendar and the cycle would therefore not have been based on data for 689/90–935/6.

Josiah b. Mevorakh al-‘Āqūlī’s treatise consists of fourteen chapters, each dedicated to one of the fourteen possible types of the Jewish year. Each chapter is made up of three elements: 1) the year type described in that chapter 2) a set of remainders assigned to this year type and 3) a fuller description of the calendar, including the beginning of months, festivals and fasts. In order to use the cycle in any given year, one must establish its remainder by taking that year’s SE date, subtracting 1000 and casting out 247s (in modern notation, (SE date-1000) *modulo* 247). One must then look for the remainder in one of the fourteen chapters. The chapter that lists the sought remainder will describe the correct course of the year for that date.

The earliest version of Josiah b. Mevorakh’s cycle correctly covered years 689/90–935/6. In later versions, the remainder lists were gradually updated in order to bring them in line with the standard calendar. In a number of manuscripts, the cycle of remainders is embedded in a 12th-century critique of the 247-year cycle authored by Joseph bar Āraḥ, in which remainders were fully updated for the second iteration of the cycle, viz., 936/7–1182/3. Due to this update year types for the first iteration of the cycle survive in only a small number of

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New York: de Gruyter, 1977), 55, 197, 254. I thank Sacha Stern for drawing my attention to this source.

96 For a detailed description of this cycle, see Vidro, “Origins”.

97 Vidro, “Origins,” 108.

98 Stern, *Calendar and Community*, 200–210.

copies.<sup>99</sup> Through a series of further, partial updates most surviving copies of Josiah b. Mevorakh's cycle were made to agree with the standard calendar up to and including 1353/4 but would have caused mistakes in 1354/5–1355/6 and later years susceptible to reiteration errors.<sup>100</sup>

Dated tables for a particular 247-year period also circulated in the Oriental geo-cultural area from the 12th century onwards. Reiteration errors are infrequent in surviving tables from the Orient (5 out of 23 tables) but some tables have been glossed with secondary notes re-dating them for future iterations of the cycle, when they would have produced mistakes.<sup>101</sup> Marks and notes in secondary hands often found in Oriental manuscripts demonstrate that these calendars have been consulted (20 out of 49 calendars, both dated 247-year tables and cycles of remainders).

Different attitudes to the cycle are expressed in Oriental manuscripts. Here a distinction must be made between manuscripts from Yemen and from other regions within the Oriental geo-cultural area. In non-Yemenite manuscripts, the cycle is explicitly refuted in only six out of thirty-nine identified manuscripts, half of which are copies of Joseph bar Āraḥ's critique of the cycle of remainders. In Yemen, the overwhelming tendency is to refute the cycle and to stress that each new 247-year calendar must be constructed by calculation.<sup>102</sup> It is likely that the 14th-century dispute caused by the use of the 247-year calendar in Yemen sensitized calendar-makers and scribes to problems involved in using the cycle.

## 2. Ashkenaz

The 247-year cycle was more popular in Ashkenaz than in all other geo-cultural areas. In my corpus there are 81 Ashkenazi-hand manuscripts copied between the 12th and the 18th centuries, and later discussions in printed sources can also be identified. In medieval Ashkenaz, 247-year calendars were most often included in prayer books and halakhic works. In later centuries, they became a staple component of early-modern books on calendar known as *Sifre Ebronot*.<sup>103</sup>

All but one calendar cycle in Ashkenaz are tables dated for a particular stretch of 247 years. One description of a cycle of remainders starting from Creation is also attested.<sup>104</sup> The majority of Ashkenazi 247-year cycles contain data carried over from earlier calendars (61 calendars with reiteration errors, and 13 calendars without). These statistics go well with the fact that only few Ashkenazi manuscripts refute the 247-year cycle (12 manuscripts). The refutations first appear in 14th century manuscripts, much later than in other areas, but are most common in *Sifre Ebronot* composed in or after the 16th century. Nearly half of all

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99 Vidro, "Origins," 120–21, 126.

100 Compare this to the earliest reiteration errors attested in dated 247-year tables, see above p. XY.

101 Jerusalem, Kapah 16, fol. 12v (Yemenite), London, BL Or. 4104, fol. 21v (Yemenite, 15th century), Oxford, Bodl. Heb. e.60, fol. 462r (Persian, 1485).

102 See page XY and footnotes 73–74.

103 On *Sifre Ebronot*, see Carlebach, *Palaces of Time*.

104 Cambridge, Trinity College F 12 22, fol. 6v (Ashkenazi, 14th century).

Ashkenazi 247-year calendars have user marks, showing that the cycles were widely consulted.

### 3. Italy

My corpus contains 32 Italian manuscripts on the 247-year cycle, which include both cycles of remainders and dated calendar tables for a particular 247-year period. Cycles of remainders most commonly occur in prayer books of the Italian rite, whereas dated tables are mainly found in calendar sections of various compendia together with other scientific, medical or halakhic texts.

Unlike in the Orient, Italian cycles of remainders explicitly divide the 247 years into thirteen 19-year cycles and start at the beginning of a 19-year cycle. The 19-year cycles are numbered 1–13 and years are numbered 1–247. The calendars are formatted as a sequence of 247 year types, followed by a description of the fourteen types of the Jewish year. Two different sequences of year types are attested, with epochs in 4998 AM (1237/8) and 5017 AM (1256/7) respectively. The algorithm for determining the place of a year within the first sequence can be written in modern notation as  $(AM\ date - 5000 + 3) \bmod 247$ .<sup>105</sup> The algorithm for the second sequence is  $(AM\ date - 5016) \bmod 247$ .<sup>106</sup> The first sequence gives correct year types for 1237/8–1483/4 (19-year cycles 264–276). The second sequence correctly covers years 1256/7–1502/3 (19-year cycles 265–277). Judging by their epochs and the fully correct calendar data, both sequences were probably put together in the 13th century on the basis of a calculation rather than by copying an existing calendar.

The first Italian sequence of remainders has been used in practice as is demonstrated by dates from Creation added in secondary hands. Although some of the added dates fall in the second iteration of the cycle, the sequence has not been updated in any copies known to me. User marks have not been found in manuscripts of the second sequence. In most copies of this sequence years are written out of order, making the calendar difficult to use.

Dated Italian tables for a particular 247 years are generally later than the sequences of remainders, and most begin in the 15th–16th centuries. All Italian calendar tables have reiteration errors and many start before the manuscript's time of copying. It is clear that these calendars are based on earlier *Vorlagen*. Many Italian tables have user marks in secondary hands such as added dates and corrected mistakes. Critique of the 247-year cycle is rare in Italian sources: I am aware of only one manuscript that refutes the cycle, a 17th–18th century calendar treatise in Moscow, RSL, Guenzburg 365 (see fol. 134r).

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105 JNUL Heb. 38°4281, fol. 298r (Italian, 1391): הרוצה לידע קביעות ראשי חדשים ומועדים וצומות וקריאת פרשיות: השנה שלכל שנה ושנה יחשוב שנת הפרט שעל חמשת אלפים שנה ויוסיף עליהן ג' שנים ויכללם יחד ויוציאם רמז רמז והנמצא בידו הוא החשבון שעומד בו וימצאהו באילו יג' מחזורים שלפניו

106 Cambridge, UL Add. 491, 2, fol. 157v (Italian, 15th century): הרוצה לידע קביעות ראשי חדשי והמועדים והצומות וקריאת פרשיות של כל שנה ושנה יחשוב השנים שעל חמשת אלפי וששה עשר לפרט ויוציאם רמז רמז והנמצא בידו הוא החשבון שעומד בו וימצאהו באלו יג' מחזורים

#### 4. Sefarad and Provence

Copies, mentions and discussions of the 247-year cycle are relatively common in Sefaradi and Provençal astronomical-calendrical miscellanies and Bibles. In my corpus there are 29 manuscripts from this area. The majority of the cycles are dated tables, although there are two Sefardi-hand copies of the first Italian sequence of remainders. Some of the Sefardi 247-year cycles are derivative from a non-reiterative calendar in the astronomical treatise *Luḥot ha-Nasi* by the twelfth-century mathematician and astronomer Abraham bar Ḥayya.<sup>107</sup> Bar Ḥayya's original table covers 65 19-year cycles and is laid out in 24 columns, each representing between one and five 19-year cycles.<sup>108</sup> In this table 19-year cycles that share the same sequence of year types are presented in one column, whereas cycles that do not share a sequence of year types with any other cycle covered by the table are given a separate column. In a number of 14th-century Sefardi manuscripts of *Luḥot ha-Nasi* this unusually structured table was turned into a reiterative calendar for five iterations of the 247-year cycle.<sup>109</sup> This reformatting of a non-reiterative calendar into a reiterative one demonstrates Sefardi Jews' close familiarity with the 247-year cycle.

The 247-year cycle is refuted in a number of works from Sefarad and Provence, including *Shalosh She'elot* by Abraham Ibn Ezra (Narbonne, 1148), *Yesod 'Olam* by Isaac Israeli (Toledo, 1310), *Ḥeshev ha-Efod* by Profiat Duran (Castille, 1395), and a number of anonymous refutations found in manuscripts. More than a half of all Sefardi and Provençal copies of the 247-year cycle exhibit reiteration errors but only few have users' glosses. The paucity of the glosses may indicate that the cycle was relatively rarely used. At the same time, the Avignon correspondence between Mordecai Nathan and his uncle Don Boniac Astruc Nasi provides direct evidence of the cycle's being used in the 15th century by some Jewish communities in the area.<sup>110</sup>

#### 5. Byzantine

Only four reiterative calendars in Byzantine hands could be identified.<sup>111</sup> Three are dated calendars and one is a unique cycle of remainders. Oxford, Bodl. Poc 368, fol. 219r (15th century) contains Josiah b. Mevorakh's cycle of remainders translated into Hebrew and dated according to the era of Creation, which was in use in the Byzantine Empire, rather than the Seleucid era common in the Near East.<sup>112</sup> Three out of four Byzantine 247-year

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107 On this work see J.M. Millás Vallicrosa, *La Obra Séfer Hešbón Mahleket ha-Hokabim (Libro del Cálculo de los Movimientos de los Astros) de R. Abraham bar Ḥayya ha-Bargeloni* (Barcelona: Consejo Superior de Investigaciones Científicas, 1959), 109–16; Y.T. Langermann 'Science in the Jewish Communities of the Iberian Peninsula: An Interim Report', in Y.T. Langermann, *The Jews and the Sciences in the Middle Ages* (Aldershot: Ashgate, 1999), 15–6; N. Garstein, 'The Relationship between Abraham Bar Hiyya's Astronomical Tables and his Treatise "Calculation of the Stellar Motions"' (MA diss, Bar Ilan University, 2016).

108 See, for example, Paris, BnF heb. 1046, fol. 2r. For a description of the table in *Luḥot ha-Nasi* see Vidro, "Calendar tables," 71–73, 76 footnote 38.

109 Cesena, Biblioteca Malatestiana Pluteo sinistro XXIX 4, fol. 3v, Parma, Biblioteca Palatina Cod. Parm. 3821, fol. 10v and Oxford, Bodl. Marsh. 114, fol 22r.

110 See above, "Public enquiries", p. XXX.

111 This may be in proportion with the low number of Byzantine Hebrew manuscripts that are generally extant.

112 See Vidro, "Origins," 134–35. On the use of the era of Creation and the Seleucid era see Stern, Krakowski, "The



cycles in the corpus would produce reiteration errors; none has users marks.

## 6. Latin

247-year cycles accompanied by descriptions of the fourteen types of the Jewish year have been identified in four Latin expositions on the Jewish calendar: *Compotus philosophicus* by an unidentified Friar John (ca. 1273, Germany),<sup>113</sup> Robert of Leicester's *Tractatus de compoto Hebreorum aptato ad kalendarium* (1294, England),<sup>114</sup> John of Pulchro Rivo's *Compotus novus* (1297, Germany)<sup>115</sup> and Nicholas Trevet's *Compotus Hebreorum* (1310, England).<sup>116</sup> In addition, Roger Bacon (ca. 1214/20–ca. 1292) is known to have possessed a Hebrew manuscript containing a 247-year table, which he sent to Pope Clement IV commenting that it was “a wonderfull work of astronomical art and highly useful for the understanding of the [Mosaic] Law and the feasts prescribed by it”.<sup>117</sup>

Understanding the calendrical background of the feasts and other events mentioned in the Old Testament and reconstructing the chronology of the Scriptures appears to have been among the main interests that Christian scholars had in the Jewish calendar.<sup>118</sup> Another, more practical, concern was establishing the date of Easter in accordance with the precepts of the Mosaic Law. The turn to the contemporary Jewish calendar was based on a notion accepted by many Hebraists that the calendar used by medieval Jews was the same as that presupposed by the Hebrew Scriptures. A composition consisting of a 247-year cycle and a description of the fourteen possible types of the Jewish year was particularly well suited for elucidating the feasts prescribed in the Hebrew Bible and reconstructing Biblical chronology. A description of the fourteen year types contained all necessary information on the Jewish months, feasts and fasts. The 247-year cycle allowed working out the calendar for years in the distant past without complicated calculations. The application of the 247-year cycle for reconstructing Biblical chronology is explicit in *Tractatus de compoto Hebreorum aptato ad kalendarium* by Robert of Leicester, who used calendrical data obtained from the 247-year cycle to work out the internal chronology of the year of the Flood and the time of the Exodus from Egypt.<sup>119</sup> To simplify the application of data in a 247-year table to Biblical events, calendars in Robert of Leicester's and Nicholas Trevet's works start at the beginning of a 247-year cycle if counted from Creation, i.e. year 1 of their tables corresponds *modulo* 247 to 1 AM. Robert of Leicester's table starts in the 19-year cycle 261, precisely 20 247-year cycles from Creation. Nicholas Trevet's table is dated for four iterations of the cycle, starting in the 19-year cycles 222, 235, 248 and 261 respectively, 17–20 full 247-year cycles

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oldest dated document in the Cairo Genizah” (forthcoming).

113 Nothaft, *Medieval Latin Christian Texts*, 573–78, 586.

114 Nothaft, *Medieval Latin Christian Texts*, 139–335, esp. 161–62, 299.

115 Nothaft, *Medieval Latin Christian Texts*, 570–611, esp. 586–87.

116 Nothaft, *Medieval Latin Christian Texts*, 336–77, esp. 349–50, 363.

117 Nothaft, *Medieval Latin Christian Texts*, 31. C.P.E. Nothaft, *Dating the Passion: The life of Jesus and the emergence of scientific chronology (200-1600)* (Leiden, Boston: Brill, 2011), 183–84.

118 Nothaft, *Medieval Latin Christian Texts*, 11–12, 14.

119 Nothaft, *Medieval Latin Christian Texts*, 174–76, 180–81.

from Creation.<sup>120</sup>

In Jewish manuscripts there is very little evidence of 247-year cycles' being used for chronology. Tables usually start near the time of copying and are not purposefully synchronised with the era of Creation. I am aware of only one manuscript, London, BL OR. 11594, fol. 2v (Sefardi, 15th century), where the position in the 247-year cycle of the Exodus (פקודה) and of the destruction of the Temple (הרבן) are marked in a table beginning in the 19-year cycle 274, 21 247-year periods from Creation. Since these events represent the start of Jewish chronological eras, it is most likely that they were noted in the table to help people date events according to these eras.

### 7. Printed

247-year cycles continued to be a staple of calendar literature in the age of printing. A reiterative table was first printed in Guadalajara around 1482, possibly by Solomon Alkabiz.<sup>121</sup> A number of 16th-century printed books include 247-year cycles, among them a calendar treatise *She'erit Yosef* by Joseph ben Shem Ṭov ben Jeshua Hai printed in Salonika in 1521 and the distinct work of the same title by Daniel b. Perahya ha-Kohen (Salonika 1568). The first *Sefer Evronot* printed for a Jewish readership was issued by Jacob Marcaria in Riva di Trento in 1561, and has a reiterative calendar entitled *'Iggul de-Rav Naḥshon*. Such tables continued to be included in printed *Sifre Evronot* and other printed works on the Jewish calendar up until the 19th century.<sup>122</sup> In all these works the calendar is explicitly said to repeat itself forever (*ḥozer ḥalila*) and is frequently attributed to Naḥshon Gaon. In many of the printed works, the included tables contain outdated calendar data carried over from earlier iterations of the cycle.

Apart from calendar literature, 247-year cycles can be found in printed halakhic works. A calendar for four iterations of the 247-year cycle was included in printed editions of the legal codes *Arba'ah Ṭurim* (*Ṭur Oraḥ Ḥayyim*) by Jacob ben Asher and *Tsedah la-Derekh* by Menaḥem ben Aharon ibn Zerah, although the original tables found in manuscript copies of these works are non-cyclical.<sup>123</sup> A 247-year calendar is also included in *Levush Malkhut* by Mordecai Yoffe (1530–1612), a commentary on *Arba'ah Ṭurim*, *Ṭur Oraḥ Ḥayyim* published in 1590. Mordecai Yoffe stressed that this cycle did not recur, but included a correct table

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120 In contrast, the table in the Latin works composed in Germany, *Compotus philosophicus* and *Compotus novus* start near the time the works' composition time and is not synchronised with the start of a 247-year period counted from Creation.

121 *Gesamtkatalog der Wiegendrucke* (online), number M1603320, accessed on 26 March 2018.

122 For the 19th century, see Lazarus Bendavid, *Zur Berechnung und Geschichte des juedischen Kalenders: aus den Quellen geschöpft* (Berlin: Nicolaische Buchhandlung, 1817) and Reuven Joseph Wunderbar, *Immerwährender Kalender*. A review of Bendavid's treatise in the *Leipziger Literatur-Zeitung* (no. 280, 4 November 1817, cols 2237–2239) referred to the included reiterative calendar as "eine dem Verfertiger eines Judenkalenders nützliche and nothwendige Zugabe". For a discussion of Bendavid's views on reiterative calendar, and his 19th-century critics, see E. Carlebach, "When does the modern period of the Jewish calendar begin," in Lauren B. Strauss and Michael Brenner (eds), *Mediating Modernity: Challenges and trends in the Jewish encounter with the modern world: essays in honor of Michael A. Meyer* (Detroit: Wayne State University Press, 2008), 43–54, esp. 46–47, 50–51.

123 See Vidro, "Calendar tables," 79, 81. Compare this with the table in some copies of *Luḥot ha-Nasi* (see above, Appendix 1, *Sefarad and Provence*).

for 247 years in his commentary to in order to provide readers with an error-free table of the familiar format.

Refutations of the 247-year cycle can be found in a number of early-modern printed works. To give just two examples, a mathematician and calendar scholar Issachar Ibn Susan published a critique and a list of mistakes in a reiterative calendar that he witnessed in Salonika, most probably a copy of the table in *She'erit Yosef* by Joseph ben Shem Tov.<sup>124</sup> A refutation of the reiterative calendar in *Arba'ah Turim* was written by Hezekiah da Silva, who in his commentary on the compendium entitled *Peri H'adash* criticised the use of the 247-year cycle, pointed out mistakes in the reiterative calendars in *Arba'ah Turim* and *She'erit Yosef*, and provided a non-cyclical calendar 'up to the end of the world'.<sup>125</sup>

#### Appendix 2: List of manuscript sources

##### Appendix 2a

Manuscripts that either contain or discuss the 247-year cycle. Where the cycle is part of a known work, the title of the work is given in brackets. Genizah fragments that belong to the same manuscript are recorded as one source. Some manuscripts contain more than one 247-year cycle. Some cycles are incomplete.

Berlin, SBB, Or. Fol. 1198, 14th–15th c., Ashkenazi, fol. 42r

Berlin, SBB, Or. Oct. 352, ca. 1300, Ashkenazi, fols 13r, 17r–17v, 20r

Berlin, SBB, Or. Oct. 3150, 1649, Ashkenazi, fols 44v–45v

Berlin, SBB, Or. Qu 682 (Joseph b. Joseph ha-Levi, *Ner Israel*), 1455, Yemenite, fols 88v–89v, 93v

Berlin, SBB, Or. Qu. 826, 16th c., Italian, fol. 36r

Bet Nekofa, Kaplan 1, 18th c., Persian, fols 62r–62v

Budapest, MTAK, Kaufmann A 370, end 14th–15th c., Ashkenazi, p. 442

Budapest, MTAK, Kaufmann A 399, 14th c., Ashkenazi, pp. 460–461, 500

Budapest, MTAK, Kaufmann A 418, 16th–17th c., Italian, p. 127

Budapest, MTAK, Kaufmann A 513, 16th c., Italian, p. 209

Budapest, MTAK, Kaufmann A 515, 1598, Ashkenazi, p. 90

Budapest, MTAK, Kaufmann A 520, 16th c., Ashkenazi, pp. 115–116

Cambridge, CUL, T-S 6K2.1, late 12th–early 13th c., Oriental

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<sup>124</sup> Issachar Ibn Susan, *Tiqqun Issachar* (Venice, 1578/9, fols 10v–11v). See above, footnote 51. See also Carlebach, *Palaces of Time*, 52–53.

<sup>125</sup> First published in Amsterdam 1706, fols 5r–6v (commentary on *Arba'ah Turim*, *Tur Oraḥ Hayyim* chapter 428).

Cambridge, CUL, T-S 10K20.2 and T-S K19.12, 13th–14th c., Oriental

Cambridge, CUL, T-S K2.8, ca. 1297, Oriental

Cambridge, CUL, T-S K2.41, 13th–14th c., Oriental

Cambridge, CUL, T-S K2.82 and T-S AS 144.72, 13th–14th c., Oriental

Cambridge, CUL, T-S K2.90, 14th c.(?), Oriental

Cambridge, CUL, T-S Ar.2.7, 13th c., Oriental

Cambridge, CUL, T-S Ar.2.12, late 12th c., Oriental

Cambridge, CUL, T-S Ar.29.31 and T-S Ar.29.3v, 13th–14th c., Oriental

Cambridge, CUL, T-S Ar.29.135 and T-S Ar.29.3r, 11th–12th c., Oriental

Cambridge, CUL, T-S NS 98.2 and T-S AS 144.118, 13th–14th c., Oriental

Cambridge, CUL, T-S NS 98.40, T-S Misc.25.29 and T-S AS 144.164, Oxford, Bodl. Heb e. 100.46, 2nd half of the 12th–1st half of the 13th c., Oriental

Cambridge, CUL, T-S NS 98.95, Oriental

Cambridge, CUL, T-S NS 312.94, 13th–14th c., Oriental

Cambridge, CUL, T-S AS 144.32, 13th c.?, Oriental

Cambridge, CUL, T-S AS 144.46 and T-S AS 144.166, 12th–14th c., Oriental

Cambridge, CUL, T-S AS 144.111, 12th c., Oriental

Cambridge, CUL, T-S AS 144.228, T-S AS 144.286 and T-S AS 203.216, 12th c., Oriental

Cambridge, CUL, Add.491.2, 15th c., Italian, fols 157r–160v

Cambridge, CUL, Add.635 (Zalman of St. Goar, *Sefer Maharil*), 1465, fol. 210r

Cambridge, CUL, Add.642, 14th–15th c., Italian, fols 186r–194v

Cambridge, CUL, Add.1200, 16th–17th c., Yemenite, fol. 166v

Cambridge, CUL, Add.1727, 16th–17th c., Yemenite, fols 252v–253r

Cambridge, CUL, Add.3127, 1399, Ashkenazi, fol. 330v

Cambridge, CUL, Add.3203, 15th c., Sefardi, 6v–7r, 9v

Cambridge, Trinity College, F 12 21, 14th c., Ashkenazi, fol. 10v

Cambridge, Trinity College, F 12 22, 14th–15th c., Ashkenazi, fol. 6v

Cesena, Biblioteca Malatestiana, Pluteo sinistro XXIX.4 (Abraham Bar Ḥayya, *Luḥot ha-Nasi*), 14th c., fol. 3v

Cincinnati, HUC 436, 1435, Ashkenazi, fols 191r–191v

Cincinnati, HUC 717, 17th c., Ashkenazi, fol. 9r

Copenhagen, Det Kgl. Bibliotek, Cod. Sim. Hebr. 37, 1749, Ashkenazi, fols 61r–61v

Florence, BML, Laur. Plut.I.08, 1553, Sefardi, fol. 43  
 Frankfurt, UB, Oct. 31, 17th c., Ashkenazi, fols 38v–39r  
 Frankfurt, UB, Oct. 35, end 13th c., Ashkenazi, fols 29v–41r  
 Frankfurt, UB, Oct. 94 (Zalman of St. Goar, *Sefer Maharil*), 1460, Ashkenazi, fol. 219v  
 Frankfurt, UB, Oct. 120, 17th–18th c., Ashkenazi, fols 19v–20r  
 Frankfurt, UB, Oct. 142, 15th c., Italian, fols 58r–72r  
 Hamburg, SUB, Cod. Hebr. 246 (Jacob ben Asher, *Arba'ah Turim*), 1464, Ashkenazi, fol. 56r  
 Hamburg, SUB, Cod. Hebr. 249, 15th c., Ashkenazi, fol. 30r  
 Hamburg, SUB, Cod. Hebr. 37, 1434, Ashkenazi, fols 122r, 125v  
 Holon, Nahum 116, 1580, Yemenite, fols 58v–60r  
 Holon, Nahum 177, 17th c., Yemenite, fols 151v–155r  
 Imola, Biblioteca Comunale, A A 3 23 Ms. N 77, 15th c., Sefardi, fol. 335r  
 Jerusalem, Ben Zvi Institute 1236, 17th c., Yemenite, fols 2r, 10r, 11v–12r, 14v–15r  
 Jerusalem, Mossad ha-Rav Kook, OL 246, 1850, Oriental, fols 1v–2v  
 Jerusalem, Kapah 16 (Joseph b. Joseph ha-Levi, *Ner Israel*), Yemenite, 9r–10r, 12v, 13v–14r  
 Jerusalem, NLI, Heb. 8°1997, late 15th c., Italian, fol. 73r  
 Jerusalem, NLI, Heb. 8°2380, 1716, Ashkenazi, fols 51r–52r  
 Jerusalem, NLI, Heb. 8°3857, 15th c., Ashkenazi, fols 60r–63r  
 Jerusalem, NLI, Heb. 38°4281, 1391, Italian, fols 298r–314v  
 Kiev, OPI 753, 17th c., Yemenite, fols 149v–150r  
 Leiden, UB, Cod. Or. 4730, ca. 1465, Italian, fols 14v–15v  
 London, BL, Add 18684, 1392, Ashkenazi, fol. 48r (marginal note in a secondary 15th-c. hand)  
 London, BL, Add 26970, 1308, Ashkenazi, fol. 182r  
 London, BL, Add 27150 (Jacob ben Asher, *Arba'ah Turim*), 1492, Italian, fol. 99r  
 London, BL, Add 27205, late 12th–13th c., Ashkenazi, fol. 175r  
 London, BL, Harley 5716 (Jacob ben Asher, *Arba'ah Turim*), 1475, Sefardi, fol. 100r  
 London, BL, Harley 5584, 14th–15th c., Ashkenazi, fols 173r–174r  
 London, BL, Or 2227, 1540, Yemenite, fols 199r–201v  
 London, BL, Or 2389, 1635, Yemenite, fols 140v, 141v–145r  
 London, BL, Or 2451, 1483–1484, Persian, fols 362v–375v, 378r  
 London, BL, Or 2674, 15th c., Italian, fols 138r–140r

London, BL, Or 4104 (Joseph b. Joseph ha-Levi, *Ner Israel*), 15th c., Yemenite, fols 10r–11r, 13r–15v, 20r, 21v

London, BL, Or 5866, 15th c., Sefardi, fols 3v–4r

London, BL, Or 9884, 15th c., Persian, fols 308r-317r, 321r–321v

London, BL, Or 10576, 16th–17th c., Persian, fols 153r–159r

London, BL, Or 10702, 15th c., Persian, fol. 30r

London, BL, Or 10765, 16th c., Yemenite, fol. 126r

London, BL, Or 11594, 15th c., Sefardi, fol. 2v

Manchester, Rylands B 3390 and Rylands B 5508, 11th–13th c., Oriental

Milan, Ambrosiana, X 123 sup (Jacob ben Asher, *Arba'ah Turim*), ca. 1479, Ashkenazi, fol. 167v

Moscow, RSL, Guenzburg 107, 1329, Sefardi/ Provençal, fol. 264r

Moscow, RSL, Guenzburg 365-1, 17th–18th c., Italian, fol. 134r

Moscow, RSL, Guenzburg 365-2, 15th–16th c., different Provençal hands, fols 147r–148r, 163v, 164v, 231r–231v, 271v

Moscow, RSL, Guenzburg 481, late 12th–early 13th c., Ashkenazi, fols 101v–102r

Moscow, RSL, Guenzburg 705, 15th–16th c., Italian, fol. 48r

Moscow, RSL, Guenzburg 746, 15th c., Byzantine, fols 186v–193r

Moscow, RSL, Guenzburg 821, 14th–15th c., Sefardi, fol. 230v

Moscow, RSL, Guenzburg 983, 13th–14th c.?, Ashkenazi, fol. 30r

Moscow, RSL, Guenzburg 1068, 16th c., Italian, fol. 47r

Moscow, RSL, Guenzburg 1379, 17th c., Ashkenazi, fols 12r–12v

Moscow, RSL, Guenzburg 1380, 1717, Ashkenazi, fol. 9r

Moscow, RSL, Guenzburg 1451, 1536, Italian, fol. 94r

Munich, BSB, Cod. hebr. 109, 15th c., Sefardi, fols 38r–38v

Munich, BSB, Cod. hebr. 128, 15th c., Provençal, fol. 28r

Munich, BSB, Cod. hebr. 343, 15th c., Sefardi/Provençal, fol. 167v

Munich, BSB, Cod. hebr. 394-1, 1677, Ashkenazi, fols 11r–12r

Munich, BSB, Cod. hebr. 394-2, 1566, Ashkenazi, fol. 72v

New York, JTS, 2435, 15th c., Byzantine, fols 50r–50v

New York, JTS, 2540, 1631, Ashkenazi, fols 32r, 41v–42r

New York, JTS, 2548, 16th c., Ashkenazi, fols 4r, 41r–v

New York, JTS, 2590, 15th c., Italian, fols 6r–16r

New York, JTS, 2641, 16th c., Italian, fols 16v–17r

New York, JTS, 4246, end 13th–beginning 14th c., Ashkenazi, fols 1r–11r

New York, JTS, 4463, 18th c., Yemenite, fols 98r–98v

New York, JTS, 4660, 1531, Ashkenazi, fol. 70v

New York, JTS, 5543, 15th c., Yemenite, fols 37r–40v

New York, JTS, 8892, 1490, Italian, fols 441r–442r, 443v–450r

New York, JTS, 9227, 15th–16th c., Yemenite, fols 1r–3r

New York, JTS, 9487, 16th c., Ashkenazi, fol. 32v

New York, JTS, ENA 1640.5 and ENA 3329, 13th–14th c., Oriental

New York, JTS, ENA 2752.21, 14th c.(?), Oriental

New York, JTS, ENA 3082.4, 1266 or later, Oriental

New York, JTS, ENA 3616.32, 1266 or later, Oriental

New York, JTS, Rab. 532 (Zalman of St. Goar, *Sefer Maharil*), 1473, Ashkenazi, fols 459r, 462v

New York, JTS, Rab. 689 (Jacob ben Asher, *Arba'ah Turim*), 1437, Ashkenazi, fol. 122r

Oxford, Bodl., Canon Or. 1, 14th c., Ashkenazi, fols 81r, 88r

Oxford, Bodl., Heb. d. 11, 14th c., Ashkenazi, fol. 4r

Oxford, Bodl., Heb. e. 45.45–56, 1152, Oriental

Oxford, Bodl., Heb. e. 60, 1485, Persian, fols 450r–462r

Oxford, Bodl., Laud. Or. 166 (Jacob ben Asher, *Arba'ah Turim*), 1470, Ashkenazi, fol. 147r

Oxford, Bodl., Marsh 114 (Abraham Bar Ḥayya, *Luḥot ha-Nasi*), 14th c., Sefardi/Provençal, fol. 22r

Oxford, Bodl., Mich. 74, 14th c., Ashkenazi, fols 3r, 12v

Oxford, Bodl., Mich. 260 (16th c., Ashkenazi): 247-year cycle (fol. 83r)

Oxford, Bodl., Mich. 292 (Zalman of St. Goar, *Sefer Maharil*), 1450, Ashkenazi, fol. 152r

Oxford, Bodl., Mich. 328, 14th c., Ashkenazi, fol. 294r

Oxford, Bodl., Mich. 330, 1559, Ashkenazi, fols 10r–11r, 21r

Oxford, Bodl., Mich. 369 (Jacob ben Asher, *Arba'ah Turim*), 1444, Ashkenazi, fol. 71r

Oxford, Bodl., Mich. 484, 16th c., Italian, fol. 169r

Oxford, Bodl., Mich. 569, 13th c., Ashkenazi, fols 89v–94v

Oxford, Bodl., Opp. 59, 14th c., Ashkenazi, fol. 164r

Oxford, Bodl., Opp. 332, 16th c., Ashkenazi, fol. 162v

Oxford, Bodl., Opp. 614, 14th c., Ashkenazi, fols 50v–55r

Oxford, Bodl., Opp. 642, 14th c., Ashkenazi, fols 308v–309v

Oxford, Bodl., Opp. 701, 1586, Ashkenazi, fol. 33r

Oxford, Bodl., Opp. 712, 16th c., Ashkenazi, fol. 295r

Oxford, Bodl., Opp. 758, 14th c., Ashkenazi, Liturgy, 338r–345

Oxford, Bodl., Opp. Add. Qu. 157 (Joseph b. Joseph ha-Levi, *Ner Israel*), 15th c., Yemenite, fols 12r–12v, 17v–18v

Oxford, Bodl., Poc. 182-1 (Obadiah b. David, Commentary on Maimonides' *Sanctification of the Moon*), 14th c., Oriental, fols 68v–71v

Oxford, Bodl., Poc. 182-2, 14th c., Oriental, fol. 169v

Oxford, Bodl., Poc. 368, 15th c., Byzantine, fol. 219r

Oxford, Bodl., Regg. 43 (Profiat Duran, *Heshev ha-Efod*), 14th–15th c., Sefardi, fol. 35v

Paris, Cluny Museum of the Medieval World, 12290, 14th c., Ashkenazi, fol. 294v

Paris, AIU, H 21 A (Zalman of St. Goar, *Sefer Maharil*), 1475, Ashkenazi, fol. 142r

Paris, BNF, heb. 20, 1300, Sefardi, fols 3r–6v

Paris, BNF, heb. 21, 14th c., Sefardi, 2r-3v

Paris, BNF, heb. 263, 1481, Italian, fols 57v–60r

Paris, BNF heb. 426 (Jacob ben Asher, *Arba'ah Turim*), 1455, Ashkenazi, fol. 102v

Paris, BNF, heb. 429 (Jacob ben Asher, *Arba'ah Turim*), 15th c., Ashkenazi, fol. 48r

Paris, BNF, heb. 605, 1401, Italian, fols 323v–331r

Paris, BNF, heb. 609, 1348, Italian, fols 298r–308r

Paris, BNF, heb. 620, 14th–15th c., Italian, fols 280r-285r

Paris, BNF, heb. 642, 15th c., Sefardi/ Provençal, fols 183v–184v (marginalia)

Paris, BNF, heb. 646, 14th c., Ashkenazi, fols 138v–139v

Paris, BNF, heb. 1032, 14th c., Ashkenazi, fols 1r–11r

Paris, BNF, heb. 1064 (Abraham Bar Ḥayya, *Luḥot ha-Nasi*), 15th c., Sefardi, fol. 81r

Paris, BNF, heb. 1077, 15th–16th c., Ashkenazi, fol. 51r

Paris, BNF, heb. 1089, 15th–16th c., Italian, fols 34v–36v

Paris, BNF, heb. 1311, 15th c., Italian, fols 91v–105v

Paris, BNF, heb. 1331, 17th c., Yemenite, fols 123r–126v

Paris, BNF, heb. 1480, 15th c. secondary hand, Ashkenazi, fol. 203r

Parma, Palatina, Cod. Parm. 350, 14th–15th c., Italian, fols 385v–392v



Parma, Palatina, Cod. Parm. 1902, 1470, Ashkenazi, fol. 276v

Parma, Palatina, Cod. Parm. 2295, 13th–14th c., Ashkenazi, fols 101v–106r

Parma, Palatina, Cod. Parm. 2467, 15th c., Sefardi, fols 46v–54v

Parma, Palatina, Cod. Parm. 3004, 15th c. secondary hand, Ashkenazi, fol. 317v

Parma, Palatina, Cod. Parm. 3134, 14th–15th c., Italian, fols 348r–355v

Parma, Palatina, Cod. Parm. 3228, 16th c. secondary hand, Italian, fol. 243v

Parma, Palatina, Cod. Parm. 3518-1, 14th c., Ashkenazi, fol. 16v

Parma, Palatina, Cod. Parm. 3518-2, 15th c. secondary hand, Sefardi, fols 38v–39r

Parma, Palatina, Cod. Parm. 3821 (Abraham Bar Ḥayya, *Luḥot ha-Nasi*), 14th–15th c., Sefardi, fol. 10v

Sassoon Collection, 368 (The Farhi Codex), 1366–1383, Sefardi, fol. 12

St. Petersburg, RNL, Evr. I 237, 14th c., Oriental, fols 11v–12r

Vatican, BAV, ebr. 152 (Jacob ben Asher, *Arba'ah Turim*), 15th c., Ashkenazi, fol. 158r

Vatican, BAV, ebr. 303, 14th c., Byzantine, fol. 190v

Vatican, BAV, ebr. 318, 14th c.?, Ashkenazi, fol. 259v

Vatican, BAV, ebr. 323, 14th–15th c., Ashkenazi, fol. 198r

Vatican, BAV, ebr. 387, 15th c., Italian, fol. 162v

Vatican, BAV, ebr. 423, 15th c., Italian, fols 30r–36v

Vatican, BAV, Ross. 437, 1448, Italian, fols 395r–403v

Vienna, ONB, Cod. hebr. 75 (Zalman of St. Goar, *Sefer Maharil*), 1468?, fol. 154r

Vienna, ONB, Cod. hebr. 175 (Zalman of St. Goar, *Sefer Maharil*), 1470, fols 6r–6v

Zurich, Braginsky, 247, 17th c., Ashkenazi, fols 45v–46r

Zurich, Jeselsohn, 16, 14th c., Ashkenazi, fols 147r–151v

Zurich Jeselsohn, 17, 1280?, Ashkenazi, liturgy: siddur, 263v–264r

Zurich, ZB, Heid. 51, 14th–15th c., Ashkenazi, fols 3r–5v

Zurich, ZB, Heid. 145, 1348, Ashkenazi, fol 45v (marginal note in a secondary 15th-c. hand)

## Appendix 2b

Manuscripts that contains calendars with mistakes due to the use of the 247-year cycle despite covering less than thirteen 19-year cycles, having no cyclicity statements and not being associated with R. Naḥshon or Josiah b. Mevorakh al-‘Āqūlī

Bern, Burgerbibliothek, Cod. 253 (Jacob ben Asher, *Arba'ah Turim*), 15th c., Ashkenazi, fol. 84r

Budapest, MTA, Kaufmann A 520, 16th c., Ashkenazi, pp. 117, 139

Cambridge, CUL, T-S K2.42, 14th–15th c., Sefardi

Cambridge, CUL, Add.391, 4 (Profiat Duran, *Ḥeshev ha-Efod*), 16th c., Italian, fols 246r, 261r

Cambridge, CUL, Add.667.1, 13th–14th c., Ashkenazi, fol. 185v

Cincinnati, HUC 439, 15th c., Ashkenazi, fols 197r–198v

Frankfurt, UB, Oct. 31, 17th c., Ashkenazi, p. 36r

Hamburg, SUB, Cod. Hebr. 91, 1412, Ashkenazi, fol. 195v

Jerusalem, NLI, Heb. 8°1282, 14th c., Ashkenazi, fols 17v–18r

Jerusalem, NLI, Heb. 8°3857, 15th c., Ashkenazi, fols 21r–22r

Jerusalem, NLI, Heb. 34°1114, 1419, Ashkenazi, fols 242r–242v

London, BL, Add 11639, 13th c., Ashkenazi, fol. 536v

London, BL, Or 2674, 15th c., Italian, fols 131v–137v

Mantua, Comunita Israelitica, ebr. 10 (Profiat Duran, *Ḥeshev ha-Efod*), 15th c., Sefardi, fol. 97v

Moscow, RSL, Guenzburg 421, 18th c., Oriental, fol. 78r

Moscow, RSL, Guenzburg 453 (Profiat Duran, *Ḥeshev ha-Efod*). 15th–16th c., Italian, fols 20v, 30v

Munich, BSB, Cod. hebr. 299 (Profiat Duran, *Ḥeshev ha-Efod*), 15th–16th c., Sefardi, fols 29r, 35r

New York, JTS, 2435, 15th c., Byzantine, fols 50v–55v

New York, JTS, 2540, 1631, Ashkenazi, fols 40r, 42v

New York, JTS, 2569, 19th c., Sefardi, fol. 124v

New York, JTS, 2590, 15th c., Italian, fols 22r–22v

New York, JTS, 2641, 16th c., Italian, fols 27r–28v

Oxford, Bodl., Canon Or. 1, 14th c. secondary hand, Ashkenazi, fol. 92v

Oxford, Bodl., Opp. 156, 15th c., fol. 82r

Oxford, Bodl., Poc. 262, 1202, Oriental, fols 249r–251v

Oxford, Bodl., Regg. 49, 1491, Byzantine, fols 71r–74v

Paris, BNF, heb. 1047, 15th c., Byzantine, fols 156r–157r

Paris, BNF, heb. 1311, 15th c., Italian, fol. 114r

Parma, Palatina, Cod. Parm. 2018, 1484, Sefardi, fol. 5v  
 Parma, Palatina, Cod. Parm. 2198, 15th–16th c., Italian, fols 45r–51v  
 Parma, Palatina, Cod. Parm. 2412, 14th c., Ashkenazi, fols 24r–28r  
 Parma, Palatina, Cod. Parm. 2776 (Profiat Duran, *Ḥeshev ha-Efod*), 15th c., Sefardi, fols 113r, 130v  
 Parma, Palatina, Cod. Parm. 3266, 14th c., Ashkenazi, fols 19r–22r  
 Toronto, University of Toronto Libraries, Fr 3-016, 14th c., Ashkenazi, fols 90v–91r  
 Vatican, BAV, ebr. 318, 15th c. secondary hand, Ashkenazi, fols 275r–277r  
 Vatican, BAV, Ross. 555 (Jacob ben Asher, *Arba'ah Turim*), 1436, Italian, fol. 78r  
 Vienna, ONB, Cod. hebr. 127 (Jacob ben Asher, *Arba'ah Turim*), 1436, Ashkenazi, fol. 61v  
 Zurich, Jeselsohn, 16, 16th c. secondary hand, Ashkenazi, fol. 146v  
 Zurich, ZB, Heid. 145, 14th c., Ashkenazi, fols 45v–46r, 167r

#### Appendix 2c

Manuscripts that contains calendars for more than but not a multiple of thirteen 19-year cycles with mistakes due to the use of the 247-year cycle

Berlin, SBB, Or. Qu 649 (Abraham Bar Ḥayya, *Luḥot ha-Nasi*), 15th c., Sefardi, fol. 1v  
 Cambridge, CUL, Add.548 (Jacob ben Asher, *Arba'ah Turim*), 15th c., Sefardi, fol. 148r  
 Cambridge, CUL, Add.1199.1 (Jacob ben Asher, *Arba'ah Turim*), 1432, Byzantine, fol. 150v  
 Cambridge, CUL, Oo.6.65 (Isaac Israeli, *Yesod 'Olam*), 16th–17th c., Sefardi, fol. 21r  
 Chicago, Newberry Library, 2 (Abraham Bar Ḥayya, *Luḥot ha-Nasi*), 15th c., Sefardi  
 Florence, Laurentian Library, Or. 491 (Abraham Bar Ḥayya, *Sefer ha-'Ibbur*), 14th–15th c., Italian  
 Frankfurt, UB, Oct. 31, 17th c., Ashkenazi, fol. 39v  
 Hamburg, SUB, Cod. Hebr. 34 (Jacob ben Asher, *Arba'ah Turim*), 14th–15th c., Ashkenazi, fol 260r–260v  
 Leipzig, UBL, B.H. fol. 8 (Jacob ben Asher, *Arba'ah Turim*), probably before 1412, Ashkenazi, fol. 133v  
 London, BL, Add 15977 (Isaac Israeli, *Yesod 'Olam*), 15th c., Sefardi, fol. 178r  
 London, BL, Add 26899 (Abraham Bar Ḥayya, *Sefer ha-'Ibbur*), 1316/1317, Italian, fol. 63r  
 London, BL, Or. 10583 (Abraham Bar Ḥayya, *Sefer ha-'Ibbur*), 14th–15th c., Italian, fol. 87r  
 London, BL, Or. 11796 (Abraham Bar Ḥayya, *Luḥot ha-Nasi*), 15th c., Sefardi, fol. 3r–4r  
 Modena, Estense University Library, a.W.8.10 (Isaac Israeli, *Yesod 'Olam*), 14th–15th c.,

Sefardi, fol. 184r

Moscow, RSL, Guenzburg 571 (Isaac Israeli, *Yesod 'Olam*), 1770, Italian, fol. 116r

Munich, BSB, Cod. hebr. 421 (Jacob ben Asher, *Arba'ah Turim*), 14th–15th c., Ashkenazi, fols 112v, 113v

New York, JTS, 5512 (Abraham Bar Ḥayya, *Sefer ha-'Ibbur*), 14th c., Italian, fol. 45r

New York, JTS, 8188 (Jacob ben Asher, *Arba'ah Turim*), 15th c., Ashkenazi, fol. 32r

New York, JTS, Rab. 527 (Jacob ben Asher, *Arba'ah Turim*), 1380, Sefardi, fol. 184v

New York, JTS, Rab. 1147 (Jacob ben Asher, *Arba'ah Turim*), 1450, Ashkenazi, fol. 106v

Oxford, Bodl., Hunt. 299 (Isaac Israeli, *Yesod 'Olam*), 1484, Sefardi, fol. 239r

Oxford, Bodl., Hunt. 327 (Abraham Bar Ḥayya, *Luḥot ha-Nasi*), 13th–15th c., Provençal, fols 3r–4r

Oxford, Bodl., Mich. 127 (Jacob ben Asher, *Arba'ah Turim*), 15th c., Ashkenazi, fol. 170r–170v

Oxford, Bodl., Opp. 51 (Jacob ben Asher, *Arba'ah Turim*), 1456, Ashkenazi, fol. 169v

Oxford, Bodl., Opp. 53 (Jacob ben Asher, *Arba'ah Turim*), 14th–15th c., Ashkenazi, fol. 93r

Oxford, Bodl., Poc. 368 (Isaac Israeli, *Yesod 'Olam*), 14th–15th c., Byzantine, fol. 206r

Paris, BNF, heb. 422 (Jacob ben Asher, *Arba'ah Turim*), 1487, Ashkenazi, fol. 70v

Paris, BNF, heb. 430 (Jacob ben Asher, *Arba'ah Turim*), 15th c., Ashkenazi, fol. 1r

Paris, BNF, heb. 1038 (Abraham Bar Ḥayya, *Luḥot ha-Nasi*), 14th–15th c., Sefardi, fols 5v–6r

Paris, BNF, heb. 1045 (Abraham Bar Ḥayya, *Luḥot ha-Nasi*), 15th c., Sefardi, fols 1v, 13v

Paris, BNF, heb. 1046 (Abraham Bar Ḥayya, *Luḥot ha-Nasi*), 15th c., Sefardi, fol. 2r

Paris, BNF, heb. 1068 (Isaac Israeli, *Yesod 'Olam*), 15–16th c., Sefardi, fol. 123v

Paris, BNF, heb. 1069 (Isaac Israeli, *Yesod 'Olam*), 1491, Sefardi, fol. 137v

Paris, BNF, heb. 1070 (Isaac Israeli, *Yesod 'Olam*), 16th c., Italian, fol. 172r

Paris, BNF, heb. 1072 (Isaac Israeli, *Yesod 'Olam*), 15th–16th c., Sefardi/Byzantine, fol. 88r

Parma, Palatina, Cod. Parm. 1741 (extract from Isaac Israeli, *Yesod 'Olam*), 15th c., Sefardi, fols 4v–5v

Parma, Palatina, Cod. Parm. 3262, 1459, Sefardi, fol. 85v

St. Petersburg, RNL, Evr. I 209 (Jacob ben Asher, *Arba'ah Turim*), 1419, Ashkenazi, fol. 118v

St. Petersburg, RNL, Evr. I 210 (Jacob ben Asher, *Arba'ah Turim*), 14th–15th c., Ashkenazi, fol. 66r

St. Petersburg, RNL, Evr. I 211 (Jacob ben Asher, *Arba'ah Turim*), 15th c. (ca. 1456?), Ashkenazi, fol. 54v

Toronto, University of Toronto Libraries, Fr 5–014 (Jacob ben Asher, *Arba'ah Turim*), 14th c.?, Sefardi, fol. 46v

fol. 56v

Vatican, BAV, Neofiti 30 (Abraham Bar Ḥayya, *Sefer ha-ʿIbbur*), 15th c., Italian, fol. 99v

Vatican, BAV, Neofiti 31 (Isaac Israeli, *Yesod ʿOlam*), 14th–15th c., Sefardi, fol. 146r

Vatican, BAV, Ross. 600 (Jacob ben Asher, *Arba'ah Turim*), 16th c.? secondary hand, Italian, fol. 76v

Vatican, BAV, Urb. 48 (Abraham Bar Ḥayya, *Sefer ha-ʿIbbur*), 13–14 th c., Italian, fol. 56v