

**SOLVING TWO PROBLEMS
RELATED TO DETERMINING THE DATE FOR EASTER**

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Abstract. *In this paper we solve two technical problems concerning Easter data. Thus over a period of 917 years, i.e. between 1583 and 2499, we will calculate Easter dates in the two churches (Orthodox and Catholic), we determine all pairs and triples of consecutive years with the same Easter dates and we will find other interesting results in this sense. We will also find the mistake in determining the date of Orthodox Easter after 2100. To justify their answers to a number of questions that may occur in connection with establishment of Easter data all results and their consequences are presented in tables.*

Keywords: *Church, Easter, Easter dates, algorithms, years.*

1. Solving problems

As we mentioned above, in this paper we solve two problems concerning Easter data; they are as follows:

a. *There have been, onwards 1583, three consecutive years with the same Easter dates in two churches: Orthodox and Catholic?*

b. *Why all the Easter dates calculated by the Orthodox Church after 2100 and recorded in the books of worship are wrong?*

First we mention that this is a technical work and, therefore we assume that the reader of this paper is familiar with the concepts being operated here, that has knowledge:

- The difference between the Jewish Passover and Christian;
- The link between establishment of the Easter date and the calendar issue;
- The difference between the Julian calendar and the Gregorian calendar;
- How was Easter celebration in the early church, until 325;
- Canon of the Ecumenical Council of Nicaea in 325 concerning the establishment of date and celebration of Easter;
- Establishment of the date and celebration of the Passover between 325 - 1582;
- Calendar reform from 1582;
- The adoption of the Gregorian calendar in different countries and its use in calculating the date of Easter;
- Pan-Orthodox Congress in Constantinople 1923;
- Algorithms for determining the date of Easter in those two Church (Orthodox and Catholic)¹.

¹ Religious and scientific information and data's are taken from: C. Blaga, *Sistemul nostru solar, (Our Solar System)*, Cluj-Napoca, Editura Albastră, 2001; S. Hawking, *Scurta istorie a timpului, (Brief History of Time)*, Bucureşti, Editura Humanitas, 2012; A. Pal, V. Ureche, V. Pop,

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Of course he has knowledge the 11 "problems" mentioned above, know that always, Catholic Easter date is between March 22 and April 25. Because of calendar reform from 1582 and establishing a difference of days between the two calendars (Julian and Gregorian), the method of calculating the Easter date in the Orthodox Church, interval convenient of the date Orthodox Easter and the interval common to both data Easter is changing according to the table below:

The transition to the Gregorian calendar			
Period	The number of days that adds	Orthodox Easter date Interval	Interval data common to both Easter
from 1583 to 1699	10	01 April – 05 May	01 April – 25 April
from 1700 to 1799	11	02 April – 06 May	02 April – 25 April
from 1800 to 1899	12	03 April – 07 May	03 April – 25 April
from 1900 to 2099	13	04 April – 08 May	04 April – 25 April
from 2100 to 2199	14	05 April – 09 May	05 April – 25 April
from 2200 to 2299	15	06 April – 10 May	06 April – 25 April
from 2300 to 2499	16	07 April – 11 May	07 April – 25 April
from 2500 to 2599	17	08 April – 12 May	08 April – 25 April
from 2600 to 2699	18	09 April – 13 May	09 April – 25 April
from 2700 to 2899	19	10 April – 14 May	10 April – 25 April
from 2900 to 2999	20	11 April – 15 May	11 April – 25 April
from 3000 to 3099	21	12 April – 16 May	12 April – 25 April
from 3100 to 3299	22	13 April – 17 May	13 April – 25 April
from 3300 to 3399	23	14 April – 18 May	14 April – 25 April

Calcul	A=1589	A=1627	A=1753	A=1875	A=1998	A=2010
$a = A \bmod 4$	$a = 1$	$a = 3$	$a = 1$	$a = 3$	$a = 2$	$a = 2$
$b = A \bmod 7$	$b = 0$	$b = 3$	$b = 3$	$b = 6$	$b = 3$	$b = 1$
$c = A \bmod 19$	$c = 12$	$c = 12$	$c = 5$	$c = 13$	$c = 3$	$c = 15$
$d = (19c + 15) \bmod 30$	$d = 3$	$d = 3$	$d = 20$	$d = 22$	$d = 12$	$d = 0$
$e = (2a + 4b - d + 34) \bmod 7$	$e = 5$	$e = 0$	$e = 0$	$e = 0$	$e = 3$	$e = 0$

Astronomie, (Astronomy), București, Editura Didactică și Pedagogică, 1986; V. Ureche, *Astronomie, (Astronomy)*, Universul, vol I, Cluj-Napoca, Editura Dacia, 1983; ***, *Rugăciuni și învățături de credință ortodoxă, (Prayers and teachings of the Orthodox Faith)*, Oradea, Editura Episcopiei Oradiei, 1990.

$month = \lfloor (d + e + 114) / 31 \rfloor$	3 (March)	3 (March)	4 (April)	(April) 4	(April)	3 (March)
$day = ((d + e + 114) \bmod 31) + 1$	30	25	11	13	6	22
Date of Easter (Julian calendar)	30 March 1589	25 March 1627	11 April 1753	13 April 1875	6 April 1998	22 March 2010
Date of Easter (Gregorian calendar)	9 April 1589	4 April 1627	22 April 1753	25 April 1875	19 April 2010	4 April 2010

To solve the two problems mentioned above, we calculated all the Easter dates for the two churches (Orthodox and Catholic) for a period of 917 years, i.e. each year from 1583 until 2499, inclusive. Thus, we used the following computational algorithms Easter data presented and exemplified in the tables below:

a) *For Orthodox Easter date:*

b) *For Catholic Easter date:*

In this case the algorithm is somehow more complicated. The examples are for the same years:

Calcul	$\Lambda=1$ 589	$\Lambda=1627$	$\Lambda=1753$	$\Lambda=187$ 5	$\Lambda=199$ 8	$\Lambda=2010$
$a = A \bmod 19$	$a = 12$	$a = 12$	$a = 5$	$a = 13$	$a = 3$	$a = 15$
$b = \lfloor (A / 100) \rfloor$	$b = 15$	$b = 16$	$b = 17$	$b = 18$	$b = 19$	$b = 20$
$c = A \bmod 100$	$c = 89$	$c = 27$	$c = 53$	$c = 75$	$c = 98$	$c = 10$
$d = \lfloor (b / 4) \rfloor$	$d = 3$	$d = 4$	$d = 4$	$d = 4$	$d = 4$	$d = 5$
$e = b \bmod 4$	$e = 3$	$e = 0$	$e = 1$	$e = 2$	$e = 3$	$e = 0$
$f = \lfloor ((b + 8) / 25) \rfloor$	$f = 0$	$f = 0$	$f = 1$	$f = 1$	$f = 1$	$f = 1$
$g = \lfloor ((b - f + 1) / 3) \rfloor$	$g = 5$	$g = 5$	$g = 5$	$g = 6$	$g = 6$	$g = 6$
$h = (19a + b - d - g + 15) \bmod 30$	$h = 10$	$h = 10$	$h = 28$	$h = 0$	$h = 21$	$h = 9$
$i = \lfloor (c / 4) \rfloor$	$i = 22$	$i = 6$	$i = 13$	$i = 18$	$i = 24$	$i = 2$
$k = c \bmod 4$	$k = 1$	$k = 3$	$k = 1$	$k = 3$	$k = 2$	$k = 2$
$L = (32 + 2e + 2i - h - k) \bmod 7$	$L = 1$	$L = 3$	$L = 3$	$L = 6$	$L = 0$	$L = 4$
$m = \lfloor ((a + 11b + 22L) / 451) \rfloor$	$m = 0$	$m = 0$	$m = 0$	$m = 0$	$m = 0$	$m = 0$
$month = \lfloor ((b + L - 7m + 114) / 31) \rfloor$	4 (April)	4 (April)	4 (April)	3 (March)	4 (April)	4 (April)
$day = ((b + L - 7m + 114) \bmod 31) + 1$	2	4	22	28	12	4
Date of Easter	2	4 April	22 April	28	12 April	4 April

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	April 1589	1627	1753	March 1875	1998	2010
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Using these two algorithms translatable into Excel program, we obtained very easily all the Easter dates of the two churches (Orthodox and Catholic), the entire period under research: 1583-2499. These data are listed in Table 1.

To get a global view of these notifications in Table 2 have passed and the different weeks between the dates of Easter obtained in Table 1 and in Table 8 and Table 9 are marked dates of Easter in the Orthodox Church, respective Catholic Church each year from period investigated.

Now to respond completely to the first question, all data in Table 2 we have divided into five tables, depending on the differences between Easter dates, as follows:

➤ TABLE 3: Easter the same dates; so differences 0 weeks (256 possibilities);

➤ TABLE 4: Easter dates to differences one week (404 possibilities);

➤ TABLE 5: Easter dates to differences of four weeks (27 possibilities);

➤ TABLE 6: Easter dates to differences of five weeks (228 possibilities);

➤ TABLE 7: Easter dates to differences of six weeks (2 possibilities).

So there is no one of those 917 years taking into account differences in two or three weeks between the dates of the two Churches Easter (Orthodox and Catholic); such differences exist, as stated above, only:

➤ 0 weeks (i.e. the same date, 256 times),

➤ one week (404 times),

➤ of a four weeks (27 times),

➤ of five weeks (228 times)

and

➤ of six weeks (twice).

From Tables 3 -7 We deduce a series of conclusions, thus:

A. *Conclusions from Table 3:*

1) There are two consecutive years with the same Easter data 37 times.

2) There are three consecutive years with the same Easter data 2 times.

3) The 255 intervals between the years with the same dates of Easter

are:

➤ 1 year: 41 times,

➤ 2 years: 17 times,

➤ 3 years: 149 times,

➤ 4 years: 21 times,

➤ 5 years: 2 times,

➤ 6 years: 3 times,

➤ 7 years: 8 times,

- 8 years: 4 times,
- 10 years: 2 times,
- 11 years: 5 times,
- 17 years: once,
- 20 years: once,
- 21 years: once.

B. *Conclusions from Table 4:*

4) There are two years consecutive with a difference of one week between Easter dates 90 times.

5) There are three consecutive years with a difference of one week between Easter dates 11 times.

6) There are four consecutive years with a difference of one week between Easter dates 5 times.

7) The 403 intervals between the years with a difference one week between Easter dates are:

- 1 year: 128 times,
- 2 years: 85 times,
- 3 years: 165 times,
- 4 years: 19 times,
- 5 years: 2 times,
- 6 years: once,
- 7 years: 2 times,
- 8 years: once.

C. *Conclusions from Table 5:*

8) There are not two, three or more consecutive years with a difference of 4 weeks between dates of Easter.

9) The 26 intervals between the years with a difference of 4 weeks between Easter dates are:

- 3 years: 10 times,
- 24 years: 9 times,
- 27 years: once,
- 30 years: once,
- 38 years: 2 times,
- 41 years: once,
- 44 years: 2 times.

D. *Conclusions from Table 6:*

10) There are not two, three or more consecutive years with a difference of 5 weeks between dates of Easter.

➤ The 227 intervals between the years with a difference of five weeks between Easter dates are:

- 3 years: 138 times,
- 5 years: 49 times,
- 6 years: 3 times,
- 8 years: 9 times,

➤ 11 years: 5 times,

➤ 13 years: 2 times.

E. *Conclusions from Table 7:*

11) There are not two, three or more consecutive years with a difference of 6 weeks between dates of Easter.

12) The interval between the years a difference of six weeks between the dates of Easter is of 30 years.

From point 1) from Conclusions A. deduce that have answer to Question I.; more, from all conclusions, we can say that we have answers to many questions of this kind.

We now pass at its second problem. In many Orthodox religious books are written dates for the celebration of Easter in the Orthodox Church. But if you check these data with the algorithm described above, we see that they shall appoint a Saturday and not Sunday, which one cannot according to the decisions of the Ecumenical Council of Nicaea in 325. The mistake is because the difference between the two calendar years since 2100 is 14 days and not by 13 days.

In fact, everyone should know that, over a period of years in which are preserved the same difference between the two calendars (Julian and Gregorian) repeats itself every 28 years; it can be an excellent exercise in Mathematics for the primary.

For example, let us consider 2100. In that year, according to our algorithm Orthodox Easter date is May 2, but the service books of the Orthodox Church is passed on May 1. According to our above statement, if there is the same difference between the two calendars, the calendar year 2100 should coincide with the 2016 or this does not happen; in 2016 02 May is a Monday – you can check with your mobile phone and not Sunday, as 2100.

2. Conclusions and recommendations

As we proposed at the beginning of this paper, we solve not only one problem but also two more, thus making the reader interested in these issues an image as complete. We must mention that the bibliographical sources that we have used have been exclusively in Romanian. More specifically, for the orthodox theology we have used orthodox religious books and information / articles on websites: <http://www.crestinortodox.ro> and <https://ro.orthodoxwiki.org>, and for the astronomy I consulted the four books of astronomy from bibliography.

We must say that I found on Internet many websites that discuss the problem calculating the date of Easter. Very interesting to us was the information on the website <http://www.gmarts.org/html/orthbydate.htm>, where are listed all data celebration of Easter in the two churches (Catholic and Orthodox) from 1583 until 4099. The calculation algorithms of Easter dates used here differ from those used by us in the paper presented and exemplified.