

## **EASTER SUNDAY DATES**

### **Why Easter Sundays Fall on Different Dates in the Western and Eastern Churches-- A Brief Description of the Reasons, the History, and the Calendars**

Panos Antsaklis

The reason for the apparent confusion regarding the dates of Easter is the fact that they are based on both lunar and solar calendars and on rules that are interpreted differently by the Eastern and Western Christian churches. The calculation of the future dates of Easter is and has always been a very important matter because it celebrates the Passion and Resurrection of Jesus Christ. The date of Easter also determines the dates of a number of other religious feasts each year, which are called movable feasts in the church calendar.

This article attempts to shed some light on the subject using simple ideas to explain a confusing and complicated matter, which needs strong collaboration between astronomers, mathematicians and church historians in order to be fully explained. When one attempts to simplify there is always the danger of oversimplification. I sincerely hope that I have avoided such shortcomings and that the reader at least appreciates the subtleties involved.

*Christmas Dates:* There is also a difference between the dates Christmas is celebrated in some Christian churches, but this is due exclusively to the differences between the Julian and Gregorian (solar) calendars and it is not difficult to explain. The lunar calendar plays no role here. In 2005 Christmas was celebrated, as every year, on December 25 by everyone. In some churches like the Russian and Serbian Orthodox churches that follow the Julian calendar, December 25 falls 13 days later in the Gregorian calendar (the Julian calendar is slower than the Gregorian) and so the 2005 Christmas was celebrated on January 7, 2006. The Greek Orthodox Church follows the Gregorian calendar in this case and celebrates Christmas on December 25 same as in the Western Churches. This distinction is still confusing and poorly understood by many in Western Churches and societies.

*Easter Dates:* Easter Sunday was celebrated on March 27 by the Western Christian Churches in 2005, but on May 1 by most Eastern Churches. The Jewish Passover was on April 24. In 2006 Easter will be celebrated on April 23 and April 16 respectively and in 2007 the date of Easter is the same for all, on April 8.

The Western and Eastern churches calculate Easter dates using the same or very similar rules. Why then do these differences occur? There are two main reasons. The first has to do with the differences between the Julian and the Gregorian calendars, and the second with the different methodologies used to calculate the date of the full moon. The Gregorian calendar is the one most of us follow today in everyday life, while the Julian calendar was the primary calendar used before the Gregorian calendar. They are both solar calendars, and they cycle after a (solar) year, every 365 days except during leap

years when they last 366 days. The phases of the moon play a significant role in the calculation of Easter dates, because Easter celebrates events that occurred immediately after the Jewish Passover, which is celebrated on a date based on the lunar calendar. Calendars based on the movement of the moon are more ancient than solar calendars and are based on the lunar month, which is approximately 29 days long.

The underlying cause of the difficulties in calculating the Easter dates is the fact that the solar year (the time it takes for the earth to make a complete revolution around the sun) is not exactly 365 days long (it is 365.24219 days long), and that the lunar month (the time between new moons) is not exactly 29 days long (it is 29.5306 days long). If the length of the solar year were exactly equal to an integer number of days we would not need corrections (leap years) and measuring the time would have been much simpler. Similarly for the length of the lunar month, the calculation of holidays in the Jewish or Moslem traditions would be much simpler if the lunar month were exactly an integer number of days long. Nature has not been very cooperative!

In the following, the exact reasons for the differences in the Easter Sunday dates between Western and Eastern Churches are explained.

### **The First Ecumenical Council of Nicaea**

The First Ecumenical Council of Nicaea in the fourth century (325 AD) was convened by Roman Emperor Constantine the Great to solve the problems raised by Arianism, but it also decided a number of other issues including the determination of the Easter date celebration. It decreed that Easter should be celebrated on the first Sunday after the first full moon in spring or after the spring equinox.

Before that time, Easter was celebrated at different dates in the different Churches and sometimes not even on Sundays. In fact, a few Christians celebrated Easter on the day of Passover. The Passover date could happen any day of the week so the main thing was to regularize the celebration, to have it on Sunday across the Christian world and in all Churches. The reason for the use of the first full moon in spring was that the day of the Passover (Pesach, to celebrate the exodus from Egypt) was the 15 Nisan--Nisan is the first spring month and 15 Nisan is the first full moon, the Crucifixion of Jesus was on a Friday and the resurrection took place on the Sunday after. Note that in the Jewish calendar each month starts with a new moon.

Unfortunately no verbatim account of the Council's decisions has survived. Instead, the matter seems to have been referred to the Church of Alexandria, a city well known for its scientific scholarship at the time. The practice of Alexandria was to celebrate Easter on the first Sunday after the earliest fourteenth day of a lunar month that occurred on or after March 21. March 20 was fixed as the date of the spring or vernal equinox as it was the date of the vernal equinox in 325 AD in the Julian calendar.

## Differences because of calculations of the dates of the vernal equinox--Julian and Gregorian Calendars

Most Eastern churches still use the Julian calendar today for the calculations of Easter dates, where March 22 is April 4 today in the more modern Gregorian calendar—there is a 13-day difference, as we saw above in the discussion of Christmas dates. So Easter cannot be celebrated in Eastern churches before April 4. The full moon date is calculated --and this is not as easy as it sounds, as we will see below--and Easter is the Sunday after that. **In Eastern churches Easter falls between April 4 and May 8. Western churches follow the Gregorian calendar and Easter falls between March 22 and April 25.** The first set of differences in determining Easter dates occurs because the Eastern and Western churches follow different calendars—Julian and Gregorian, but also use different dates for the vernal equinox. Eastern churches fix the vernal equinox on March 20, the earliest full moon is on March 21 and Easter can take place on March 22 or after which in the modern Gregorian calendar is on April 4 or after. Western churches follow an astronomically correct vernal equinox, which occurs on March 20 or less frequently on March 21 in the Gregorian calendar. Without trying to add complications it should be pointed out that the exact time of when a day starts or the vernal equinox occurs depends on one’s location on earth’s surface. It is generally accepted that Jerusalem should be the point of reference for the exact dates of the equinox, which is an instant of time and not a whole day. In addition, although a new day today starts at midnight, this was not always the case; for example in the Jewish calendar even today a new day starts at sunset! These considerations give us some sense of the difficulties involved if one wants to be absolutely correct. Also notice that the term “vernal equinox” is used instead of spring, as the vernal equinox is the first day of spring in the northern hemisphere and Jerusalem, but not in the southern hemisphere where it is the first day of fall!

\*\*\*\*\*

### SIDEBAR-Further Clarification of the First Council of Nicaea’s decision

During the Middle Ages this practice was more succinctly phrased as “**Easter is observed on the Sunday after the first full moon on or after the day of the vernal equinox.**” The Church of Rome used its own methods to determine Easter until the sixth century, when it adopted the Alexandrian method as converted into the **Julian calendar.** Specifically, at around 525 AD things were made more precise by Dionysius Exiguus (he introduced the Anno Domini year counting that we still use today). Specifically, Pope John I requested that Dionysius compute a table for future dates of Easter, celebrated on the Sunday following the first full moon after the vernal equinox. Dionysius Exiguus ("Dennis the Small" or Minor) 470-540 AD was a 6th century Dacian monk, who lived in Rome, and who was born in Scythia Minor in what is now Dobruja Romania. In about 525 AD, Dionysius produced his *Liber de Paschate*. Dionysius' definition of the Easter date (per the First Council of Nicaea) was that Easter is the Sunday following the first Luna XIV (the 14th day of the moon) that occurs on or after *XII Kalendas Aprilis* (21 March) (kalendas means the first day of the month, and the date given counts days

backward starting with 1 on the first day of the given month, which is according to the Roman custom). The change from 15 Nisan of the Jewish Pesach to Luna 14 probably has to do with the fact that on the Hebrew calendar days start at sunset, while in the Christian A.D. calendar (which was also introduced by Dionysius) days start at midnight. Dionysius' method of computing Easter Sunday dates is called the Julian method. This was not widely accepted until it was described and defended by the Venerable Bede in his *De Temporum Ratione* (725 AD). Dionysius used a 19-year cycle for the calculation of the full moon--see sidebar on calendars for explanation of the 19-year cycle.

\*\*\*\*\*

### **Differences because of calculations of the dates of the full moon**

Additional differences in determining Easter dates occur because Eastern and Western churches follow different calculation methods for the full moon (the full moon in the calculations of Easter dates is *not* the astronomical full moon, but a fictitious mathematically calculated approximation called the Paschal moon).

The Jews originally celebrated Passover on the first full moon following the vernal equinox (this is the time instant when the sun passes the equatorial plane from South to North). After the destruction of Jerusalem in 70 A.D. and the dispersal of the Jews, Passover was celebrated on different dates, sometimes even before the vernal equinox, because calculations were based on local pagan calendars. So many Christian churches stopped regulating the observance of Easter by the Jewish Passover. As an alternative to calculating Easter by the Passover, Paschal Cycles were devised.

**Easter Sunday is the Sunday following the Paschal Full Moon date of the year.** The **Paschal Full Moon** is a calculated date for the first full moon in the spring, and it may differ from the real full moon by a number of days--from 1 to 3 days. This difference arises because the calculated date is based on lunar cycles and the dates of the full moon are adjusted periodically to synchronize with the solar calendars in use today. Specifically, the Paschal Full Moon is the first calculated full moon after March 20, which was the equinox date in 325 AD; that is the Paschal Full Moon is the full moon on or after March 21. These calculated full moons are called Ecclesiastical Full Moon dates as they are used by the Christian churches; they are approximated astronomical full moon dates not the actual ones. The Paschal Full Moon may occur from March 21 through April 18 and the date of Easter is from March 22 through April 25 in the Gregorian calendar in the Western churches and from April 4 to May 8 in the Eastern churches.

The long term behavior of the moon can be described using the 19-year cycle or Metonic cycle--see sidebar--and this was the method used by all churches until 1582 when the **Gregorian calendar** was introduced. Eastern churches continue to follow the 19-year cycle for the calculation of the Paschal Full Moon; in addition they make sure that Easter always falls after the day of Passover. At the time when the Gregorian calendar was introduced, the method for determining Easter dates was also changed. First, as it was already mentioned, the vernal equinox was not March 20 any longer, but it could also be

March 21 depending on the correct time instant of the equinox. Second, the method for calculating the full moon was also refined. Specifically, for Easter dating the 19-year moon cycle used was corrected with 8 days every 25 centuries leading to an average lunar (synodic) month of 29.53069 days, which is accurate to less than a second. This Easter dating method uses the Gregorian calendar and the new 8 days per 25 centuries moon cycle correction is called the **Gregorian method**, and it is used by most Western churches today. The Paschal Full Moon dates in the Gregorian calendar always occur within 3 days, before or after the astronomical full moon date.

For the reader to get a sense of the differences the following table is included that highlights Eastern and Western Easter dates and also includes the dates of the Passover and of the astronomical full moon. Note that Passover *always* occurs before the Eastern Easter but not always before Western Easter.

### Easter Sunday Dates

Year	Eastern	Western Easter	Passover	Astronomical Full Moon
2000	30 April	23 April	20 April	18 April
2001	15 April	15 April	8 April	7 April
2002	5 May	31 March	28 March	26 April (March 22)
2003	27 April	20 April	17 April	16 April
2004L	11 April	11 April	6 April	5 April
2005	1 May	27 March	24 April	24 April (March 25)
2006	23 April	16 April	13 April	13 April
2007	8 April	8 April	3 April	12 April
2008L	27 April	23 March	20 April	20 April (March 21)
2009	19 April	12 April	9 April	9 April
2010	4 April	4 April	30 March	28 April (March 30)

Note that the Passover holiday begins at 6 p.m. (or sunset) on the previous day and so the Passover dates given above may be slightly different in other sources.

\*\*\*\*\*

### SIDEBAR-On Calendars

In the following a brief explanation of calendars and of the calculation of time are included. Understanding calendars is a big step towards understanding fully the differences in Easter date calculations in the Western and Eastern Churches. .

### Julian and Gregorian Calendars

Measuring the passage of time accurately has always been very important in the lives of people. Making errors of when to sow or harvest can have devastating consequences. Today we measure time in terms of (solar) days and years. A (solar) day corresponds to a complete revolution of the earth around its North-South axis, and a year corresponds to a

complete revolution of the earth around the sun. A (mean tropical) year currently is 365.24219 days long. Note that the length of the year is not exactly constant; due to tidal friction, the earth's rotation decreases slowly--thus increasing the absolute day length and so shortening the year length as expressed in days.

The **Julian calendar** was the solar calendar introduced in Rome in 46 BC by Julius Caesar and slightly modified by his successor Augustus. It established the 12-month year of 365 days with each 4th year (leap year) having 366 days and the months having 31 or 30 days except for February that has 28 days or 29 days during the leap year--February was considered an unlucky month for the Romans and so they wanted to keep it short! So the Julian calendar assumes that the solar year is exactly 365.25 days long.

The difference between the 365.25 days length of the year according to the Julian calendar and the 365.24219 actual length of the year introduced about 10 days error in 1500 years. So the vernal equinox (equal length of day and night which is something that can be easily measured) that fell on March 20 at Caesar's time did not happen until the end of March 1500 years later. Obviously there was need for some corrections.

The **Gregorian calendar** which is the solar calendar now in general use, was introduced by Gregory XIII in 1582 (by the Papal Bull "Inter Gravissimas"; Aloisius Lilius and Christoph Clavius were the designers) to correct the errors in the Julian calendar. In that system only centenary years divisible by 400 should be leap years--so 2000 AD was a leap year but 1900, 1800 or 1700 were not leap years. The Gregorian calendar assumed that the solar year is 365.2425 days long. In order to catch up, 10 days in 1582 were suppressed, making October 5 be called October 15! The 10 days difference between the two calendars in 1582 has grown to 13 days today, and so December 25 in the Julian calendar is January 7 in the Gregorian calendar and this is why some Eastern Churches (e.g. Russian and Serbian) celebrate Christmas in January. Since the Gregorian calendar assumes a year length of exactly 365.2425 days and not 365.24219, there is an error of 1 day in 3226 years and so the calendar will need to skip one leap day around A.D. 4000!

Which churches do and do not follow the Gregorian calendar and when they started using it? The Gregorian calendar was not immediately adopted. Most European countries on the continent converted to the Gregorian calendar by 1700; England and its American colonies, including the US, converted in September 1752. The reason many churches did not adopt it was the change in the calculation of Easter, which was introduced at the same time as the calendar. The church of Greece adopted the Gregorian calendar in the 1920s but still uses the Julian for the calculation of Easter. The Russian and Serbian churches, among others, use only the Julian calendar as their liturgical calendar.

## **Lunar Calendars**

A lunar month (synodic month) is 29.5306 days long. 12 lunar months make a lunar year which is 354.37 days long. So the lunar year is about 11 days shorter than the solar year, and in 3 lunar years we fall 33 days or a little more than a lunar month behind the solar cycle. After 33 years the first day of the year of the lunar calendar is back where it is

supposed to be, having fallen behind an entire solar year. The lunar month and year is the basis of the **Moslem calendar**. Now the ninth month of the Mohammedan year is named Ramadan and as a consequence Ramadan does not occur at the same time every year (in the solar calendar) although it occurs at the same month in the lunar year.

Keeping up with the sun and the seasons is very desirable and so there is need for corrections to synchronize lunar and solar calendars. The long term behavior of the moon was described using a **19-year cycle** called the moon cycle or **Metonic cycle**. Meton an ancient Greek had discovered that in 19 solar years there were exactly (almost) 235 full moons or lunar months ( $235 \times 29.5306 = 6939.691$  days; while  $19 \times 365.24219 = 6939.6016$  days). This is equivalent to 19 lunar years plus 7 lunar months left over. The Babylonians added the 7-month discrepancy through the 19 year cycle one month at a time. Each 19-year cycle has 12 12-month years and 7 13-month years. This calendar is a lunar-solar calendar-based on lunar months but changed to keep up with the sun and the seasons. The **Jewish calendar** today is a lunar-solar calendar. To keep in synchronization with the seasons a leap month is added approximately once every 3 years. Note that in the Jewish calendar each day starts at sunset and each month starts with a new moon--on the evening when the crescent is first visible (in modern solar based calendars the day starts at midnight or 12:00 AM).

In this 19-year cycle the lunar month is 29.53022 days long, instead of 29.5306. This adds to about a difference of 1 day approximately every 310 years. Note that if the 19-year moon cycle calendar is corrected with 8 days every 25 centuries, then an average lunar month of 29.53069 days is obtained which is accurate to less than a second and so it is following the solar calendar very accurately indeed. This is the correction used to calculate Easter by most Western churches after 1582 and it is called the **Gregorian method**.

One could use an 84-year cycle instead of a 19-year cycle, which has  $84 \times 365.24219 = 30680.343$  days. This method was also used in the early church. So the 84-year cycle corresponds to 1038.934 lunar months (determined by dividing by the 29.5306 days in a lunar month) or almost exactly 1039 lunar months (this is 86 lunar years with 7 lunar months left over). The 84-year cycle, consists of 4 19-year cycles (also called Metonic cycles) plus an 8-year addition. 8 years have 2921.9375 days which correspond to 98.9461 lunar months or 8 lunar years and about 3 extra lunar months. These 3 extra lunar months are inserted together with 4 19-year cycles to generate the 84-year cycle. Note that the 3 lunar months added every 8 years stems from an ancient Greek invention called the *octaeteris*, where three extra lunar months are inserted into an eight-year cycle. The first Olympics starting in the eighth century B.C. followed this cycle, alternating between gaps of 49 and 50 lunar months rather than the every four solar years system we adopted for the modern Olympics which is based on the modern solar calendar.

**Notes and References:** At Vatican II in the 1960's the suggestion was made to fix the date of Easter on a particular Sunday, say the second Sunday in April. In 1997 the World Council of Churches meeting in Aleppo, Syria suggested using astronomical measurements of the vernal equinox and the full moon at the meridian of Jerusalem to determine the date of Easter. Currently no church has adopted any of these proposals. Regarding references, several references, in hardcopy and electronic were consulted to write this article. The easiest way to start looking deeper into these topics is to search the web for Easter date, ecclesiastical calendar, paschal full moon, first Ecumenical Council. Interesting articles may be found at <http://en.wikipedia.org/wiki/Computus> and at <http://www.assa.org.au/edm.html#OrthCalculator>. Dr. Lewis Patsavos, Professor of Orthodox Canon Law at the Hellenic College/Holy Cross School of Theology in Brookline, Massachusetts, has written a brief, very informative article on the subject of the dates for Orthodox Easter.

Notre Dame, Indiana  
January 2006