An old Julian calendar shifted by one month

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In this paper we want to comment the great work „Calendars In The Making“ by Sacha Stern et al. (in the following abbreviated with CM) Especially the dual-dates documents of Ilaria Bultrighini are a great source. With our own calendar program we can verify almost all of their results.

But it is said that in 6 cases of 88 new dual dated sources, the discrepancy between documented and calculated dates is exactly one month[1], and this cases are explained as scribal errors. We have found also sources outside of CM with this discrepany and meet this shifting by one month again and again. In our opinion this discrepancies of exactly 1 month appear way to often to be just scribal errors, and we propose that behind them there must have been a real used alternative Julian calendar, which was shifted by exactly one month compared to the Julian calender which is used in our today's calendar implementations. Since between 31 CE and 46/47 CE the correlation of the Macedonian months with the Babylonian month underwent a shift of one month[2], it can be easily explained how our proposed shifted Julian calendar (in the following SJC) my have appeared - the Macedonian names were converted to Latin names after the shifting took place. In the following, while we comment the sources in CM, we will also add some documented solar eclipses which we can identify with the help of the SJC (and to our knowledge, they are identified for the first time)

Let us begin with a dual dated ostracon, which mentions the date
4 Domitian, XIV Kalends June, Payni 24, Saturday.[3]

It was before wrongly converted by Tcherikover to 18 May 85 CE (which is a Monday) but Stern corrected that to 18 June (which is Saturday) This shows us that already in 85 CE not the Julian calendar, but the SJC was to be applied.
And also the ostracon shows, that not the old Egyptian calendar was meant, but the new Alexandrinian Egyptian, we call it EgyptianNew, introduced 22 BCE. In the year 23 BCE, Egyptian and EgyptianNew aligned with the same dates. And the algorithm from EgyptianNew was later applied to the Coptic calendar.

Our Mathematica implementation of SJC is as follows:

```
ToFixed[JulianShifted[y_,m_,d_]]:=ToFixed[Julian[y,m+1,d]];
JulianShifted[fixed_Integer]:= Module[{j},j=Julian[fixed];JulianShifted[j[[1]],j[[2]]-1,j[[3]]]];
```

Also in later Byzantine times, we will find this calendar again, with other epochs. While after many disputes there was decided an epoch of 1 Sep 5509 BCE as the „beginning of the world“, especially astronomical sources like the „Chronicon Paschalis“ preferred 5511 BCE, and were used to gived proleptic dates to past astronomical events. To

1 CM p. 119 note 77. In this work, the counting of pages numbers is restarted chapter for chapter, and to quote unambigiously from it, we use the page numbers of the whole pdf.

2 https://webspace.science.uu.nl/~gent0113/babylon/babycal_months.htm

3 CM p. 60 note 97

make our implementation complete and be able to analyse such documents, we add
ToFixed[ByzantineProleptic[y_,m_,d_]]:=ToFixed[Julian[y - 5512,m+1,d]];
ByzantineProleptic[fixed_Integer]:= Module[{j},j=Julian[fixed];
ByzantineProleptic[j[[1]]+5512,j[[2]]-1,j[[3]]]];

Back to the ostracon: it contains the date
4 Domitian, XIV Kalends June, Payni 24, Saturday

This in our days unusual notation, can be analyzed with the function **Roman**, which has 5 input parameters: the first one, the Julian year, is in our case the well documented fourth reign year of Domitian, AD 85; the second parameter is the Julian month; the third has three possible values: Kalends are 1, Ides are 2, and Nones are 3 - in our case it is 1; the fourth parameter is the day before the Kalends in our case 14, and we should be aware, that XIV Kalends was before XIII Kalends; and the fifth parameter is boolean and only True as the 25th February in a leap year.

With that said, we apply this function with

Map[ConvertDateTo[Roman[85,6,1,14,False],#]&, {Roman,EgyptianNew,Julian}]
{ante diem XIV Kalenda Iunii, LXXXV ,24 Pachon 85 C.E.,19 May 85 C.E.}

DayOfWeekC[Julian[85,5,19]]
Thursday

What happened here, the converted date is not 24 Payni, the day of week not Saturday - is something wrong with our function? Not at all, it works as expected, just the date in the source is not described in the common Julian calendar, but in the SJC system!
We increase the second parameter, the month, by 1, and look:

Map[ConvertDateTo[Roman[85,7,1,14,False],#]&, {Roman,EgyptianNew,Julian}]
{ante diem XIV Kalenda Iulias, LXXXV ,24 Payni 85 C.E.,18 June 85 C.E.}

DayOfWeekC[Julian[85,6,18]]
Saturday

Next source is an inscription from Cyprus[4]:
7 Domitian Tybi 25 sambat 6' (=SabbatWeek Day 6 Friday).

Stern proposes the date 28. Dec 87 in the (actual valid) Julian calendar, that matches 29 Tybi in old Egyptian (and 1 Tybi in the new). It is indeed a Friday:

ConvertDateTo[Julian[87,12,28],Egyptian]
29 Tybi 835 A.N.

DayOfWeekC[Julian[87,12,28]]
Friday

4 CM p. 61

But this proposed date has also his disadvantages:
a) Domitian was since September 81 CE emperor, so December 87 would be his 8th reign year, not his 7th
b) Since 23 BCE the new Egyptian calendar was in use, and the old one only in rare cases for religious purposes
c) Even in the old Egyptian calendar this Friday matches 29 Tybi, not 25 Tybi.
Therefore, instead of 28 Dec 87, we want to propose the 20 Jan 87 as the correct date. Since the inscription considers the Sabbat week, it came probably from a jewish milieu, so the calculated day Saturday started from the sunset, and all the hours before it was Friday.

ConvertDateTo[Julian[87,1,20],EgyptianNew]
25 Tybi 87 C.E.

DayOfWeekC[Julian[87,1,20]]
Saturday

ConvertDateTo[EgyptianNew[87,5,25],Julian]
20 January 87 C.E.

In the Niceaa council, the lunar new year was not allowed to begin before 15th Thoth, which was 12th Sept

ConvertDateTo[Julian[325,9,12],EgyptianNew]
15 Thoth 326 C.E.

Inscription of Milan 425 CE[5]

ConvertDateTo[Julian[425,8,12],Roman]
pridie Idus Augusti, CDXXV

DayOfWeekC[%]
Wednesday

This fits well.

Next source 1:[6]
27 Epiphi = IV Kalends Aug
Here we remember about the mentioned shifted month, SJC works:

5 CM p. 64
6 CM p. 121, source 1

```
Module[{akt, jul, rom},Do[akt=Egyptian[i,11,27];
jul =ConvertDateTo[akt,Julian];jul=Julian[jul[[1]],jul[[2]]+1,jul[[3]]];
rom=ConvertDateTo[jul,Roman];
If[rom[[3]]==1 && rom[[4]] == 4, Print[akt," = ",rom," =",jul]],
{i,850,750,-1}]]
```

27 Epiphi 814 A.N. = ante diem IV Kalenda Augusti, LXVII =29 July 67 C.E.
27 Epiphi 813 A.N. = ante diem IV Kalenda Augusti, LXVI =29 July 66 C.E.
27 Epiphi 812 A.N. = ante diem IV Kalenda Augusti, LXV =29 July 65 C.E.
27 Epiphi 811 A.N. = ante diem IV Kalenda Augusti, LXIV =29 July 64 C.E.

Next source:[7]

```
Map[ConvertDateTo[EgyptianNew[62,11,29],#]&, {Roman, EgyptianNew, Julian}]
```
{ante diem X Kalenda Augusti, LXII ,29 Epiphi 62 C.E.,23 July 62 C.E.}

And next sources:[8]
```
Map[ConvertDateTo[EgyptianNew[62,8,6],#]&, {EgyptianNew, Roman, Julian}]
```
{6 Pharmuthi 62 C.E.,Kalenda Apriles, LXII ,1 April 62 C.E.}

```
Map[ConvertDateTo[EgyptianNew[94,11,8],#]&, {Roman,EgyptianNew,Julian}]
```
{ante diem VI Nonas Iulias, XCIV ,8 Epiphi 94 C.E.,2 July 94 C.E.}

```
Map[ConvertDateTo[EgyptianNew[109,11,6],#]&, {Roman, EgyptianNew, Julian}]
```
{pridie Kalenda Iulias, CIX ,6 Epiphi 109 C.E.,30 June 109 C.E.}

```
Map[ConvertDateTo[EgyptianNew[119,12,11],#]&, {Roman,EgyptianNew,Julian}]
```
{pridie Nonas Augusti, CXIX ,11 Mesori 119 C.E.,4 August 119 C.E.}

In the following we will concentrate more on the sources that don't fit so well

Outside source:[9]
Solar eclipse of 1 April 116 CE, by the editor wrongly estimated as 1 March 114:
“έτους ενάτου Τρα'ιανού αυτοκράτορος, μηνός Ξανδικού νουμινία, ο ήλιος εκλείπων εσκοτίσθη“
(Own translation: „In the ninth year of the emperor Trajan, in the month Xandikos at begin of the month, the sun darkened while eclipsed“)
Latin translation resp. addition by Cassius Dio, inclusive an anachronistic anno-domini year (remember, anno domini was developed by Exiguus AD 525)
"Consulatus C. Clodius Anno CXIV, Kalendis Martiis, sol obscuratus est ita ut stellae apparerent, et terrae motus secutus est."
("In the year 114, on the Kalends of March, the sun was darkened so that stars appeared, and an earthquake followed.")

7 CM p. 121, source 2
8 CM p. 121, sources 3 ff.
9 Πλίνιος, Επιστολές, 6.20, κατα Κασσιων Διων, Ιστορία Ρώμης, 68.24.1

Here, the editor has misplaced the reign years of Trajan. Measuring in the later introduced AD years, Trajan started his reign AD 98, so his 9th reign year has to be AD 116. Additionally, we consider the shifted month of SJC, so that the solar eclipse must be placed on 1 April 116.
We check this out:

SonnenfinsternisAlternate[116]
{{116,3,31,21,52,14.9995,A,58.9N,177.9E,01m19s},
{116,9,24,1,31,34.9757,T,58.6S,118.2E,01m39s}}

The time here in 31 March is UTC time, the local time in Byzantic area would be 1. April. Of course, on 1st March was no eclipse, neither 114 ether 116.

Next source[10]:
The shift of one month was way to often to be a scribal error, the solution is the SJC calendar

Map[ConvertDateTo[EgyptianNew[189,3,21],#]&, {EgyptianNew,JulianShifted}]
{21 Athyr 189 C.E.,JulianShifted[188,10,17]}

ConvertDateTo[EgyptianNew[194,6,27],#]&, {EgyptianNew,JulianShifted, Roman}]
{27 Mechir 194 C.E.,JulianShifted[194,1,21],ante diem IX Kalenda Martii, CXCIV }

The shift of one month was way to often to be a scribal error, also pointed out by M. Amelotti and De Romanis[i].

Outside source: eclipse of 14 “May” 215 CE[11]
“έτους τρίτου Αυρηλίου Αντωνίνου, μηνός Αρτεμισίου ιδ, ο ήλιος εκλείπων εσκοτίσθη“
(Own translation: „In the third year of Aurelius Antoninus, at the 14th of the month Artemisios, the sun darkened while eclipsed“).
Again, a later editor brought a Latin translation with anachronistic anno domini year:
"Anno CCXV, Idibus Maiis, sol obscuratus est"
(„In the year 215, on the 14th of May, the sun was darkened ")
Of course, we have the shifted month of SJC, the eclipse was in 14th June 215:

SonnenfinsternisAlternate[215]
{{215,6,14,18,19,9.19455,A,28.5N,98.1W,00m34s},
{215,12,8,7,8,20.9293,T,47.3S,64.0E,01m46s}}

Greek translators of Roman notation may have interpreted like II Kal./Ides/Nones as 2 days before, III as 3 days before etc., hence we have often a one day discrepance.[12]

Outside source: Eclipse misplaced at 25 December 290 CE[13]

10 CM p. 124, source 23
11 Cassius Dio, Ιστορία Ρώμης, 78.24
12 CM sources 32, 74, et al.
13 Porphyry, Life of Plotinus, 15

"ἐν τῷ ἔτει τῆς βασιλείας Διοκλητιανοῦ, ἡμέρᾳ γενεθλίῳ τοῦ Ἡλίου, ἡλίου ἐσκοτίσθη."
("In the year of Diocletian’s reign, on the birthday of the Sun, the sun was darkened.")
This eclipse was misplaced on 25 Dec 290 CE, because the “birthday of the sun” was understood as the Roman festival of *Dies Natalis Solis Invicti*. Porphyry tied it to Neoplatonic symbolism. However, on that 25th Dec was no eclipse. An alternative may be the 21 Dec 298

CM source 39, technical hint: The given date is one of the last days of 315 CE, in such edge cases there is to be used an increased Egyptian year, else it will be calculated the Julian year 314 CE

Map[ConvertDateTo[EgyptianNew[316,4,30],#]&, {Roman,EgyptianNew,Julian}]
{ante diem VI Kalenda Ianuarias, CCCXVI ,30 Choiak 316 C.E.,27 December 315 C.E.}

Outside source: eclipse misplaced at 6 June 316 CE[14]
Griech. Text: έτους ςις Κωνσταντίνου βασιλέως, μηνός Ιουνίου ς, ηλίου έκλειψις εγένετο ώρα τρίτη
(Again, we have an anachronistic anno domini year 6 June 316, so this text didn't come from an eye witness. The same editor added a Latin translation, where he forgot a C, so that the year will be 216 CE):
"Anno CCXVI, VIII Idus Iunias, sol defectus est"
("In the year 216, on the 6th of June, the sun eclipsed")
There was no eclipse, either at 6. June 216 neither at 6 June 316. But we don't forget the shifted month of SJC, which is the solution: the eclipse was at 6 July 316:

SonnenfinsternisAlternate[316]
{{316,1,11,17,47,13.0421,T,38.5S,80.1W,03m18s},
{316,7,6,4,22,57.2454,A,36.7N,115.9E,02m37s},
{316,12,31,6,57,40.1035,A,0.4N,73.3E,00m58s}}

Again and again we meet the Julian calender shifted by 1 month.[15]

Outside source: eclipse of 20 July 483 CE, misplaced by editors at 20 June 484 or 20 June 486[16]:
“έτους εϡϟε, μηνός Ιουνίου κ, ημέρα τετάρτη, ηλίου έκλειψις εγένετο ώρα δευτέρα“
(„In the year 5995, 20th June, day Wednesday, a solar eclipse occured in the second hour“)
20.6.486 was no eclipse and the day was not Wednesday

SonnenfinsternisAlternate[486]
{{486,5,19,10,15,51.7751,T,27.0N,22.1E,06m54s},
{486,11,12,8,42,44.0016,A,14.6S,45.6E,10m43s}}

DayOfWeekC[Julian[486,6,20]]
Friday

14 Consularia Constantinopolitana
15 CM sources 60, 67, 68, 80, 83
16 Chronicon Paschalis

20.6.484 was Wednesday, but without eclipse:

DayOfWeekC[Julian[484,6,20]]
Wednesday

SonnenfinsternisAlternate[484]
{{484,1,14,6,43,20.512,T,35.0N,66.5E,03m04s},{484,7,8,18,56,4.67823,P,64.1S,133.0W,},{484,12,4,6,0,40.5977,P,67.2S,93.7W,}}

But fortunately we have the clue. The Chronicon Paschalis rejects the Byzantine start of the world 5509 BCE, favorizes 5511 BCE and does not count a year zero, so we have to go 3 years before 486 AD. And additionally, we have to consider the shifted month. Here is the solution:

ConvertDateTo[ByzantineProleptic[5995,6,20],Julian]
20 July 483 C.E.

On this day was an eclipse:

SonnenfinsternisAlternate[483]
*{{483,1,24,14,42,21.075,T,9.4S,40.8W,04m03s},
{483,7,20,17,21,44.7934,A,5.3N,84.9W,07m18s}}*

And yes, it was a Wednesday:

DayOfWeekC[Julian[483,7,20]]
Wednesday

Outside source: eclipse of 2 October 544, by editors misplaced as 2 September 547 CE[17]
“έτους ς,νς, μηνός Σεπτεβρίου β, ηλίου έκλειψις εγένετο ώρα δευτέρα“
(„In the year 6056 on the 2^{nd} September, an eclipse of the sun occured“)
Here the interpreters had a hard day, and misplaced the date as 2 Sept 547, where no eclipse occured:

SonnenfinsternisAlternate[547]
*{{547,2,6,7,25,49.3501,T,17.7N,62.5E,03m07s},
{547,8,1,12,32,14.331,A,21.3S,17.0W,01m48s}}*

But we remember that the Chronicon has it's own year for the start of the world, and also it uses normally the shifted months:

ConvertDateTo[ByzantineProleptic[6056,9,2],Julian]
2 October 544 C.E.

17 Chronicon Paschalis

And look, the eclipse can be localized:

SonnenfinsternisAlternate[544]
{{544,4,8,3,24,33.9611,A,10.4N,126.9E,04m29s},
{544,10,2,17,22,38.8277,H,3.5S,84.5W,00m31s}}

Outside source
Eclipse of 2 September 601 CE[18]
"Anno DCI, IV Nonas Septembris, defectio solis facta est hora tertia, et terrae motus secutus est."
("In the year 601, on the 2nd of September, an eclipse of the sun occurred at the third hour, and an earthquake followed.")

SonnenfinsternisAlternate[601]
{{601,3,10,8,9,4.99756,T,35.3N,43.1E,02m47s},
{601,9,2,10,40,33.1696,A,43.5S,3.3W,01m34s}}

Fits perfectly

Outside source
Eclipse of 27 February 602 CE[19]
"Anno DCII, III Kalendas Martii, sol in scutum nigrum mutatus est."
("In the year 602, on the 27th of February, the sun was changed into a black shield.")

SonnenfinsternisAlternate[602]
{{602,2,27,19,11,10.1504,A,11.6S,104.3W,02m23s},
{602,8,22,22,38,19.4799,T,9.5N,161.7W,04m26s}}

Fits perfectly

Outside source
Eclipse of 12 August 603 CE[20]
Latin Source (Marianus Scotus, *Chronicon*)
"Anno DCIII, II Idus Augusti, tenebrae media die factae sunt, et aves ad cubilia redierunt."
("In the year 603, on the 12th of August, darkness fell at midday, and birds returned to their nests.")

SonnenfinsternisAlternate[603]
{{603,2,16,22,47,25.7071,A,63.4S,128.4W,06m13s},
{603,8,12,15,5,31.1621,T,56.4N,29.3W,04m33s}}

Fits perfectly

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18 Annales Fuldenses
19 Isidore of Seville, Etymologiae
20 Marianus Scotus, Chronicon

Outside source
Eclipse of 16 July 790 CE[21]
"Anno DCCXC, XVII Kalendas Augusti, solis lumen subtractum est per horam, et terrae motus secutus est."
("In the year 790, on the 16th of July, the light of the sun was withdrawn for an hour, and an earthquake followed.")

SonnenfinsternisAlternate[790]
{{790,1,20,2,58,47.0476,A,5.8S,133.9E,08m07s},
{790,7,16,18,47,43.3062,T,18.0N,104.1W,03m03s}}

Fits perfectly

Outside source
Eclipse of 22 December 968 CE
Latin Source (Leo the Deacon, *Historia*):
"In solstitio hiemali, solis eclipsis qualis numquam ante acciderat facta est... Stellae clarissimae apparuerunt, et sol sine lumine visus est."
("At the winter solstice, an eclipse of the sun such as never happened before occurred... The brightest stars appeared, and the sun was seen without light.")

SonnenfinsternisAlternate[968]
{{968,1,2,19,57,14.5664,A,8.4S,122.7W,00m21s},
{968,6,28,14,46,57.4666,A,11.7S,49.0W,04m01s},
{968,12,22,9,26,8.97014,T,41.8N,28.3E,02m28s}}
Fits perfectly

Outside source
Total Solar Eclipse of August 2, 1133[22]
"Anno MCXXXIII, ii Nonas Augusti, eclipsis solis facta est hora circiter sexta, et sol obscuratus est quasi luna."
("In the year 1133, on the 2nd day before the Nones of August [August 2], an eclipse of the sun occurred around the sixth hour, and the sun was darkened like the moon.")

SonnenfinsternisAlternate[1133]
{{1133,2,7,2,36,56.2825,A,44.3S,160.7E,04m49s},
{1133,8,2,11,51,40.8927,T,45.8N,16.5E,04m38s}}

Fits perfectly

21 Alcuin of York, Epistolae
22 Anglo-Saxon Chronicle, MS E

In CM, p. 102, the last evolution of the calendar with Makedonian names in the Byzantic area is mentioned:
Kaisar 31 days, 2. Apellaios 30, 3. Aydunaios 31, 4. Peritios 31, 5. Dystros 28, 6. Xandikos 31, 7. Artemisios 30, 8. Daisios 31, 9. Panemos 30, 10. Loos 31, 11. Gorpiaios 31, 12. Hyperberetaios 30[23]
The month Kaisar is a renamed Dios, because Christianity had taken over and Dias = Zeus was no longer worshipped. Now, the year started according to the Byzantine „creation of the world“ on 1st September - and that makes it easy to recognize that in this list, the shift has already taken place: the Dystros with it's 28 days cannot correspond to another month but February, so renaming from here the months with Latin names makes the month Kaisar to be an October!

23 I. Bultrighini, chap. 2 in: Sacha Stern et al, Calendars in the Making, p. 86

[i] CM p. 125, source 29