

Eppure si muove

....despite tidal braking

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Abstract:

The pearled solar eclipse of 1912.04.17 occurred only 60 hours *after the TITANIC disaster* had cast its shadow upon this exciting event. The data collected during this most elusive eclipse are compared to those generated by Xavier JUBIER's 5MCSE, the well-known solar eclipse retrodiction freeware, offering the choice between 2 DeltaT algorithms, and exact 3D GPS coordinates for the observation site such as the balloon Globule at 900 meter over Rethondes, *see* http://xjubier.free.fr/site_pages/solar_eclipses/xSE_GoogleMapFull.php?Ecl=+19120417&Acc=2&Umb=1&Lmt=1&Mag=0&Lat=49.41497&Lng=2.93697&Elv=900.0&LC=1&Zoom=15&DdT=1 best with Firefox. Reports of dozens of solar eclipses spread over four millennia will be reviewed in this way.

For the last 4'000 years, the Earth's spin slowdown key-parameter $\Delta T(t)$ will be assumed to behave as

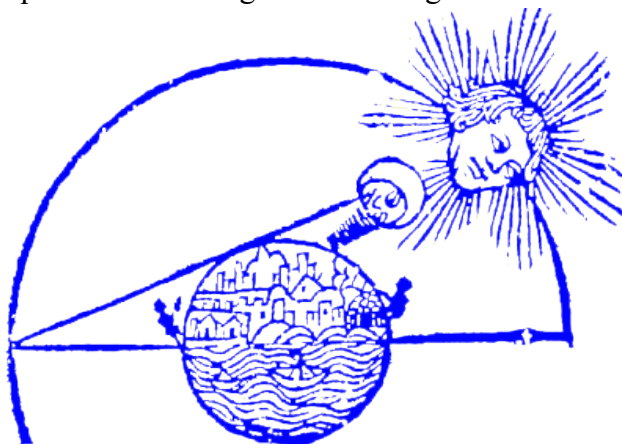
$$\Delta T(t) = 30.65 * t^2 \quad [s], \quad \text{where } t \text{ is expressed in centuries.}$$

Add. 2024.04.08/ An alternative value for the period from -1911 upto +1912 used for our 2024 Canon SAROS is:

$$\Delta T(t) = 20 + 32.4 * t^2 \quad [s],$$

An appropriate ephemeris SI day, as origin of time axis, appears to be **Julian Day 2'398'000.5**. Excellent agreement has been found between our *Geo-Chronological Model* and the records described in World Annals of all reliable candidates of ancient solar eclipses. Those data are compiled in the Table SAROS, *see* <https://www.archaeometry.org/saros.pdf>.

One might speculate if the seconds in excess of this Model compared to actual DeltaT values is the consequence of recent global warming.



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1. Time Scale

The accuracy in retrodiction of past Solar Eclipses is bound to an adequate Modeling of the slowing-down of the Earth's spin. The key parameter of this Model is the Length of the Day. The *secular length of the day* λ is defined as:

$$\lambda = (36524.24)^{-1} \text{ [cy]}$$

while the *circadian length of the day* L(D) :

$$L(D) = 24 \text{ [h]} \times 60 \text{ [m/h]} \times 60 \text{ [s/m]} = 86'400 \text{ [s]}$$

With the introduction of Atomic clocks and SI seconds, one has to introduce an ideal D_o -Day . The length of this reference day is:

$$L_o (D_o) = 86'400 \text{ [s SI]}$$

In divergence with commonly chosen timing for D_o , i.e.: 1800.01.01, in the case of Kevin D. PANG, K.K. YAU & H.H. CHOU in Geo.Res.For.3-4,1998, pp.459-488, in their analysis of Ancient Chinese Solar Eclipses, we prefer the ephemeris SI day:

$$D_o = \text{JD } 2'398'000.5 \text{ , JD meaning Julian Day. i.e. } 1853.05.27 / 12:00 \text{ UT.}$$

In 1583, the year Galileo GALILEI observed that a pendulum could be used for keeping time reliably, Joseph-Juste SCALIGER, the chronologist born in Agen, published in Lutecia "*De emendatione temporum*" [On the Correction of Chronology], the genial dating system he conceived after his lucky escape to Geneva from the St Bartholomew' massacre. SCALIGER named this first linear time scale **Julian Day** in honor to his father Julius Caesar de L'ESCALLE. The introduction of such a *Reform for Chronology* represents a deep paradigmatic change.

The time of occurrence of a solar eclipse will hereafter be referred as :

$$t = \lambda \cdot (\text{JD} - D_o) \text{ [cy]}$$

From the cumulative *Geophysical* difference ΔT

$$\Delta T(t) = \text{UT} - \text{AT} \text{ [s]}$$

between the Atomic Time defining L_o , and Universal Time defining $L = L(t)$ follows the difference in " LOD", the length of the day:

$$\Delta L = L(t) - L_o = \lambda \cdot d\Delta T / dt \text{ [s]}$$

The rate of change of L(t) is therefore :

$$dL / dt = \lambda \cdot d^2\Delta T / dt^2 \text{ [s} \cdot \text{cy}^{-1}]^2$$

The average, fortnightly rate of change of *secular lod* is minute (ppm) compared to the rate of change of the fortnightly *lod* ups & downs due to lunar tidal, see <https://www.archaeometry.org/timetale.html>

2. Slow-down of Earth' Spin

The secular Earth's rotation rate

$\omega = 47.34 \cdot 10^9$ [" / cy] might be expressed in terms of the L(t)

$\omega = 2\pi / L$ [rad . s⁻¹] and its time variation, as:

$d\omega/dt = -2\pi \cdot L^{-2} \cdot dL/dt$ [rad . s⁻¹ . cy⁻¹] whence:

$$\dot{\omega} / \omega = - L^{-1} \cdot \lambda \cdot d^2 \Delta T / dt^2 \text{ [cy}^{-1}\text{]}$$

Our Geo-Chronological Model assumes a parabolic time dependence for $\Delta T(t)$:

$$\Delta T(t) = c \cdot t^2 \text{ [s], whence}$$

$$\dot{\omega} / \omega = - L^{-1} \cdot \lambda \cdot 2 \cdot c = -0.63377 \cdot 10^{-9} \cdot C \text{ [cy}^{-1}\text{]}$$

According to J.G. WILLIAMS (*"Diurnal and semidiurnal tidal contribution to lunar secular acceleration"*, EOS Trans Am. Geoph.Un. 73,43,126, 1992) the LLR (lunar laser ranging) data indicates a secular acceleration of the Moon

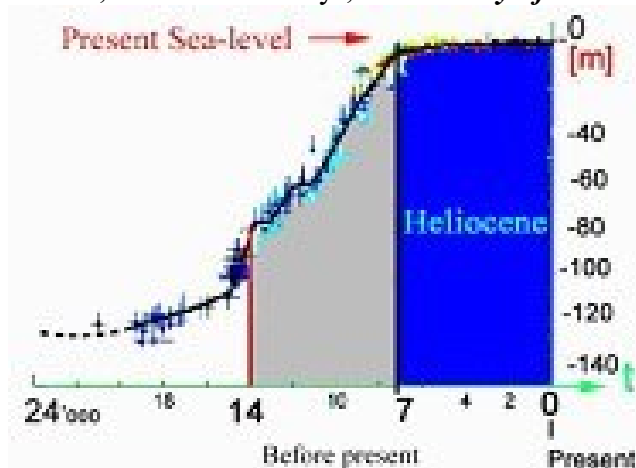
$$\dot{n} = -25.88 \pm 0.5 \text{ [" / cy}^2\text{]}$$

According to K. LAMBECK (*The Earth's Variable Rotation"*, Oxford Univ Press, 1980) the secular acceleration of the Moon induces a **tidal braking** of the Earth:

$$\dot{\omega}_t / \omega = +1.07 \cdot 10^{-9} \cdot \dot{n} = -27.7 \cdot 10^{-9} \text{ [cy}^{-1}\text{]}$$

t , the *tidal braking*.

According to Robert Rohde, over the last 4 kyr, *the stability of the sea-level*,



http://commons.wikimedia.org/wiki/File:Post-Glacial_Sea_Level.png and <https://www.archaeometry.org/helios.htm> suggests that there has been, no change in the overall secular tidal braking of the Earth over the last half of the heliocene.

$$\dot{\omega}_t / \omega = -0.63377 \cdot 10^{-9} \cdot C_t \text{ [cy}^{-1}\text{]}, \text{ with}$$

$$C_t = -27.7 \cdot 10^{-9} / -0.63377 \cdot 10^{-9} = 43.7 \text{ [s . cy}^{-2}\text{]}$$

Tidal Braking is NOT the only force in action. As established by PANG et al. (op.cit.) for Ancient Chinese *Solar Eclipses*, **C** lies within two boundaries :

$$27.5 < \mathbf{C} < 32.5 \quad [\text{s} \cdot \text{cy}^{-2}]$$

As the data presented farther suggest, for the last 4'000 years, an unique c-value, well inside Pang's criterion, suffices to retrodict satisfactorily all available data, and this value is :

$$\mathbf{c} = \mathbf{30.65} \quad [\text{s} \cdot \text{cy}^{-2}].$$

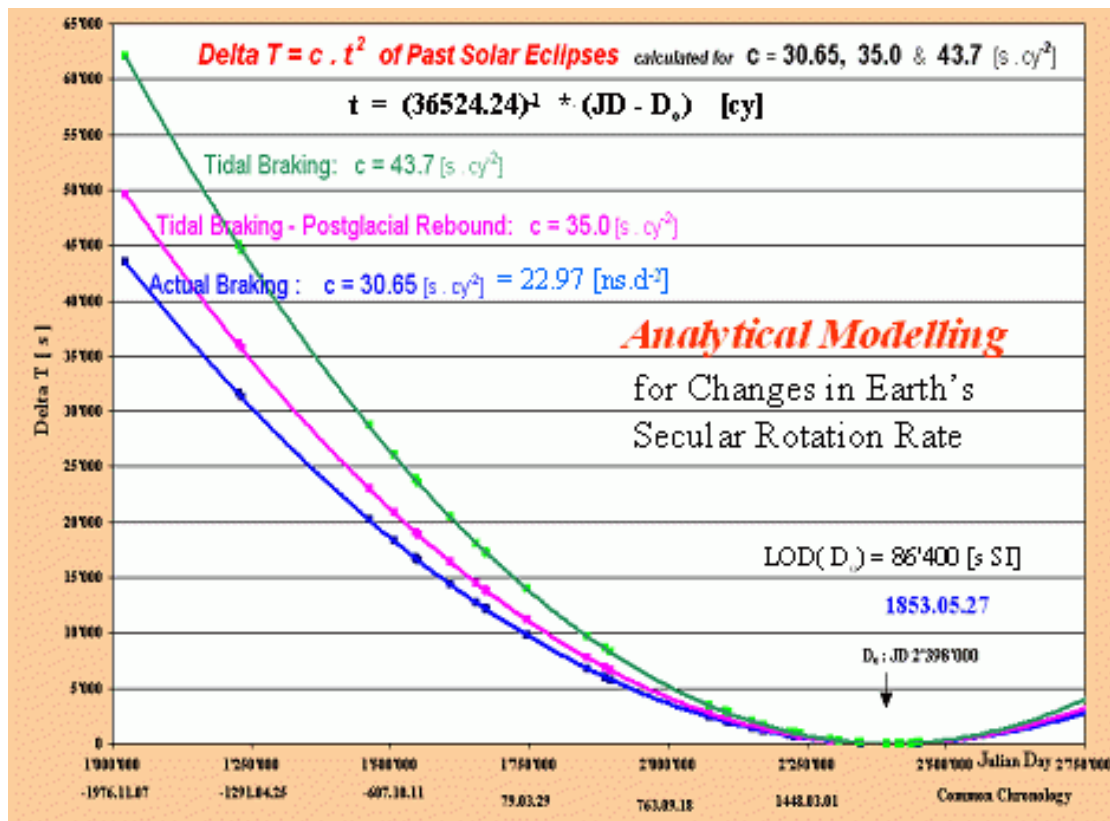
The observed secular rate of change of the Earth's spin is therefore

$$\dot{\omega}/\omega = -19.6 \cdot 10^{-9} \quad [\text{cy}^{-1}]$$

leading to an overall secular non-tidal acceleration

$$\dot{\omega}_{nt}/\omega = \dot{\omega}/\omega \times \dot{\omega}_t/\omega = +8.1 \cdot 10^{-9} \quad [\text{cy}^{-1}]$$

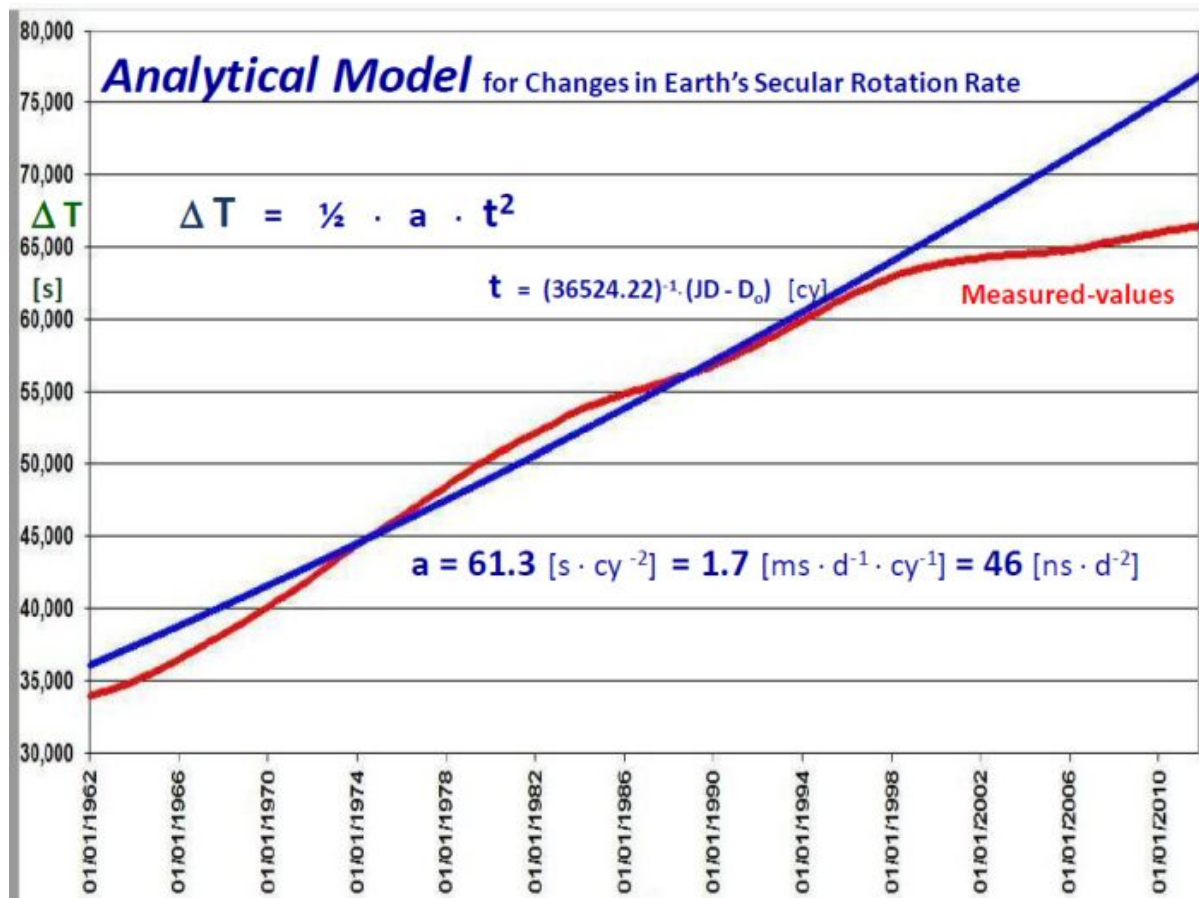
The combined effect **c_{tr}** of Tidal Braking and post-glacial Rebound (or change of oblateness) is **c_{tr} = 35.0** [s . cy⁻²]. Those results are shown in the **de REYFF-Chart** ΔT(t = λ [JD-D₀])



for 1/ tidal braking; 2/ post-glacial rebound; 3/ Solar eclipses data.

Post-glacial *Rebound* is not the only Non-Tidal forces at work. For other smaller components, J.O. DICKEY listed, from core outwards: viscous torque, topographic coupling of the mantle to the core, electromagnetic coupling, continental drift, earth-quakes, **sea level loading**, tsunami, ocean currents, ground water, winds, and atmospheric loading.

The limit of validity of this hypothesis is provided by the occurrence, over the last decade of a decrease of the actual ΔT , (possibly an effect of global warming ?). In the graph the experimental values of LOD measured since 1962 against extragalactic sources are compared with the continuous slow-down Model.



The software used in the present analysis is 5MCSE of Xavier JUBIER. To introduce into 5MCSE the DeltaT of our Model, one should add into the url: **&DdT=1** e.g, for the Hipparchus eclipse, of -128.11.20, the url is:

http://xjubier.free.fr/site_pages/solar_eclipses/xSE_GoogleMapFull.php?Ecl=01281120&Acc=2&Umb=1&Lmt=1&Mag=0&Lat=40.146&Lng=26.398&Elv=10.0&Zoom=10&LC=1&DdT=1

3. VLA Canon of Observed Solar Eclipses

Our Geo-Chronological Model has been applied to both, more recent and older solar eclipses, resulting in a new Canon of Solar Eclipses.

Table SAROS <https://www.archaeometry.org/saros.pdf> presents output data generated by 5MCSE for **dozen of relevant solar eclipses**: timed according to the Geo-Chronological Model and precisely located thanks to GoogleEarth.

"Relevant" means here for which *Annals Records* are not - at least too obviously - apocryphal, and provide *sufficient information to make a qualified guess* :

- i) a fair estimate of the *location* of the observation site,
- ii) a convincing *date* for the eclipse,
- iii) a plausible order of *magnitude* of the eclipse at the observation site.

Such criteria have not been used in the other CANONS available on the web, such as the monumental *Ancient & Medieval Eclipses in European Sources* of F.K.GINZEL, originally published in Berlin, in 1899.

The solar eclipse **SAROS 26/40** (-1301.06.05) was supposed to be reported on a SHANG turtle bone oracle, excavated in Xiaotun, near Anyang (Henan), see <https://www.archaeometry.org/dating.htm>. It is an interesting example how, a Geo-Chronological Model, could comfort a linguistic interpretation or another. Instead of adjusting Delta T in order to produce a 6 [m] long totality over Xiaotun, the Magnitude retrodicted is a mere Magnitude of 0.83...i.e.: *does not qualify to be listed in Table SAROS*.

Another example which does not qualify is **SAROS 75/37** (+45.08.01). The historian Dio Cassius (Bk60/24) reproduce the imperial decree explaining the phenomenon of solar eclipses http://penelope.uchicago.edu/Thayer/E/Roman/Texts/Cassius_Dio/60*.html, a unicum in the History of Sciences. In year 798 (ab urbe condita), 2 year before the 800th birthday of the City of Rome, since there was to be an eclipse of the sun on his birthday, Emperor Claudius feared that there might be some disturbance in consequence, inasmuch as some other portents had already occurred; he therefore issued a proclamation in which he stated not only the fact that there was to be an eclipse, and when, and for how long, but also the reasons for which this was bound to happen. It turns out that the totality happened 2500 km south of Roma, therefore the retrodicted Magnitude is only 0.31. Though it is a *worth mentioning Solar eclipse prediction!*

SAROS 118/43 (1560.08.21), discussed in the next Chapter, is bound to another example not qualifying for an entrance in the Table, due to the partial unreliability of the Annals. One should notice that, *prior to year 840 Common Era*, most solar eclipses *have been used to date Annals*, with the uncertainty associated to such a guess-work. Those *proto-historical* eclipses are marked in the Table SAROS with grey background. A graphical presentation of those results is given in the above *de Reyff'- Chart*.

4. Geo-Chronological Model vs. Solar Eclipses

Table SAROS <https://www.archaeometry.org/saros.pdf> presents a formatted, *compact* version of the data studied so far. One will note the surprisingly high degree of coherence between the available records of all those solar eclipses and their retrodicted values. So far the classical empirical approach has been to attempt best-fitting of the solar eclipses records, at the cost of assuming reliability of the available, often dubious, information.

With our Model, one has a tool to pin-point *deviant behaviour of the Earth, if any...* For completeness, about the wide range of interpretation of solar eclipses, let us remember that, in 1929, N.A.MOROZOV suggested that the "*THUCYDIDES Triad*" was the "*contribution*" of J. KEPLER, to *proof scientifically* the date of the Peloponnesus War...

To demonstrate the interest of this Geo-Chronological Model, let us cross-examine both retrodictions, and Annals reports for a few dozen of solar eclipses:

1) SAROS 134/43 on 2005.10.03

According to *Bulletin de l'IERS*, the Delta T-value for this day was **65 seconds**.

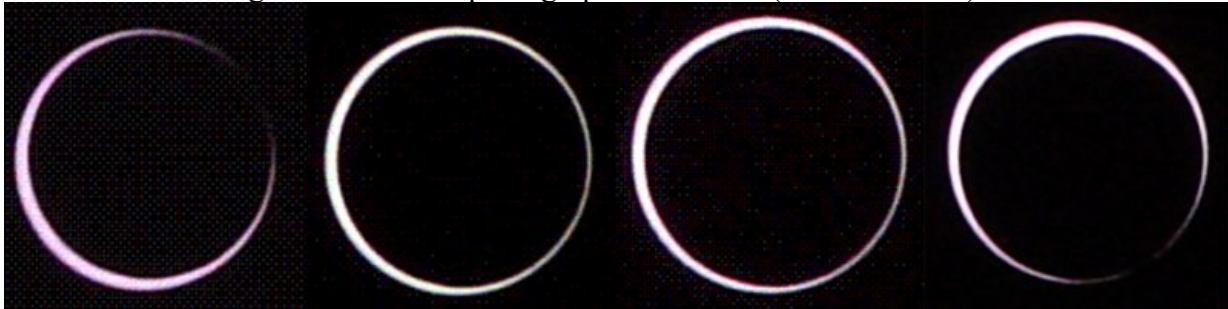
The Geo-Chronological Model generates, though, a higher value, i.e. $\Delta T = 71$ [s].

If this rebound trend (induced by global warming?) would go on in the future, this might signal the end of the past "quiet" 4000 years long period.

With the value $\Delta T = 71$ [s], **5MCSE predicts @ E1.41887 / N38.7347 (Pitiüses Islands.)**
C2 at 09:02:08 UT Max at 09:03:47 UT C3 at 09:05:25 UT
 with a magnitude of 0.960, a height of 34° and a duration **3m 17s**.

In comparison, with the **measured value** (intergalactic Quasars), $\Delta T = 65$ [s], one **predicts**
C2 at 09:02:18 Max at 09:03:55 C3 at 09:05:31
 with a magnitude of 0.960, a height of 34° and a duration **3m 14s**.

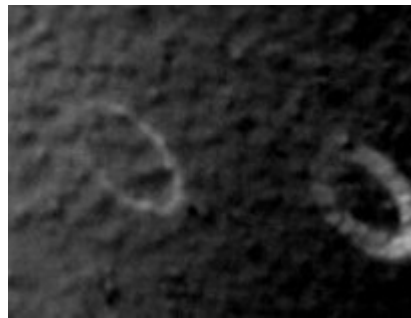
Those last results agree with VLA's photographic records (with filter 10^{-5})



09:02:27 UT 09:03:43 UT 09:04:13 UT 09:05:23 UT

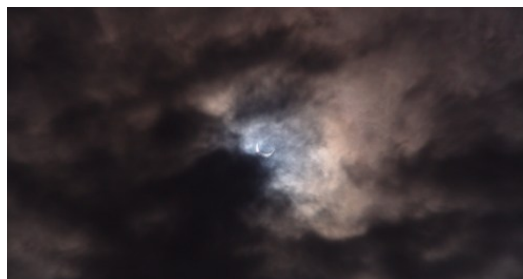
The indicated UT-time is the one of the GPS-calibrated clock of the camera

As documented by VLA at 09:04:07 UT, one can observe the maximum of an annular eclipse,
 using, here, one $\varnothing 1\text{mm}$ & one $\varnothing 2\text{ mm}$ holes in a foil,



with a resulting four-fold intensity difference in the images projected onto a wall.

On 2005.10.03 @ E1.4 / N38.7 at 08:50 UT, we took a picture *without any artificial filter* in front of the camera, the light of the *solar crescent* being naturally filtered by the clouds.



Those most exciting conditions of *observation* lasted for about 3 minutes.
 Before the invention of protective glasses, the occurrence of such conditions allowed nearly optimal *naked eye observation of partial solar eclipses ...*

2) SAROS 137/30 on 1912.04.17

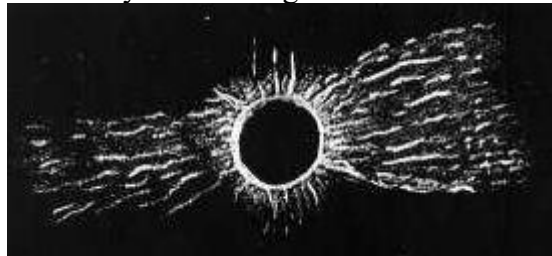
In the Annals 1912 of the Société Astronomique Française, published by Camille FLAMMARION, one finds precious data on this exceptional eclipse. A special page is devoted to this event, please click on <https://www.archaeometry.org/19120417.htm>

3) SAROS 126/41 on 1900.05.28

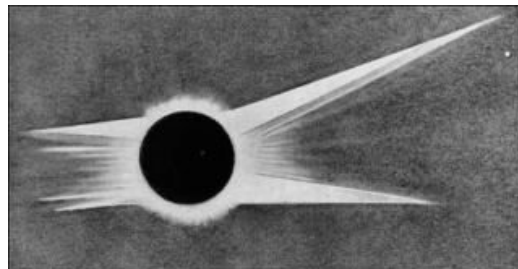
The drawing of the corona due to Fr. MOREUX at site @ $W 0.72 / N 38.27$ is particularly interesting : "...couronne tissées de fils...presque irréels"



It is corroborated @ $E3.1 / N 36.7$ by the drawing of A.C. CROMMELIN



and the one of E.W. MAUNDER



4) SAROS 133/29 on 1724.05.22

@ $E2.107 / N48.81$, in the Trianon from Versailles, Jacques CASSINI & LOUIS XV proceeded to the first chronometric observation of a solar eclipse, comforted by the measurements of DESLILE at Paris Observatory. DE REYFF, see <https://www.archaeometry.org/trianon.pdf>, discussed the consequences of this important scientific event, see communication at SEC 2011 <https://www.archaeometry.org/cassini.pps>

5) SAROS 133/25 on 1652.04.08

@ $W5.806 / N54.713$, the duration of totality was 21 seconds. The observation of Dr WYBERG <http://eclipse.gsfc.nasa.gov/SENL/SENL200404.pdf> on the Northern border of the Belfast Lough are most precious, because Carrickfergus was also just at the Northern border of the totality path. "... [the Sun was reduced to] a **very slender crescent of light**, the Moon all at once threw herself within the margin of the solar disc with such agility that she seemed to revolve like an upper millstone, affording a pleasant spectacle of rotatory motion." This eclipse represents therefore a most important test of our Model.

6) SAROS 137/13 on 1605.10.12

The so-called "Noirceur" @ E5.37 / N43.29, over Marseille leads one to presume that, on an October afternoon, a magnitude of 0.985 looks particularly dark. For comparison, let us note that the pictures taken in Geneva on 1912.04.17 with a magnitude of 0.889 look already pretty grim.

7) SAROS 112/58 on 1567.04.09

For this pearly eclipse @ E12.457 / N41.902, 5MCSE retrodicts $M = 0.997$. The Vatican was slightly North of the narrow totality path. CLAVIUS (1537-1612) claims to have witnessed two Eclipses of the Sun in the space of 7 years. CLAVIUS reported in 1593, a quarter of century after SAROS 112/58, <http://eclipse.gsfc.nasa.gov/SENL/SENL200404.pdf>, in *Sphaeram Ioannis de Sacrobosco, Commentarius*, p.508, reads: *The other I saw at Rome in the year 1567 also about midday in which although the Moon was placed between my sight and the Sun it did not obscure the whole Sun as previously (i.e. in Lusitania) but a narrow circle was left on the Sun, surrounding the whole Moon on all sides.*

One might guess, that, he saw the FLAMMARIUM partial corona.

8) SAROS 118/43 on 1560.08.21:

This eclipse was total over Granada and Oporto. while in Coimbra, @ W8.412/N40.221, the retrodicted Magnitude was 0.996, In the report previously quoted, CLAVIUS said: *"One of these I observed about midday at Coimbra in Lusitania in the year 1559, in which the Moon was placed between my sight and the Sun with the result that it covered the whole Sun for a considerable length of time."* Obviously, after such a long time he could not remember well the year, because in Portugal, around 1559, the only solar eclipse occurred a year later. If he saw himself the eclipse at all, did he remember his site of observation correctly ?

9) SAROS 121/28 on 1431.02.12

This eclipse was total over Perugia @ E12.39/N43.11 at 14:38UT Antonio dei Veghi, in Diario dall'anno 1423 al 1491. <http://eclipse.gsfc.nasa.gov/SENL/SENL200402.pdf> wrote:

"On February 12 at about the 21st or 22nd hour, the Sun was completely obscured and in front of the Sun was placed a black circle like a little wheel. It became as dark as night and the sky revealed the stars. The birds went to roost as they usually do at night. Everyone was feeling ill at ease as a result of this event. It began half an hour before the Sun was covered over. It gradually lost its light even to the hour stated above. . ." Time here was obviously counted since sunset the day before.

10) SAROS 115/33 on 1239.06.03:

In Arrezzo 250 paces long.... In Mende, totality with 98%....!!!!

At least nine different Annals, relate the event, i.e:

Coimbra (Chronicon Conimbricensis)

Toledo (Anales Toledanos)

Mende (Arch. Gévaudaises, 1913)

Montpellier (Zurita, Anales de la Corona de Aragon)

Firenze (Storie Fiorentina)

Siena (Archivo de Duomo di Siena)

Arezzo (RISTORO d'Arezzo: *Della composizione del mondo*)

Cesena (Annales Caesenates)

Split (Thomae Historia Pontificum Salonitanorum et Spalatinorum)

RISTORO d'Arezzo's report is most interesting: the totality there was the longest, i.e. **350** seconds: *"while I was in the city of Arezzo, where I was born, and in which I am writing this book, in our monastery, a building which is situated towards the end of the fifth latitude zone, whose latitude from the equator is 42 and a quarter degrees (vs GPS N43.46), and whose westerly longitude is 32 and a third (vs GPS E11.87), one Friday, at the 6 th hour of the day (vs 12:15UT), when the Sun*

was 20 deg in Gemini and the weather was calm and clear, the sky began to turn yellow and I saw the whole body of the Sun covered step by step and it became night. I saw Mercury close to the Sun, and all the animals and birds were terrified; and the wild beasts could easily be caught. There were some people who caught birds and animals, because they were bewildered. The air and the ground began to become cold; and it began to be covered and uncovered from the west." I saw the Sun entirely covered for **the space of time in which a man could walk fully 250 paces.**

This early chronometry exercise reveals that the paces in a monastery are *twice slower* than mine...

This *multi-site solar eclipse observation* represents a unique opportunity to **audit medieval Annals.** Translating Arch. Gévaudaises, 1913 <https://www.archaeometry.org/mende.pdf> gives: "A.D. 1239,...the 3rd of nones of June,...between nones (i.e.:3 p.m.)and noon,...there was a total solar eclipse". While at the 8 other observation sites, totality lasted between 3 to 6 minutes, in Mende, the magnitude did not reach 98%, see <https://www.archaeometry.org/saros.pdf>

11) SAROS 121/14 on 1178.09.13

The information given in Arch. Gévaudaises, 1913, is minimal. It is based on "*Chronicle and custom of Bishop GUILLAUME IV de Peyre*" (1194), quoting ADELBERT III, his predecessor in Mende. The site is therefore supposed to be @ E 3.50 / N44.52 . The report reads: "*Eleven hundred after seventy eight, the Moon hid the Sun in its 21st day*". Only the year is mentioned, what is already most precious, but "its 21st day" is a weird way of describing the new Moon.

12) SAROS 96/25 on 1176.04.11

Michael the Syrian gave in his Chronicles an accurate description of the totality over Antioch @E36.16/N36.20 : In this year 1487 (Seleucid Era) on New Sunday the 11th of the month of Nisan at daybreak, at the end of the Office, the Sun was totally obscured, night fell and the stars appeared. More details in https://www.archaeometry.org/seleucid_era.pdf.

Ibn al-Athir reported in his Chronicle under year 571 (Anno Hegirae): its freight in Cirze @E42.17 / N37.42 at the age of 16 years,: In this year the Sun was eclipsed totally and the Earth was in darkness so that it was night and the stars appeared. This was the forenoon of Friday the 29th of Ramadan at Jazirat Ibn 'Umar.

13) SAROS 102/43 on 1133.08.02 :

Honorii Augustodunensis: *Summa Totius et Imagine Mundi.*

"Duke Frederick . . . set fire to the town of Augsburg and killed many of its citizens . . . An eclipse of the Sun occurred on the 4th day before the Nones of August at midday for about an hour, such as is not seen in a thousand years. Eventually the whole sky was dark like night, and stars were seen over almost the whole sky. At length the Sun, emerging from the darkness, appeared like a star, afterwards in the form of a new Moon; finally it assumed its original form."

Distinguished researchers have confused Honoré d'Autun, with the city of Augsburg ! Our Model restores the truth... The totality over Regensburg, @E12.0886/ N49.0188, the residence of the famous author of *Imagine Mundi*, lasted 2m 45s.

14) SAROS 111/29 on 1033.06.29

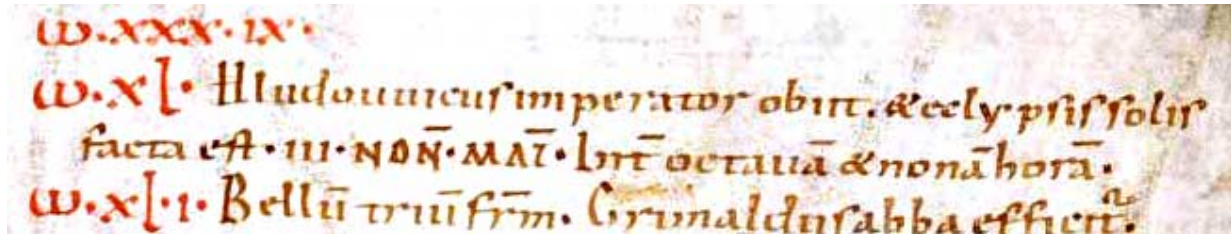
For the eclipse @ E 4.659 / N 46.434: with a retrodicted magnitude 0.985 over Cluny, the Annals mention the appreciation:... "*truly frightening*": *La même année, la millième après la Passion du Seigneur, le troisième jour des calendes de juillet, un vendredi vingt-huitième jour de la lune, se produisit une éclipse ou obscurcissement du soleil, qui dura depuis la sixième heure de ce jour jusqu'à la huitième et fut vraiment terrible. Le soleil prit la couleur du saphir, et il portait à sa partie supérieure l'image de la lune à son premier quartier. Les hommes, en se regardant entre eux, se voyaient pâles comme des morts...». The time mentioned between the 6 and 8th hours after dawn is consistent with the retrodicted time of the first & last penumbra contacts, i.e.09:42 & 12:45 UT. The date, mentioned as the 3rd day before the July Calendars, is indeed June 29th. The depiction of the maximum: i.e. the Sun was carrying on his upper part the image of the Moon at its 1st quarter, is consistent with retrodiction time of 11:13 UT.*

15) SAROS 115/18 on 968.12.22

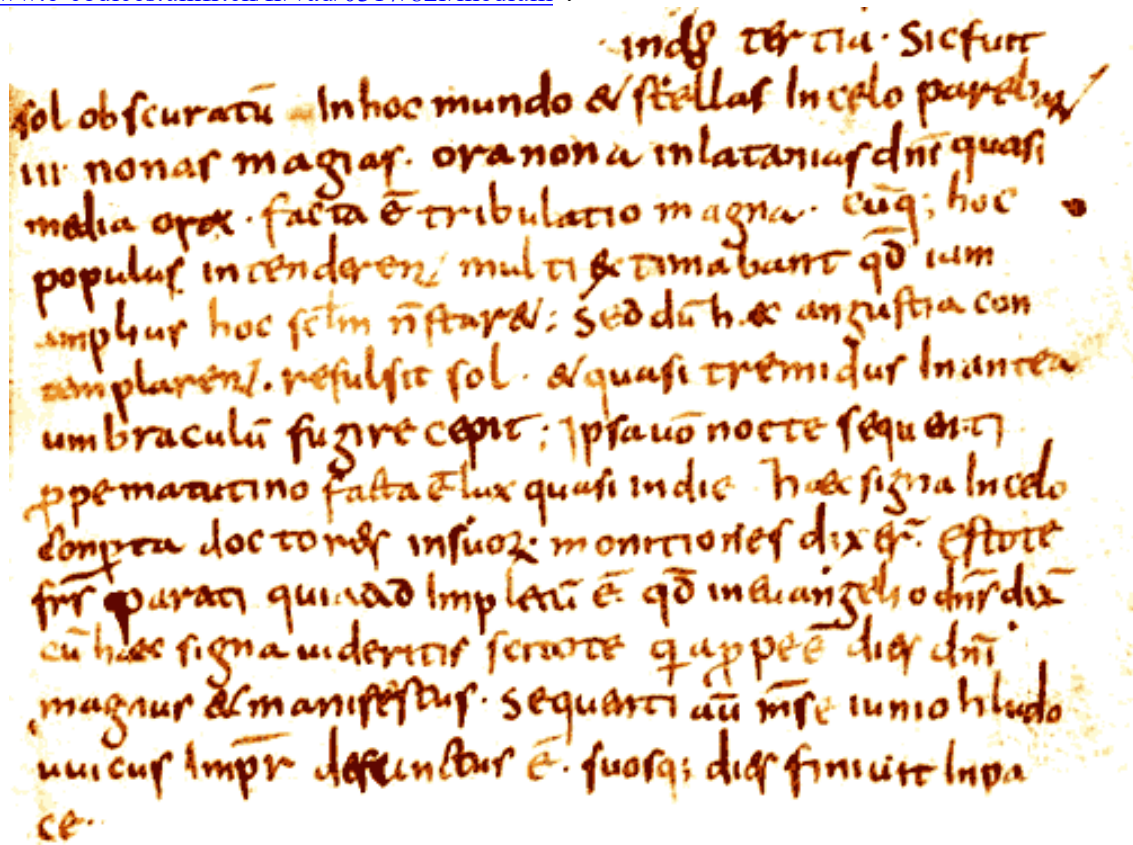
The solar corona @ E29. / N41. is described in *Leo DEACONIS Historiae* as: a narrow headband, shining around the edge of the disk.

16) SAROS 90/55 on 840.05.05

With the description of this eclipse @E9.37 /N47.42, in the *Annales Sangallenses*, <http://www.e-codices.unifr.ch/de/csg/0915/204> one has the very first Chronicle description of an eclipse. Previous annals' reports were themselves dated on the basis of eclipses! Year 840 is, in this sense, the beginning of modern History of solar eclipses.



The year, here, is explicitly given: ω.xl. with the Greek letter ω standing for 800. This Chronic is corroborated by the *Chronicon Andreas Presbyter Bergomas, saec. IX, Historia 620, 255 line 9* in webpage <http://www.e-codices.unifr.ch/fr/vad/0317/82r/medium> .



This Chronicon of ANDREAS Bergomatis is available on the web since June 2009. The death of LOUIS I, just mentioned in CSG, is usually assumed to occur on 840.06.20. It is described in ANDREAS B. Chronicon in relation to this long eclipse over Bergamo, and the 3rd year of indiction: May 840 matches the 3rd year of the 35th indiction (*indiction* is the 15 years long ecclesiastical fiscal period introduced by CONSTANTIN on 312.09.01. For the precise day in May, both Chronicles indicate 3 days before the None's of May, which, is indeed May 5th, and for the hour, St-Gallen mentions between the 8th and 9th hour (of the day).

For St-Gallen, GPS gives 03:17 UT for sunrise, 8h30 added to it gives 12:47 UT while 5MCSE retrodicts 12:38 UT. For a more in-depth discussion, see <https://www.archaeometry.org/timetale.htm>

17) SAROS 79/29 on 71.03.20

This eclipse was total for half a minute over the city of Athens, while it is believed that the poet PLUTARCH spent most of his life in his city of Chaeronea. In *De facie in orbe lunae*, PLUTARCH lets an Athenian (friend of his ?) called Lucius, describe a solar eclipse: *...beginning just after noonday* Later, Lucius described *"...a kind of light visible about the rim, keeping the shadow from being profound.."* what corresponds well to the partial corona, as coined by FLAMMARION

18) SAROS 62/54 on 65.12.16

For the eclipse over the Kingdom of CHU, with magnitude of 0.997 over the capital Xuzhou @ E117.15/ N34.25 one might ask if it has not been instrumental in enforcing Buddhism.

19) SAROS 79/18 on -128.11.29

The totality path crossed over the Hellespont, e.g. 17 s duration @ E26.398/N40.146 while 1/5 of the sun disk was still visible in Alexandria @E29.9 /N31.2: this matches exactly with the description given by PAPPUS and CLEOMEDRE of the characteristics of the eclipse used by the *Greek astronomer* HIPPARCHUS in his evaluation of DE-M, the Distance Earth-Moon, in terms of RE, the Earth Radius. We do not know how HIPPARCHUS actually proceeded. A qualified guess has been 90 Earth Radii <http://www.phy6.org/stargaze/Shipparc.htm> . Another approach is: as the height of the sun was only 12° over the horizon, it must have been easy to remember its position over the landscape and then to estimate the azimuths of the two observation sites, i.e. 233° and 239° as retrodicted by 5MCSE. The ratio RE / DE-M equals the ratio of a 1/5 of the sun apparent angle 0.5°/5 and of the 6° difference in azimuth, i.e. 0.1° / 6° = 1/60, The distance from Alexandria to the Moon is then 60 Earth Radii. As expected, there exist other opinions on HIPPARCHUS... e.g.: On the web-site of the School of Mathematics, Uni. St Andrews, <http://www-history.mcs.st-andrews.ac.uk/Biographies/Hipparchus.html> forwarding the claims of G J TOOMER, HIPPARCHUS on the distances of the Sun and Moon, Arch. History Exact Sci. 14 (1974), 126-142 it is boldly stated that HIPPARCHUS used the eclipse on -189.03.14, on his birthday so to speak...

20) SAROS 75/27 ON -135.04.15

Totality path crossed over Babylon. Full discussion is at https://www.archaeometry.org/seleucid_era.pdf

21) SAROS 69/24 on -309.08.15

The totality zone with its southern border at the bay of Syracuse @E15.29 /N37.07, makes the tale of the escape of AGATHOCLES to sounds plausible.

22) SAROS 50/42 on -462.04.30

Out of the eclipse @ E10.32 /N36.83 emerged, in 1995, <https://www.archaeometry.org/cdz.htm> the hypothesis that this event might have been instrumental in the institution of the cult of the Goddess TANIT <https://www.archaeometry.org/tanit.htm> in Carthage. 5MCSE retrodicts M=0.985 at 12:39 UT.



23) SAROS 42/62 on -477.02.17

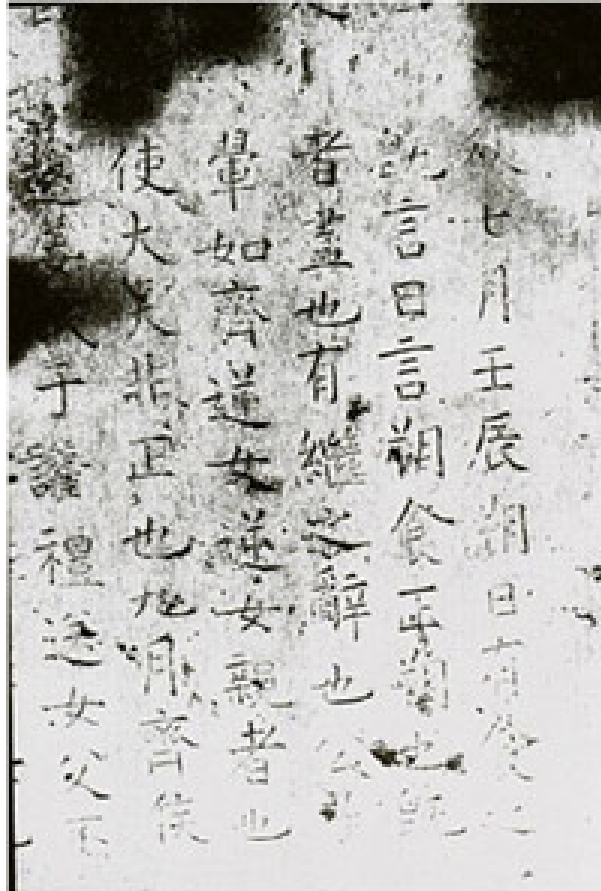
For this annular eclipse @ E23.38 / N38.36 the Theban poet PINDAR, while 40 years, old, wrote an Ode (Paens, IX) to the citizens of his city, evoking the long annular eclipse: *....star supreme, reft from us in the daytime !* and the threats of the Theban winter: *...an unspeakably violent snow-storm*

24) SAROS 44/42 on -708.07.17

This eclipse @E116.576 /N35.401 is the first reported in Chinese Annals, see:

http://www.astro.uni-bonn.de/~pbrosche/iaucomm41/meetings/ga2000/as_li.html.

This stele, photographed by Li CiYuan, is now at Xian. It is a later copy of earlier Annals from



Jining @E116.576/ N35.401, what became 150 years later the native place of Confucius.

One reads 7th month (counted from winter solstice) and Renchen, the 29th day of the Jiazi, the "60 days Chinese week". Taking into account the algorithm for the Jiazi $(JD-10)/60$, one obtains $(1'462'659-10)/60=24'377$ with a rest of 29. Associated with the name of LU HuangGong, the chief of the kingdom of Lu provides unmistakably the date of this nearly 2 minutes long solar eclipse, i.e., a very strong argument for the Geo-Chronological Model.

25) SAROS 26/38 on -1337.05.14

During the eclipse @ E30.90 /N27.67 the totality over the site, where two years later

AKHENATEN, see <https://www.archaeometry.org/nefertiti.htm>, will inaugurate his capital Akhet-Aten,

26) SAROS 23/14 on -1911.09.24

For the annular eclipse @E111.7° / N27.67, one deals with the oldest solar eclipse ever mentioned.

This "Double Sunset" which took place at sun dawn over Chande, in western part of the San Miao Kingdom, has first been described by PANG et al in GeoRes Forum pp 479-481.

5. Conclusion

The solar eclipse of +840.05.05 described in the Codices Electronici Sangallenses 915 confirms the validity of both Common Chronology and the Geo-Chronological Model.

The excellent agreement between our solar eclipses retrodictions with Xavier JUBIER's 5MCSE & World Annals strongly advocates for the use of ΔT given by the Geo-Chronological Model as input data to 5MCSE. Keeping in mind that, at the decade level, deviations from a strict parabolic decrease might reach up to 30 sec, those small oscillations, mainly harmonic O1, invalidate wild oscillating behaviour used previously as default values.

The solar eclipse of -1301.06.05, previously boldly assumed to have been described on an oracle bone of the Shang Dynasty, as well as the solar eclipse of +1133.08.02, reported in Regensburg by Honorii Augustodunensis, the famous author of *Imagine Mundi*, misleadingly assumed by previous researchers to have been in Augsburg, or the solar eclipse of +1239.06.03 misleadingly described as "total" in Mende Archbishopric Annals cast more than a doubt upon the classical approach of "Best-fitting Delta T".

The retrodicted parameters of SE are consistent with a mean non-tidal acceleration of the Earth

$$\dot{\omega}_{nt}/\omega = + 8.1 \cdot 10^{-9} [\text{cy}^{-1}],$$

constant over the last 4'000 years.

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