Buenaventura Suarez, S.J. (1679-1750) Part 2: His book, lunario

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In the previous paper (part 1 *Rev. Mex. Fis. E* **57** (2011) 121–133) we have analyzed some aspects of the astronomical production of Buenaventura Suarez, a Jesuit missionary that worked in the Reductions of Paraguay in the early 18^{th} century. To date, his only existing manuscript is the book "Lunario de un Siglo"; a sort of almanac containing a hundred years calendar of: moon's phases, solar and lunar eclipses predictions and ecclesiastical dates. In this paper (part 2) we shall analyze the contents of Father Suarez's opus, its structure, scope and the accuracy of its predictions. Thereafter we shall concentrate on the reasons why Suarez translated from Portuguese into Spanish the book "True Theory of Tides: according to the incomparable gentleman Isaac Newton" by Jacob de Castro Sarmento, a London-based Portuguese physician and Fellow of the Royal Society. We suggest that Suarez probably shared with Sarmento the common conviction that the Moon's phases had an influence upon human beings. This might explain why Suarez included a Moon's phase calendar into his book.

Keywords: Buenaventura Suarez; Newtonianism; eclipse prediction.

En el artículo previo (pate 1 *Rev. Mex. Fis. E* **57** (2011) 121–133) hemos analizado algunos aspectos del trabajo astronómico de Buenaventura Suárez, un misionero jesuita que trabajó en las Reducciones del Paraguay a comienzos del siglo 18. Su único manuscrito que sobrevive a la fecha es el libro "Lunario de un Siglo; una especie de almanaque conteniendo un calendario centenario de: las fases lunares, predicciones de eclipses solares y lunares, y fechas eclesiásticas. En el presente trabajo (parte2) analizaremos el contenido de esta obra del Padre Suárez, su estructura, visión y la certeza de sus predicciones. De ahí en adelante nos concentraremos en las razones del porqué Suárez tradujo del portugués al español el libro "Teoría verdadera de las Mareas, de acuerdo al incomparable caballero Isaac Newton" escrita por Jacob de Castro Sarmento, médico portugués residente en Londres y miembro de la Real Sociedad. Mencionamos que Suárez probablemente compartía con Sarmento la creencia popular que las fases de la Luna tenían una influencia sobre los seres humanos. Esto podría explicar el porqué Suárez incluyó en su libro un calendario lunar.

Descriptores: Buenaventura Suarez; Newtonismo; predicción de eclipses.

PACS: 01.65+g; 01.65+q.

1. Introduction

Between 1701 and 1732 Buenaventura Suarez wrote "Lunario de un Siglo" (from now on, "*Lunario*"), a sort of almanac containing a hundred years calendar (1740-1841) of: moon's phases, solar and lunar eclipses predictions and ecclesiastical dates [1]. According to his biographer Guillermo Furlong Cardiff, this is the only Suarez's manuscript that survives to present day [2]. The book went through several editions: the first edition published prior 1738, of which no known copies have survived, a second edition of 1748 (Lisbon), a third of 1752 (Barcelona) and fourth of 1856 (Corrientes, Argentina) [3]. Beyond any doubt Buenaventura Suarez is best remembered for this book. But what were the reasons for this manuscript to become a success? The obvious answer is its contents. However, before we analyze the book's contents, we must make a comment on its title and the book's nature.

Lunaries, Lunarios or Selenodromos, find their place within a kind of medieval astrological genre whose purpose was the prediction of the moon's influence in human affairs. It was believed that this effect depended on the moon's age or phase of cycle. Their predictions stretched from the proper time for bloodletting to seed planting. In this respect, the title of Suarez's book *Lunario* can be misleading, guiding the reader to believe that the manuscript was exclusively of astrological usage. As we shall see, this book does not entirely fall into this situation. In fact, in spite of a decline by the late 17^{th} century in the practice of astrological prognostications, Suarez's book still contains a speckle of this habit as the transition of astrology into astronomy was not an event but a slow process. We shall return to this point at the end of this paper. But we must say that on the whole, the information contained in the book was meant to be useful for longitude estimates, as it included eclipses predictions. In addition it contained a liturgical almanac that incorporated calculated dates for movable ecclesiastical celebrations for a period of 100 years. These religious festivities depend on a combination of lunar cycles and the civil calendar, and were already calculated by Suarez in his manuscript. Readers looking up for a particular festivity date could consult the tables given in the *Lunario* without going into the tedious practice of calculating these dates using the phase of the moon calendar included in the same *Lunario*. In this matter, the inclusion of a moon's phase calendar seems to be redundant and unnecessary. So what was the purpose of including lunar phase tables in the book? To answer this question we shall explore the reasons why Suarez translated from Portuguese into Spanish the book "Theorica Verdadeira das Marés conforme à Philosophia do incomparável cavalheiro Isaac Newton", by Jacob de Castro Sarmento [4].

For our purposes we have divided this article into sections. In the next section we describe the format of *Lunario*. Then in the third we analyze in order each segment of the book's contents: Title page, Letter of dedication, Introduction, table of geographical positions, Editor's note, Religious calendar with astronomical ephemerides and, Instructions on how to expand the lunar almanac. We shall be making appropriate comments on each segment together with -were applicable- comparisons to NASA's modern day ephemerides values. The fourth section will deal with Sarmento's life and his book. The final section will present our conclusions.

2. Description of his book *Lunario*

We had access to a facsimile of the second edition of the *Lunario* published by the National University of Misiones, Argentina [5]. This facsimile is an exact copy from the original volume printed in Lisbon in 1748 which is presently in custody at the Biblioteca Nacional de Argentina. In addition we had gain access to the original third edition in care of the Public Library of the National University of la Plata in Argentina. Both documents differ slightly and those differences, for the purpose of the present paper, are of no concern.

The 1748 edition consists of 217 pages each of 16.8 cm height and 10.9 cm wide, corresponding approximately to an octavo format. This handy format made the book easy to carry around for mission fieldwork. The book is written in Spanish, however in the opening letter of dedication, accompanying Christian aphorisms appear in Latin.

The layout of Suarez's second edition book is as follows: title page (1 page), a blank page, an extensive letter of dedication to Society of Jesus (4 pages), an introduction (6 pages), a table of geographical positions of 70 locations worldwide (3 Pages), list of contractions and symbols (1 page), an editor‘s note (1 page), religious calendar with astronomical ephemerides (186 pages), a blank page, instructions on how to expand the almanac for forthcoming years (12 pages). Next we shall examine pertinent sections of the book.

3. Contents description

3.1. The title page

Enclosed in a double frame, reads as follows:
"*Lunario / of a century /that starts in January of the year 1740, and ends in / December of the year 1841 comprising / one and one hundred years /* [It] *contains the main / aspects of the sun and the moon been these, conjunctions, oppositions, and / quadratures of the Moon with the Sun according to their / true movements; and news on the eclipses of both luminaries, / that will be visible through all the century in these missions /of the Society of Jesus in the Paraguay Province / aspects and eclipses hours are evaluated / for the meridian pertaining to the town of / the illustrious martyrs / St. Cosme and St. Damian /and* [they may be] *extended to other places by means of a / table of meridian differences, / to be found at the beginning of the Lunario / Placed at the end, easy rules [are given] / so that anyone without* [employing] *mathematics or arithmetic / may develop, from this centennial Lunario / those almanacs for the / next following years, from 1748 to 1903 / By Father Buenaventura Suarez, / of the Society of Jesus / + / In Lisbon / in the printing press of Francisco da Silva / With all required licenses / Year of 1748"*

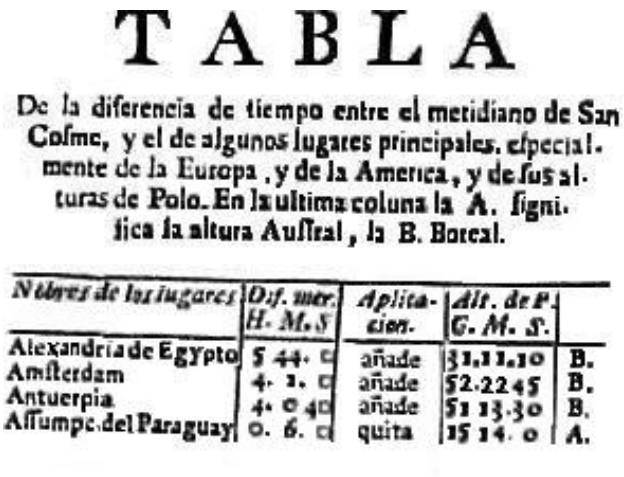
As the reader can notice, the title itself gives a brief summary of the contents of Suarez's book.

3.2. Letter of dedication

The book begins with a four pages dedication letter. In this rather flattering letter, Suarez dedicates his opus "*To my always venerated and beloved mother the Society of Jesus*". This comes as no surprise as the Society celebrated in 1740 the bicentennial anniversary of its foundation and Suarez finished his *Lunario* shortly before. Apart from this, we would like to remark a statement written by Suarez at this point, explaining his own motives for writing his opus: *"I made this Lunario, useful to agriculture and medicine, at the expenditure of the celestial influx of the divine medics, and prodigious martyrs in Christ, St Cosme and St Damian..."* aside from acknowledging this pair of Saints as sources of inspiration he admits that his work is useful to agriculture and medicine. A modern reader might question on what grounds an ephemerides book may be useful to medical practices, but we must remember that early medicine in the 18^{th} century was still linked to astrological prognostications and as we have already mentioned, Suarez's Lunario still reflects the remains of an astrological cultural precedent.

3.3. Introduction

In this book segment, Suarez makes us known that he has been witting lunar ephemerides each year for the past 30 years *i.e.* from around 1709, and at this point he has decided to write the present ephemerides updated to last for the next hundred years. He says that for this purpose he has used-among others- the tables of Philiphe de la Hire (1640-1719) published in Paris in 1702 [6]. In fact, as we shall see, the layout of some parts of Suarez's book follows de la Hire's format. In addition Suarez explains that for eclipse predictions he has deviated slightly off de la Hire‘s data, by using his own astronomical observations made between 1706 and 1739. To perform those observations he makes clear that he has manufactured his own telescopes, clocks etc., as we have already discussed in the precedent paper (Buenventura Suarez: Part 1). Then he reveals the type of observations made with his instruments, such as Solar, Lunar and Jovian satellites eclipses (observations that Suarez does not incorporate into the *Lunario*). He then expresses that his eclipse records were sent to Father Nicassius Gramattici S.J., his correspondent in Europe (see Buenventura Suarez: Part 1, Sec. 3), who in turn sent him back his own measurements together with those made by Nicolas de la Isle (Delisle) S.J.



TABLA

De la diferencia de tiempo entre el meridiano de San Cosme, y el de algunos lugares principales, especialmente de la Europa, y de la America, y de sus alturas de Polo. En la ultima coluna la A. significa la altura Austral, la B. Boreal.

Nombres de los lugares	Dif. mer. H. M. S	Aplicacion.	Alt. de P. G. M. S.	
Alexandria de Egypto	5 44. ☐	añade	31.11.10	B.
Amsterdam	4. 2. ☐	añade	52.22 45	B.
Antuerpia	4. 0 40	añade	51 13.30	B.
Assumpc. del Paraguay	0. 6. ☐	quita	25 14. 0	A.

FIGURE 1. Table of time differences and longitudes in Lunario (fragment).

(1688-1768) in Petersburg and Ignacio Koegler S.J.(1680-1746) in Beijing. Suarez tells us that with these observations together with those provided by Pedro Peralta (1663-1743) in Lima, and his own measurements, he was able to determine the local longitude of his base camp in the Reduction of San Cosme which happens to be at 321 degrees and 45 minutes from the isle of Ferro in the Canaries. Here we highlight that the figure for the longitude given by Suarez corresponds, in modern terms to a longitude of 38° 15' W (Greenwich) and comes close to the actual value for old San Cosme's Reduction 37° 42.3' W (Data SIO.NOAA U.S. Navy). We remark that this implies an amazing difference between longitudes of only half a degree.

3.4. Table of geographical positions

With the knowledge of the true longitude of San Cosme, Suarez presents a table showing time differences between San Cosme and 70 cities around the world. Figure 1 shows part of this table. The table heading reads "*On the time difference between the San Cosme meridian and some principal places, especially in Europe and the Americas and on their pole altitudes. In the last column: A means austral* [south] *latitude and B boreal* [north]".

The table consists of five columns. The first column enlist names of places, the second gives the time difference in hours minutes and seconds between San Cosme meridian and the respective place of the same line, the third column indicates the reader either to add the tabulated difference or subtract it from the local reader's time. The fourth indicates the latitudes of the locations, while the last column describes whether the latitude is in Austral or Boreal (see Fig. 1).

As already mentioned, Suarez tabulated data was based on de la Hire tables as he acknowledges in his *Lunario*. Therefore we cannot judge the accuracy of Suarez's table as the tabulated values shown are not only his values which depend on his own estimation of San Cosme meridian –which we have already shown that is remarkably accurate- but on the accuracy of de la Hire tables which in turn depended on

Tabula IV. Catalogus Locorum insigniorum cum differentia temporis addenda vel subtrahenda tempori Meridiani Parisiensis, vel Observatorii Regii, eorumque altitudine Poli.

Nomina Locorum.	Differ. temporis. H.	M.	S.		Altitudo Poli. G.	M.	S.	
Abbavilla.	0	2	12	Add.	50	5	30	B.
Agra Mogoris.	5	24	0	Subt.	28	30	0	b
Alenconium.	0	9	30	add.	48	29	0	b
Alexandria. *Ægypt.*	1	52	0	subt.	31	12	0	b
Ambianum.	0	0	12	add.	49	53	46	b
Amsterodamum. *Holl.*	0	10	10	subt.	52	21	30	b
Ancona. *Italiæ.*	0	47	40	subt.	43	54	0	b
Anlegavium.	0	12	15	add.	47	27	0	b
Antipolis.	0	19	11	subt.	43	34	12	b
Antuerpia.	0	8	30	subt.	51	10	0	b
Aquæ Sextiæ.	0	12	25	subt.	43	31	0	b
Aracta Syriæ.	2	50	0	subt.	36	0	0	b
Arelatum.	0	8	20	subt.	43	34	0	b
Argentina, *Strasbourg.*	0	22	0	subt.	48	35	30	b
Armuria, *Ormus.*	3	58	0	subt.	27	30	0	b

FIGURE 2. Table of time differences and longitudes de la Hire's book (fragment).

the collective effort of his colleagues around the world at calculating their own longitudes at different observatories. For purposes of comparison, Fig. 2 shows part of a table belonging to the book by De la Hire. The table heading –in Latin- reads: *"Catalogue of emblematic places with time differences for adding or subtracting from the Paris meridian or the royal observatory, including their polar altitudes"*. This table enlists data for 126 places.

The reader can readily see in Fig. 2, that de la Hire's table format is the same as that of Suarez's table. Moreover a further complete comparison of both tables shows that Suarez adjusted, to San Cosme meridian, most of the values published by the French astronomer, with the exception of data for those places in the Americas that at the time of de la Hire's publication were either unknown or not yet measured. Among those places Suarez added: Asuncion in Paraguay, Buenos Aires, Cartagena of Indias, Cordoba of Tucuman, Havana and Panama. What is more, Suarez left out of his table data for places that he probably considered not important, but added Petersburg, Ingolstadt and Freiburg, places were Jesuits had already established observatories. A pair of Portuguese cities appeared in Suarez tables not displayed in de la Hire's table: Evora and Coimbra. Incidentally it is interesting to spot that de la Hire's table shows a record for a place named "Argentina" which was the old given name for Strasburg. Argentina in the Americas did not exist at that time.

3.5. Editor's note

Here the editor informs that the pages corresponding to the ephemeris of years 1739 to 1748 have been omitted since the publication of *Lunario* suffer a delay of several years and for that reason there was no case in including past years in the present 1749 edition.

3.6. Religious calendar with astronomical Ephemerides

This section is the longest of *Lunario* and contains the core material of the book. The data here enclosed covers each

2 *Lunario*

PAra el año de 1748. Biffiesto, regulado al Meridiano del Pueblo de San Cofme en las Miſſiones del Paraguay de la Compañia de Jeſus.

Notas vulgares		*Fiestas movibles*	
Aureo numero	1.	Septuageſim.	11. de Febr.
Epacta	*	Ceniza	28. de Febr.
Letras Dominicales	g. f.	Paſqua	14. de Abril.
Letra del Martyrol.	P. mai.	Aſcenſion	23. de Mayo.
		Pentecoſtes	2. de Junio.
Temporas.		Corpus	13. de Junio.
Marzo	6. 8. 9.	Adviento	1. de Diziemb.
Junio	5. 7. 8.		
Septiemb.	18. 20. 21.		
Diziemb.	18. 20. 21.		

Eclipſe Lunar

Un Eclipſe parcial de Luna ſe podrá ver en eſtas Miſſiones el año de 1748. a 3. de Agoſto á la noche.

Su principio en San Coſme hor. 6. min. 35.
Su medio hor. 7. min. 44.
Su fin hor. 8. min. 52.
Su duracion ſerá de 2. horas y 17. min.
Los digitos eclipſados haria el Sur ſeran 5. min. 21., que es poco menos de media Luna.
No ſe verá eclipſe de Sol en eſtas Miſſiones el año de 1748.

FIGURE 3. Sample of an even-numbered page of the ephemerides section.

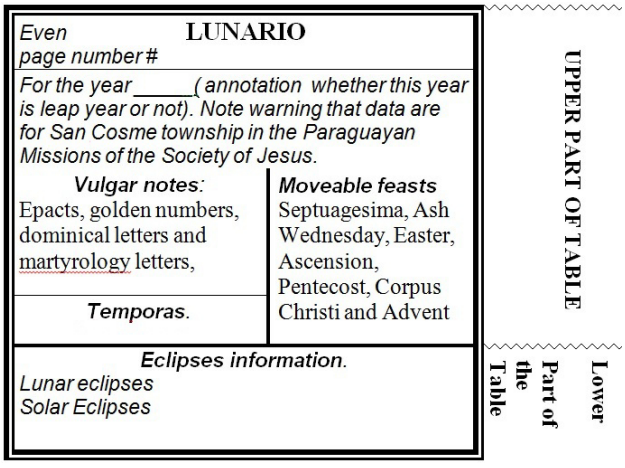


FIGURE 4. Layout of the even-numbered pages of the ephemerides section.

year from 1752 up to and including 1840 (for the 1752 edition). Information for each single year is presented in two successive pages: odd- numbered and even-numbered pages.

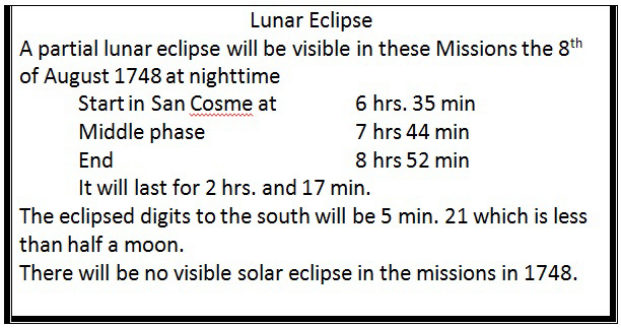


FIGURE 5. Translation for even-numbered page for 1748.

3.6.1. The even – numbered pages

The even pages layout is the same throughout the section for all the years and it can roughly be divided into two parts (see Figs. 3 and 4). The upper part contains heading and below information of ecclesiastical nature. The ecclesiastical information is displayed into three groups of data: Movable holydays, Temporas and "Vulgar notes".

Under the headline of "vulgar notes" Suarez presents four auxiliary numerals: epactas [7], golden numbers [8], dominical letters [9] and martyrology letters [10], all used to compute dates of Catholic celebrations. These religious festivities are partially defined in terms of astronomical events. The most important moveable feast for Catholics is Easter which must be celebrated during the first Sunday after the "full moon" following the northern hemisphere vernal equinox. For the Roman Catholic Church the equinox is reckoned to be on March 21 even though the equinox occurs in most years on March 20. Besides the so called "full moon" does not currently correspond directly to any astronomical event. Instead is defined as the 14^{th} day of a lunar month as determined from a table, given that the actual full moon may occur on different dates depending on the geographical situation of the observer. This situation arises from Church's need for celebrating Easter on the same Sunday around the world. So the yearly values for the aforementioned auxiliary numerals given by Suarez, serve the interested readers in Church liturgy to combine: lunar cycles, weekly cycles, leap years and the Church own arbitrarily set up rules, with the civil calendar to obtain their appropriate celebration dates.

Under the headline of "Movable feasts" are holidays that do not always occur the same date each year and they depend on the date of Easter day. For the Roman Catholic Church these are: Septuagesima, Ash Wednesday, Easter, Ascension, Pentecost, Corpus Christi and Advent.

The Temporas are four periods of penitential practices along the year. The liturgical calendar observes ember days (*quantur tempora i.e.* four days) during which Christian followers practiced obligatory fast and abstinence.

All things considered it is clear that this segment of the Lunario, is loosely connected to astronomical events that are the focus of the present paper, so we shall not dwell more

on this part of the Lunario. Interested readers are referred to their local Catholic Church. But what really concerns us here is the information given by Suarez on the lower part of the even pages, that is, the eclipses predictions.

The lower part of the table (of the even numbered pages, see lower part of Fig. 4) presents information on eclipses' occurrence and the time circumstances for each event.

As an example of the information given by Suarez in the lower part of the table we present in Fig. 5 a translation corresponding to the year 1748.

To evaluate the quality of Suarez's data we have compared his predictions with those provided by the Cannon of Espenak & Meeus (NASA /TP-2009-214172) [11]. The eclipse number corresponds to the Cannon catalogue number 09039, calendar date 1748 Aug 08 and Saros series 134. We have transformed Suarez's timetable to Universal Times (UT) estimating old San Cosme to be located at 56° 19.75 W, based on an image retrieved from Google earth (v. 6.02.2074). For the local UT calculation we have neglected the time correction ΔT, given in the Canon, being the latter of only 13 seconds. For comparisons on the Eclipse intensity we have used the Canon Umbral magnitude which is the fraction of the moon's diameter immersed in the umbra at the instant of greatest eclipse and we have compared it to Suarez's datum assuming his scale to be duodecimal (*i.e.* Total immersion equal to 12 digits) for the values given in "digits" and sexagesimal for those in minutes.

The following table shows the comparison,

Table II

Lunar eclipse comparison table

Ephemerides	Canon of Eclipses	Lunario
Date	August 08 1748	August 08 1748
Type of eclipse	Partial	Partial
Umbral magnitude	0.4287	0.422
Partial phase duration	134.9 m	137 m
Instant of greatest eclipse (UT)	23:23	23:29

Suarez also produced accurate predictions for solar eclipses. As an example we analyze his prediction for a total solar eclipse dated September 16, 1773. His predictions are translated into English bellow in Fig. 6.

Once again, to evaluate the quality of Suarez's data we have compared his predictions with those available in the Cannon of Espenak & Meeus (NASA /TP-2009-214172) [12]. The eclipse number corresponds to the Cannon catalogue number 09039, calendar date 1748 Aug 08 and Saros series 134. This event was a total eclipse. Figure 3 shows the path of the total eclipse's shadow (black broad line) and the partial shadow (in gray zone) covering most part of South America [13]. It is clear from Fig. 7, that the eclipse as seen from San Cosme was partial.

The second Eclipse will be Solar at midday the 16th of September.
Start of eclipse h. 11 min. 15
Middle of eclipse hor. 00 min 45 in the afternoon
End of eclipse hor. 2 min 1
It will last for 2 hrs. and 17 min.
The eclipsed digits to the south will be 6 digits and 17 min. which is a bit more than half a Sun.

FIGURE 6. Translation for even-numbered page for 1773.

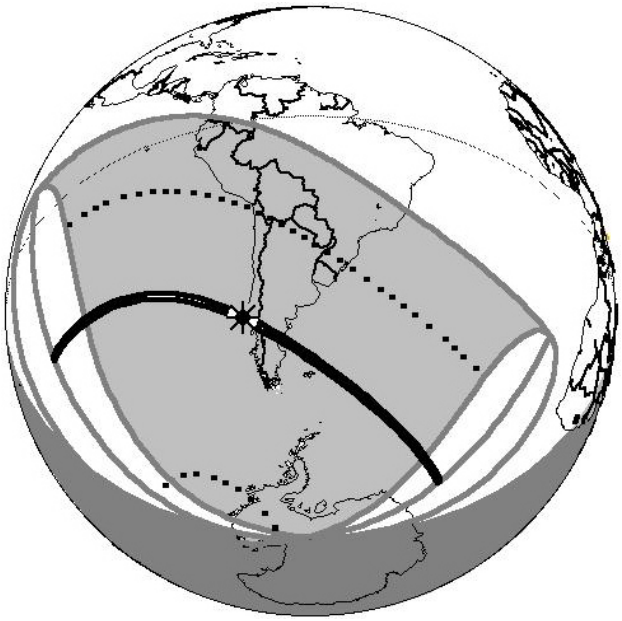


FIGURE 7. Path of the September 16 th, 1773 eclipse (after Mc Glaum).

	For the year... (leap year)		odd page number #
Month	Moon´s Phase	Day:Hour:Minute	Before or after noon.
January	New, crecent, etc	DD: hh:mm	mor/after
⋮			
December			

FIGURE 8. Layout of the odd-numbered pages of the ephemerides section.

For comparison purposes we have gotten the principal parameters of the eclipse assuming San Cosme as the place for which the eclipse parameters were obtained by Suarez, assuming the observation coordinates 56° 19' W, 19° S. With the latter data we have converted Suarez's predicted timetable to Universal Time (UT). Table III shows the comparison between modern-day values of the eclipse's parameters and those predicted by Suarez's.

An analysis of Table III shows that Suarez's predictions are shifted, all in the same direction, by mere 13 to 14 minutes. In this respect, the reader must remember that Suarez already calculated San Cosme position with an error of half a degree which in turn represents a shift of + 2 minutes in the assignment of his local time values, which do not totally account for the small time differences between his values and

Table III

	NASA*	Suarez	Modern-day conversion	Difference
Start of				
Partial Eclipse	14:57:28.6	11:25	15:10	+13 m
Maximum	16:16:09.3	00:45 in the afternoon	16:30	+14 m
End	17:32:47.3	2: 01	17:46	+14 m
Magnitude	0.484	6 digits 17 min	0.524	8.3%
Duration	2 hrs 35 min 18.7 s	2hr 36 min	2:36	40 s

***Eclipse predictions courtesy of Fred Espenak, Goddart Space Flight Center, NASA**

NASA's. However his eclipse's duration prediction shows a negligible error of 40 seconds.

3.6.2. The odd-numbered pages

Each odd number page presents a moon's phase calendar for every one of the 12 months of the corresponding year. A simplified layout of the pages is shown in Fig. 8.

The nature of this part of the book might have to do with what we had already comment, that is a mystical belief that some type of medical procedure has to be timed according to the lunar phases. We have already pointed out that in the letter of dedication of the Lunario, Suarez states that one of the purposes if writing this book is to make is useful "*to agriculture and medicine"*. Further ahead we shall elaborate on this point, after finishing the Lunario description.

3.7. Instructions on how to expand the lunar almanac

This is the last part of *Lunario*. In it Suarez presents some easy rules to extend part of the almanac for future years up to year 1903. The reader may read -in the long version of the Title page of *Lunario*- that Suarez establishes 1903 as an upper bound for his *Lunario.* We shall give the reasons why.

Suarez begins explaining that an average lunar month last 29 days, 12 hours, 44 minutes and 3 seconds (29.53 days). Then he notices that 767 lunar months are almost equal to 62 civil calendar years, with a difference of 4 days and 1/2 hour. In effect, on the one hand 767×29.53 makes 22,649.51 days and on the other 62 years + 4 days – 1/2 hour = 62×365.25 + 4 - 0.0208 makes 22649.48 days. So this means that a whole number of lunar months *i.e.* 767, coincide, rounding up with, a whole number of years, that is 62. So the calendar repeats itself every 62 years. Since Suarez calendar ends in the year 1841 (see title page) then the extended version for future years will end in 1841 + 62 years, that is in 1903. Finally, Suarez makes known that the eclipses will not repeat on the same dates. If effect, the 767 lunar months is not an interval of an eclipse cycle, be a Saros cycle or any other.

4. Sarmento and Suarez

According to Furlong, Suarez translated from Portuguese into Spanish the book "*Theorica Verdadeira das Marés. . . "* by Jacob de Castro Sarmento [14]. In this section we investigate the nature of Sarmento's book. We show that Sarmento was a firm believer that Moon's phases exerted an influence on human health. By translating Sarmento's book, Suarez implicitly shows that he had the same ideas as Sarmento, and that was the reason for Suarez to include a moon's phase calendar into his *Lunario*.

Jacob de Castro Sarmento FRS (1691-1762) was the correspondent of Suarez in London. Details of his life can be found elsewhere, here is sufficient to say a few words on his life [15]. This personage, formerly named Henrique de Castro Almeida, changed his name to Jacob de Castro Sarmento. He was one of those Portuguese crypto-Jews who fled the Inquisition and went to London in the early 18th century. After fleeing the Portuguese Inquisition, he was welcomed into the Sephardic fold of Bevis Marks congregation in London. Sarmento had already studied medicine at the University of Coimbra, Portugal and continued his medical studies at the University of Aberdeen, becoming the first Jew to obtain a PhD in the UK. He was a pioneer of the smallpox vaccine and a quinine water remedy (using South American Chinchona bark) [16,17]. As consequence of his research he was admitted to the Royal College of Physicians and later elected Fellow of the Royal Society in 1729.

In England Sarmento embraced the so called doctrine of "Newtonianism" which in simple words involves following Newton's conception of the universe as being governed by rational and understandable laws [18]. While Newton's contributions were primarily in physics and mathematics, his principles and methods were extrapolated to many strands of the Enlightenment epoch, influencing philosophy, political thought and theology. As example of this far-flung influence, the religious philosophy Deism, for one, is strongly Newtonian. Sarmento was a fervent advocate of Newtonianism and made efforts to integrate it with Jewish theology. In 1758, he resigned from the Synagogue, though his letter to the parnassim (ruling committee of the community) merely states that he held different views. He died in 1762.

Sarmento was keen to make use of Newtonian principles in medical topics. As we have already mentioned, he wrote the book "*Theorica Verdadeira das Marés conforme à Philosophia do incomparável cavalheiro Isaac Newton (London, 1737)*". At the Introduction of his work Castro Sarmento wrote,

"...the true and unchanging way to philosophy consist of, as our illustrious author [Newton] teaches us, in observing with attention Nature's phenomena and from it deduce the causes that can universally produce the same phenomena by the laws of Mechanics; once found such causes they must be admitted as laws or secondary causes [19] *from which Nature is governed and conserved*" [20].

Then at the same Introduction of his book he explains why is important to know the causes of tides *i.e.*, universal gravitation, as they are part of the "secondary causes" that produce the influence of the Moon on the human body,

" I must tell you that the knowledge of the forces of the Sun and Moon, that cause the flux and reflux of waters deserve worth concern and contemplation by the Physician, in the treatment of maladies that cannot be well explained, so as to relief some symptoms, even without the exact and true knowledge of the said forces. The [following maladies] cannot be conceived without their concourse [of the forces]: epileptic seizures, periodic vertigos, repeating only during new and full moons. Face stains, in young epileptic girls, changing color and size in accordance to moon's phases. The fury of the maniacs, that vehemently repeats in full and new moon; from which it derives the practice of calling these people, Lunatics. Periodic palsy, observed to follow the moon's course. Bleedings emerge merely in the course of a new moon. Wounds exuding substances whose amount, known by experience, follow moon's motions. Nephritic pains and periodic urinary suppressions are constantly following the moon's motion and repeat with full moon. And finally acute pain crisis cannot be explained or understood without comprehending of those forces" [21].

This convinces us that Suarez shared with Sarmento the belief that the moon's phases had an influence upon human health and reinforces our supposition that the moon's phase calendar, included in the contents of Suarez's book, was intended to be, *"...useful to...medicine..."* as is written in the Lunario's dedication page by Suarez own hand.

Finally we must point that the ideas on moon's phases and human health are given at the beginning of Sarmento's opus and are not the main topic of his book. We must stress that the fundamental purpose of his book was to explain the educated Portuguese layman, the mechanism of tides based on Newton's Law of Gravity. Sarmento's book is a non-mathematical account on Edmond Halley's theory of Tides. Its importance lays on the fact that it was the first intent to introduce Newton's theories to Portugal. Consequently, Suarez's translation deserves attention as it is also an early intent to introduce Newton in the Americas as early as the 1740s.

5. Final comments

To sum up, we consider Suarez's book as a multipurpose manual: it had the right size, it was cleverly organized, covering precise eclipse ephemerides for those who wanted to determine geographical longitudes by the eclipse method, it contained tables of geographical locations; besides it was also meant to facilitate missionary work by giving dates of religious feast days and tempers, and it included a moon's phase calendar presumably to help the medical practitioner.

Our work showed that Suarez successfully predicted eclipses. He was an excellent astronomer. But he was also a man of his time. His view of nature was accompanied by the belief that Moon's phases had an influence upon human health, a perception that was shared by a good number of his contemporaries.

Newton showed that the same force of gravity that makes an apple fall to the ground also operates to keep the Moon revolving around the Earth. Suarez rightly understood that if gravity operates between celestial bodies then it must operate in mundane matter like seawaters or our own human body. And indeed it does, as it keeps our feet on the ground. But Suarez was wrong on the influence of Moon's phases. Nevertheless the point here is that Suarez somehow realized that there was no distinction between earthly and celestial matter, a position opposed to the scholastic doctrine. That was his "heresy" and perhaps the reason why his translation did not survive to our days. Even so, he brought an early glimpse of Newton's theories to the Americas.

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1. Buenaventura Suarez SJ "*Lunario de un Siglo*" Francisco da Silva Ed. Lisbon 1748.
2. Guillermo Fúrlong Cárdiff SJ *Glorias Santafesinas: Buenaventura Suarez, Francisco Javier Iturri, Cristóbal Altamirano* Edit. Surgo, Buenos Aires (1929) p. 102. From now on "Glorias".
3. Furlong "*Glorias*" p. 115.
4. "*True Theory of Tides: according to the incomparable gentleman Isaac Newton*" (London 1737) In Portuguese.

5. Buenaventura Suarez "*Lunario de un Siglo*" Col. Ed. Especiales Universidad Nacional de Misiones (2009) ISBN: 978-950-579-141-1
6. Phillipe de la Hire "*Tabularum Astronomicarum Pars prior, de Motibus Solis et Lunae, necnon de Positione Fixarum, ex ipsis Observationibus deductis, cum Usu Tabularm*, etc." Paris 1702.
7. The Epacta number is the surplus days of the solar over the lunar year; hence, more freely, the number of days in the age of the moon on 1 January of any given year.
8. A golden number is a number assigned to each year in sequence to indicate the year's position in a 19-year Metonic cycle.
9. Dominical letters are letters A, B, C, D, E, F and G assigned to days in a cycle of seven with the letter A always set against 1^{st} of January as an aid for finding the day of the week of a given calendar date and in calculating Easter. A common year is assigned a single dominical letter, indicating which letter is Sunday (hence the name, from Latin *dominica* for Sunday). Leap years are given two letters, the first indicating the dominical letter for January 1 to February 28, while the second letter indicating the dominical letter for the rest of the year.
10. A Martyrology letter is a character indicating a year given in a table of a book about Christian martyrs
11. Five Millenium Canon of Lunar Eclipses (Espenak & Meeus) NASA TP-2009-21172
12. Five Millenium Canon of Solar Eclipses (Espenak & Meeus) NASA TP-2009-21172
13. The global map appearing in Figure 3 is based on a plate by *Dan McGlaun* appearing in Five Millenium Canon.
14. Furlog "*Glorias*" page 139.
15. See for instance "*Dr. Jacob de Castro Sarmento and Sephardim in medical practice in 18^{th} –century London*" Richard David Barnett. Jewish historical Society of England (1982) ASIN: B0007BQFY2
16. J. de Castro Sarmento "*Do uso, e abuso das minhas agoas de Inglaterra, pello inventor das mesmas agoas*" Gale ECCO Print Editions (2010) (in portuguese) ISBN: 978-1140710424
17. J. de Castro Sarmento "*Dissertatio in novam, tutam, acutilem methodium inoculationis, seu transplantationis variolarum. Per Jacob a Castro medicum Londinensem*" Gale ECCO Print Editions (2010) (in Latin) ISBN: 978-1170622513
18. Matt Goldish "*Newtonian, Converso, and Deist: The lives of Jacob (Henrique) de Castro Sarmento*" Science in Context, 10, pp651-675 (1997). doi:10.1017/S0269889700002854
19. Sarmento is using the term "*secondary cause*" in a scholastic sense and by extension he tacitly recognizes the First cause *i.e.* God.
20. *"...o verdadeiro e imutável modo de filosofar consiste, como nos ensina o nosso autor ilustre, em observar atentamente os fenómenos da Natureza e deles deduzir tais causas que possam produzir universalmente os mesmos fenómenos por leis mecânicas; e achadas ditas causas se devem admitir como leis ou causas secundárias pelas quais se governa e se conserva a Natureza*". "True Theory of Tides..." pp 10-13
21. *"...devo advertirte, que o conhecimiento das forças do Sol, e Lua, que causan o Fluxo, e Refluxo das Agoas, merecem tanto a consideraçam, e contemplaçam do Medico, na cura das Doenças, que se nao podem explicar bem, e remediar alguns dos Symptomas dellas , sem un exacto e verdadeyro conhecimento das mesmas forças. Nem se podem totalmente conceber sem oseu concurso, as Epilepsias, e Vertigens periódicas, que repetem somente nas luas novas, eluas cheas. Aquela Moça Epileptica, que tinha humas manchas na cara, que na côr, egrandeza, variavam conforme as Phases da lua. As furias dos Maniacos, que repetem com mayor vehemencia na lua nova, e na lua chea: donde naceo, e teve origen o chamar a os loucos geralmente Lunaticos. As Parlesias periódicas, que se tem observado seguir constantemente o curso da lua. Os fluxos de Sangue que appareciam somente no tempo da lua chea. As chagas cujo effuluxo de materias se achou por experiencia seguirem o movimiento da lua, e repetindo siempre cuando chea. E finalmente as Crises das Dolenças agudas, que se nao podem explicar ou entender sin comprehençam, e concurso da quellas forças.*" Ibid page 13.