of logarithm in astronomy. The other books written by Ottoman scholars about logarithm are Şerho Cada-
viş't-Enab by Gelenbevi İsmail Efendii in 1787; Loga-
rima Risalei by Hüseyin Rüfük (d.1817) and Logar-
rima Risalei by Mümtazade Osman Sıhib (d.1864).10

Ottoman scholars lived with mathematics always as one inside the other. They were informed of the productions of other scholars on the world. They made many original contributions to the mathematical research and education. Some of their contributions were translated into the other languages and were used as the guide works. So they took their places in the history of world classicals. As a tradition, all Ottoman mathematicians were interested also in the other scientific branches like astronomy, science, engineering and made important contributions to these fields. Unfortunately the history of Ottoman mathematics is one of least researched fields in the context of the history of mathematics in the Islamic civilization. There are many original works of Ottoman mathematician in the libraries of Turkey which are not studied in detail from the perspective of scientific history. I think if they are studied in detail a better picture of Ottoman mathematics will become visible.

1 Hariri Diligen, "Hunot'da İlahi İlahâ'/İlahâ' Ilahâ' Kitâb- 

ic, 1902.

2 A. Sıhib Diligen, "Hunot'da İlahi İlahâ'/İlahâ' Ilahâ' Ila-
hâ' Kitâb- 
ic, 1902.

3 Hariri Diligen, ibid.

4 Hariri Diligen, "Hunot'ta İlahi İlahâ'/İlahâ' Ilahâ' Ila-
hâ' Kitâb- 
ic, 1902.

5 Hariri Hançer, "İlahi İlahâ'/İlahâ' Ilahâ' Ilahâ' Ila-
hâ' Kitâb- 
ic, 1902.

6 Green Ippi, "Ottoman Mathematics Astronomical Cen-
turies I and II Berlin", Osmanli Bilim Arastirmalar- 
ic, 1902.

7 ibid.

8 ibid.

9 ibid.

10 ibid.

DECIMAL TRIGONOMETRIC TABLES IN THE WORK OF 

TAHLİYÜDÎN 'CERİDE EL-DÜRER VE HARİDE 

EL-FİKER' (PREPARATION AND USE)

ASSOC. PROF. DR. REMZİ DEMİR

ANKARA UNIVERSITY, FACULTY OF LANGUAGE, HISTORY AND GEOGRAPHY / ANKARA - TURKEY

INTRODUCTION

The sixteenth century was the golden age for the Ottoman Empire and the Ottomans, as in other fields of scholarship it nurtured great scientists. Some prime examples of the scientific studies carried out in this century are studies made in the fields of mathematics, astronomy and geography.

But these studies were not examined in detail from the point of view of scientific history, and their values have not been determined from the point of view of Islamic scientific history or from the point of view of world scientific history. Our information about the field of scientific activity in the 16th century, as well as that for other centuries of the period, are rather shallow.

Tahliyudin ibn Maruf (1536-1585) is the most important scientist of this period and may be for all Ottoman periods. Tahliyudin was born in Darausus, after learning akhib (religious) and nabil (scientific) sciences, he began to work as a government official. He worked as a university professor and hâlî (judge of Islamic canons law and, in Ottoman history, governor of a district of a city) in various cities. He studied in many different fields of science, he was especially interested in mathematics, astronomy and physics. Apart from this, he wrote theoretical works related to the making and repairing of observational instruments, clocks and automations. But his most important contribution was to establish an observatory in Istanbul (1584) in the period of Murad III (1574-1595), and to carry out astronomical observation.

Three zâfs (books of astronomical tables) were produced as the result of these observations. These are, Sihâ Münitsâh el-Ejhâr fi Melâdit el-Felâh el-

Dosûr, Tohib Zîh el-A'jârîl el-Shâmîl Sihâ Aşâra fi 

Dosût el-Orumâlêsh el-Marâdîsh (1580) and Ceride 

el-Dürer ve Harinde el-Fiær (1584). Tahliyudin gathered together the results of his observations made at the Istanbul Observatory in these three zâfs, works which were of extreme importance from the point of view of Ottoman scientific history. Looking at these works it is possible to determine what the information level of the Ottomans was in mathematics and astronomy in the 16th century. Up until now, one, Sihâ Münitsâh el-Ejhâr has been partially studied and Ceride el-Dürer has been studied in detail.

The aim of this work to present the last zâf, Tahliyudin’s Ceride el-Dürer and Harinde el-Fiær, with its main points, and to show the ways of preparing and using of decimal trigonometric tables in the introduction of this book. Because one side of this subject is interested in the history of interpolation method, the history of interpolation will be gone into as well, and the place of interpolation formula being used to find the values between two argument by Tahliyudin in the history of mathematics will be determined.
The CONTENT OF CERIDE EL-DÜRER VE HARİDE EL-FİKER

The name of the third zih written by Taklîyûdîn is Ceride el-Dürer ve Haride el-Fiker. This work was completed in Istanbul and presented to his protector and sponsor, Hoça Saudetür Elfenbi (1536-1599).

Ceride el-Dürer was not divided into sections, after a žihna (foreword and dedication) and an Muhaddidin (introduction), the necessary information for using the zih was systematically listed and the following subjects were presented sequentially: definition of the arcs forming in the heavens and how to find them using trigonometry, the definition of trigonometric functions, the determination of namaz (Islamic prayer) times and the direction of Kibîl (Mecca), how to define the spheres that were needed to draw the results of the observational instruments commonly used by the Ottoman astronomer and time-keeper, for example, the isterha (call to prayer) and the rüah (quarter) board, in other words, the drawing of the different types of surfaces, the definition of astronomical terms and the presentation of astronomical operations. Also, the making and using of three different kinds of sundials, the hastil (sundial) and the kâmbî (right angle) and the quale (declivity), the determination of gurûs (the first day of the months) in the Arabî (Arabic) and Râmî (solar) years used by Muslims, 584 behind the Western calendar calendar, the movements of the sun and the moon, the solar eclipses and lunar eclipses, the months and the days of the seven calendars used in the Arabic world, known as Eski Arabî (Ancient Arabic), Suriyani (Syria), Kebîl (Copitic), Babonušami (Nebuchadnezzar), Mevîl (Christian), Fisrîl (Persian) and Hebrîl (Hebrew) and how to convert them were covered.

There are a total of 44 tables in Ceride el-Dürer, excluding the trigonometric tables in the Muhaddidin. 35 of these are astronomical, the remaining 9 are astrological. More tables, prepared in accordance with the latitude (40° 58') and the longitude (50° 49') of Istanbul, contain observations of the sun and moon, but no tables are included concerning the observation of planets. The "star tables" was one of the most important tables prepared in Hâfez (Hâfez is the Modern calendar, starting in 622 a.d., thus this year is 1581 a.d.), containing information of the angular positions; i.e., altitude, longitude, declinations, and rehnumain, you. One table was composed by Nescudîn ibn Murîd, the brother of Taklîyûdîn, and this table shows the gurûs of the Arabî - Kâmin (Arabic lunar) months which are equivalent to the gurûs of the Şarîr - Mârî (religiously observed) months. The most important characteristic of the astronomical tables is that the fractional quantities were expressed using the decimal system, instead of the traditional system in which the denominator is a power of 60.

The information presented in this work by Taklîyûdîn, in the sections of Ênbuna and Muhaddidin are important and valuable for scientific history.

No one before this could simplify the approximate computation, which involves using different numerical systems, of the Namaz times and the direction of the Kibîl, the calculation of the ruha, istek Kate and the drawing of hastil and kâmbî. Many important scientists and philosophers were interested in this subject before him, but no one was successful. Gyûsîsûdîn Cemîl el-Kâfi strove to understand the decimal system, but he was not successful, for the information available to him was not sufficient; he could not reach the target of converting whole numbers and fractions, nor could he unlock the secrets of astronomical operations.

According to the statement of Taklîyûdîn in the Muhaddidin of Ceride el-Dürer; all mathematicians and astronomer choose the Hindu Calculating System, because each place in a number has 10 numerals, including zero and this makes arithmetical operations and other systems and subjects easy. All significant and insignificant works were produced using these numerals. After the difficulties that arose from writing the numbers from left to right were realized, the scientists reverted to the sixteenth part system, where the whole denominator is a power of 60 (el-Nihe el-Sîhibecheh) and used this system instead. The application of this system requires a lot of hard work and patience, but the decimal system (el-Nihe el-Aşçariyeh) combined the easiest and simplest aspects of these two systems.

Taklîyûdîn did not stop here, and because he was afraid that confusion might be created by Hindu numerals, he proposed a new numeral system that was written from the right to left, like the Ottoman script of the time. This new system is a resultant system, that brought together the functional sides of the Ehdâ (enumeration by letter) numerical system, that was well known by Muslim mathematicians and astronomers, and the Hindu numerical system. The numerals of this system are the first 9 numerals of the Ehdâ system and zero, and they are written from right to left, separated from each other. But the new numerical system is decimal, like the Hindu numerical system. The new decimal system is similar to the sixteenth part system; in this system, one degree equals ten minutes, one minute equals ten second, one second equals ten, going on as degree, minute, second, were wanted. If ten degrees come together as a unit, they make one "Merfî", when ten "Merfî" come together as a unit, they make one "Maaonâ" or "Mazdî", and so it continues, as "Mâzîlî", "Mâzîlî", were needed. It is shown quantitatively as; "1°, 10', 10", 10'10", 10'/10", 10'/10'10",..."

Then Taklîyûdîn says that:

"A person who knows the subject well will not meet any difficulties with the Hindu fractional operations (common fractional operations). The fractional operations here, in comparison with the Hindu fractional operations are very easy, because the denominator is always 10 and factors of ten, and all that needs to be done is to make the denominators equal 3 and he proposes the use of decimal fractions.

After these, Taklîyûdîn put in order the four tables in the Muhaddidin; these trigonometric tables were prepared according to the decimal system.
samples (second) and silice (the sixtieth part of a second). Like the tangent-cotangent table that will be explained below, the sine table was prepared for three decimal places, in other words, it showed the place of one per thousand as 1.101. Because the maximum size shown in one place in the degree row is 10, one like to day, Taklyyidin taking 10 for the radius of the unit circle.

The second table, used to find the natural tangent and cotangent values of the arcs, has four rows. The first row shows the degrees, in increments of one degree, from 1 to 90, for all the arcs, the second row shows the natural tangent values of the arcs from top to bottom and the cotangent values of the arcs in the fourth row are from bottom to top, the third row shows the difference between the two natural values, one after another, and the fourth row shows the degrees, in increments of one degree from 90 to 0 for all arcs. The natural values between the tangent - cotangent row and the difference row are shown in degrees; daeha (minute), siy_zippe (second) and daehi (the sixtieth of a second), and the natural value of the tangent 90 degrees and the cotangent 0 degree were stated as "infinite". For the determination of natural values of the tangents of the arcs between 89° and 90°, or the natural values of the cotangents of the arcs between 0° and 1°, in order to use the interpolation method it would be necessary to be known its difference (infinite - 572,501). But if a finite quantity is subtracted from an infinite quantity, the remainder will be an infinite quantity, as well. However the second infinite quantity is less than first infinite quantity. Taklyyidin said that although it seems strange, there will be infinite quantities of different sizes.

Taklyyidin barely mentioned other cosine functions. The determination of natural values of this function, \( \cos A = \sin (90° - A) \)

This equation is found sufficient.

Taklyyidin did not give any information on how he prepared these two tables. Probably, he benefited from tables prepared using the sixtieth part system, and he may have used the conversion operation suitable for the decimal system.

To determine the natural values of trigonometric functions of arcs in daeha, daehi and siy_zippe, Taklyyidin prepared two tables, each having two rows, as mentioned above. He used the first table to convert the arc minutes of the sixtieth to the arc minutes of the results and the second table is used to convert the arc seconds of the sixtieth to the arc seconds of the results.

**USING THE INTERPOLATION METHOD TO FIND INTERMEDIATE VALUES**

To find the natural values of arcs and the arcs of natural values, Taklyyidin ibn Maruf used a method derived from these four tables, called the Talif Mubyn el-Satyn (reaching the intermediate values) and there are two components of this method. One of them, "al-Talif" (finding the sine, finding the natural value of an arc, interpolation) and the other "al-Takli" (finding the arc, finding the arc of a natural value, interpolation) define these operations.

In the "al-Talif" operation, if the desired size of the arc is given in degrees and minutes, the first sine value is found for the given degree from the sine table, then the decimal arc minute for the equivalent of the sixtieth part of the arc minute is taken from the tables for the conversion of minutes and this value is multiplied with the difference of the two sine values on the same line. The product is then added to the sine value, and the approximate value is found. If the arc is known in degree, minute and second, and its sine value is desired, then the operation is continued. Take the decimal arc second for the equivalent sixtieth part of the arc second from the table for conversion of seconds and carry out the same operation, adding the result to the values of the degree and minute. To find the tangent and cotangent of an arc, the same method is to be followed.

**EXAMPLES**

**Sample 1:** Find arc \( \sin (2.673°) = ? \)
1. \( \sin (2°) = 0.035 \)
2. \( \sin (2°) = 0.035 \)
3. \( \sin 20° = 0.3401 \)
4. \( 0.3401 \times 0.035 = 0.0119 \)
5. \( 0.3401 \times 0.035 = 0.0119 \)
6. \( 0.0119 + 0.035 = 0.0474 \)
7. \( 0.0474 + 0.035 = 0.0824 \)
8. \( 0.0824 + 0.035 = 0.1179 \)

**Sample 2:** Find arc \( \sin (6.799°) = ? \)
1. \( \sin (6°) = 0.2079 \)
2. \( \sin (6°) = 0.2079 \)
3. \( 0.2079 \times 0.035 = 0.0072 \)
4. \( 0.0119 + 0.035 = 0.0474 \)
5. \( 0.0474 + 0.035 = 0.0824 \)
6. \( 0.0824 + 0.035 = 0.1179 \)
7. \( 0.1179 + 0.035 = 0.1534 \)
8. \( 0.1534 + 0.035 = 0.1889 \)

But it is pointed that, because of the characteristics of the tangent and cotangent function, for operations with small values and rounded errors, when the arc becomes larger the errors also become larger, for example:

\( \tan (87°) = 208.822 \)

is a true value, but the result using the tangent - cotangent tables of Taklyyidin is 215.463. A difference of 6.641 is an unacceptable error.

In the El-Takli operation, if the sine value is known and the arc value is wanted in degree and minute, firstly, like above, if the difference, found in the sine table, in the value between the arc value for the given sine and the arc value for the sine is less than 1 degree, then the smaller value is subtracted from the other and the value found is divided by the difference between the two sine; in this way the decimal minute value is obtained. From the table for the conversion of minutes, the minute value for base 60 is taken for the decimal minute value, then the operation is completed. Using the table for the conversion of seconds, in the same way it may be theoretically possible to reach the arc values in seconds, but if the last table prepared by Taklyyidin is not taken into account, and because of the rounding off of the operation, the right results cannot be obtained. Taklyyidin, to find the arc values for the given tangent and cotangent values, uses the same methods.

Interpolation is a method that has been used by mathematicians and astronomers since ancient times. For example, the mathematicians of Babylon, utilizing the tables that showed the values of exponential quantities, used linear interpolation to find the intermediate values. Batlamyos, when preparing the table of chords in the first book of al-Masesti had two principles, the first was that if chord A is known as being 1/3, then A can be approximated, using interpolation.

In the Islamic world of the Middle Ages, the Muslim mathematicians and astronomers followed Batlamyos. They used the sine and tangent tables instead of the table of chords; in order to determine the intermediate values they used interpolation and generally tried to give statements of interpolation and interpolation algorithms.

According to Silâh Zeki, the Turkish scientific historian, the sine table prepared by the Muslim mathematicians in the 9th century utilized the table of chord of Batlamyos, until the middle of the 9th century without any disagreements or debate. Towards the end of the 9th century, Ebi'l-Velî el-Buzâzî (940 - 999) put the tangent and cotangent functions into trigonometry and also wanted to establish the trigonometric tables used for astronomical calculations at that time on a firm footing. To do this, he calculated again the sine of a 30 degree arc, using this method in his book, Kitâb al-Maşıestî, in Sažemî Fasîl (the eighth section) of Baynî nâmâ (the fifth chapter) of Birinci Musâîdî (the first article).

Ebi'l-Velî at first formed the theorem, "If the sum and the subtraction of two arcs are less than 90°, the difference between the sines of the totals and the sine of the larger arc is less than the difference between the sine of the larger arc and the sine of subtraction".

If the sum and subtraction of A and B are less than 90°, B is larger than A. This can be written:

\[ \sin (B + C) - \sin (B - C) = \sin (B + C) - \sin (B - C) \]

Ebi'l-Velî, Veflî, trying to find sine 30° or 16/32 degrees, used this inequality, known as "Tadil Malâyın al-Saâraya" and worked to determine the two limit values, one for each with that sine (16/32) between them. To use the method of "Tadil Malâyın al-Saâraya", the difference between sine 16/32 and sine 15/32 is larger than one third of the difference between sine 18/32 and sine 15/32.

\[ \sin(16/32) - \sin(15/32) > 1/3 \sin(18/32) - \sin(15/32) \]

This inequality was proved by Ebi'l-Velî. Veflî. This proof can be shown using algebraic symbols.

Ebi'l-Velî - Velî found, \[ \sin (B + C) - \sin (B - C) = \sin (B + C) - \sin (B - C) \] at first. B = 16/32° and C = (13/32)°. Then

\[ \sin (17/32) - \sin (16/32) < \sin (16/32) - \sin (15/32) \]

or,

\[ \sin (17/32) < 2 \sin (16/32) - \sin (15/32) (1) \]

is found. Secondly, for

\[ B = 17/32° \text{ and } C = (13/32)° \text{ taking,} \]

\[ \sin (18/32) - \sin (17/32) < \sin (17/32) - \sin (16/32) \]

or,

\[ \frac{1}{2} \left( \sin (18/32) + \sin (16/32) - \right) < \sin (17/32) (2) \text{ is found,} \]

the left side of the inequality (2) is less than sine (17/32), this is put into inequality (1).

\[ \frac{1}{2} \left( \sin (18/32) + \sin (16/32) - \sin (15/32) \right) < 2 \sin (16/32) - \sin (15/32) \]

or,

\[ \sin (18/32) + \sin (16/32) < 4 \sin (16/32) - 2 \sin (15/32) \]

Subtracting sine (15/32) from the two sides and rearranging,

\[ \sin (18/32) - \sin (15/32) < 3 \sin (16/32) - 3 \sin (15/32) \]
Hākimî, was not linear, and it has been said that it was similar to another algorithm expressed in an early period of Chinese literature. After Ibn Yûnis, there were also some people interested in this subject. In just the same way, it has been known that non-linear algorithms were proposed by Al-Birûni (973-1048) and el-Kâşi. Light must be brought on the development period of the interpolation method by gathering all the available information.

The interpolation algorithm of Ibn Yûnis was reached in such a way. From a table which included sine values for each 30 minutes, 0 ≤ p ≤ 89 and 1 ≤ q ≤ 59 accepting, to find value of sin(p , q)

\[ \sin p = a \]

\[ \sin (p ; 30) = d \text{ and} \]

\[ \sin (p + 1) = c \]

are defined, an approximate value of \( \sin(p ; 30) \), for example the value of \( d \), is found using the values \( p \) and \( p + 1 \) by the interpolation method,

\[ d = \frac{1}{2}(a+c) \]

is obtained. Then an "interpolation base" (Aid el Tādīd) \( D \) is defined. That,

\[ D = b - d \]

After that, for given \( q \) and \( p \), is approximately computed by linear interpolation and the \( Dq \) fraction of \( D \) added,

\[ Dq = \{ 4q (60 - q) \} / 3600 \] V D

choosing,

\[ \sin (pq) * a + q / 600a - d \]

is obtained. Because of the term \( Dq \), the interpolation algorithm of Ibn Yûnis or algebraic formula, is not a non-linear, but a nearly linear, equation. Somewhat apart, if \( q = 0 \) and \( q = 60 \), \( Dq \) takes maximum value.

The formula of Ibn Yûnis,

\[ \sin (pq) * \sin p + 1 \sin (p + 1) - \sin p \times 9/60 + \]

\[ Dq \]

is expressed in this form, in the case of showing the arcs in degrees and minutes, the difference between the formula of Ibn Yûnis and the formula of Tâkîyûldîn is \( q \), but this term provides that the values of Ibn Yûnis are approximately less than the values reached by Tâkîyûldîn by 1,000 times; this result can not be disputed. The formula of Ibn Yûnis is;

\[ \sin (pq) * \sin p + (\sin (p + 1) - \sin p) \times 9/60 + \]

\[ \{4q (60 - q) \} / 3600 \] x \( \sin (p ; 30) \times 1/2 \sin (p + \sin (p + 1)) \]

The formula of Tâkîyûldîn;

\[ \sin (pq) * \sin p + \sin (p + 1) - \sin p \times 9/60 \]

For \( \sin (75\degree ; 18\degree) \), from the formula of Ibn Yûnis,

\[ \sin (75\degree ; 18\degree) * \sin 75\degree + \sin 76\degree - \sin 75\degree \] x 18/60 + \[ \{4x18 (60 - 18) \} / 3600 \] x \( \sin (75\degree ; 30\degree) \) - 1/2 \[ \sin 75\degree + \sin 76\degree \]

\[ \sin (75\degree ; 18\degree) * 0,967 267 762 \]

is found. For, \( \sin (75\degree ; 18\degree) \) from the formula of Tâkîyûldîn,

\[ \sin (75\degree ; 18\degree) * \sin 75\degree + \sin 76\degree - \sin 75\degree \] x 18/60 \[ \sin (75\degree ; 18\degree) * 0,967 267 800 \]

is obtained, the error of the formula of Ibn Yûnis is,

\[ 0,967 267 762 - 0,967 267 800 = 0,000 030 \]

\[ 990 / \text{less} \]

is found. In that case, \( s \), the true value of function\n
\[ s' = \text{the approximate value of function then the} \]

\[ \text{Error Percent} = 100 (s - s') / s \]

is defined, using this error equation, the errors of these equations can be computed. It is seen that the error of the equation of Ibn Yûnis is approximately one per million, but the error of the equation of Tâkîyûldîn is approximately three thousand per million. The same result can be obtained with other examples, this shows us that the formula containing the term of \( Dq \) of Ibn Yûnis gave more accurate values than the formula of Tâkîyûldîn.

Tâkîyûldîn, in order to improve his interpolation algorithm or formula to find the seconds of the intermediate arcs, could have used the work of Ibn Yûnis or other Muslim mathematicians, who came after him, living between the 9th century and 16th centuries, for example, el-Kâşi. Therefore, the question must be asked, why did Tâkîyûldîn, an excellent mathematician of his age, if he had used the work of Ibn Yûnis or another mathematician influenced by him, put the term of \( Dq \), which effect the results more into his formula and prepare his trigonometric tables taking into account \( Dq \) ? His first intention in writing Carûda el-Dîner was, possibly, to show the use of the decimal fractions in trigonometry and astronomy, for this reason he could have found the accuracy of his formula sufficient and he avoided \( Dq \) because it made the algorithm too long. Moreover, because of the values of trigonometric functions in the sine and tangent - curvilinear tables which be prepared were shown to the place of one and the values computed by the formula of Tâkîyûldîn began to deviate after the place of one hundred thousandths, there is no need to use the term \( Dq \).

Interpolation has been investigated as a subject of numerical analysis and has become a base for the calculation of the differential and integral in contemporary mathematics, but its history in the West is complex and contentious. It has been understood that the works on this subject were closely related to the solutions of the problems which scientists encountered in the 17th and 18th centuries. One of the problems was to make the circle square and the other was to find the intermediate value between two given values.

As known, it became necessary to make more accurate the intermediate values of some parameters found by interpolation, utilizing the tables used in trigonometry, logarithm and in maritime sciences, and to bring them to an advanced position, in parallel with the improvement of astronomy at first, then geography and then maritime studies in this period. But it is impossible to reach this point by the common method of linear interpolation (the term interpolation belongs to the English mathematician Wallis) and it was necessary to improve the non-linear interpolation techniques in the field of non-linear functions, like trigonometric functions.

The first rule of interpolation that has the qualities needed was showed in Arithmetica Logarithmica (1624), the work of Henry Briggs (1561 - 1630) six centuries after Ibn Yûnis. However, the key formula was given by James Gregory (1638 - 1675) and independent from this, Newlon (1642 - 1727). Newton, fundamentally using the works of John Wallis (1616 - 1703), studied the problem of making the circle square and he showed that there were three different methods can be used; interpolation, the theorem of bisection and continuous variables. But according to Newlon, it is easy to compute the area of a curve using the interpolation method.

Tâkîyûldîn, not using the decimal point, prepared a fifth table to separate the whole part and the fractional part from a fractional number to determine the place of the numbers in the number, obtained after converting and multiplying or subtracting from on another for astronomical computations. muehdâs, mœkâbîl, muâsîfî, muwîfî, mûqâl, dâlibî, dâlibu, wâlî, mûsâ'î, naüsî, and handânas, that is to say respectively hundred thousands (10⁴), ten thousands (10³), thousands (10²), hundreds (10¹), tens (10⁰), ones (10⁰), one tenth (1/10), one hundredth (1/100), one thousandth (1/1000), one ten thousandth (1/10000), one hundred thousandth (1/100000)

This table is used in the following way, for example, supposing that Tâkîyûldîn used the decimal point, 27.325 and 3.11 are the given numbers, 84,98075 being the product of them, we want to separate the fractional part from the whole part of.
84,98075. We find the smallī, which show the place of one thousandth (1/100) for the first multiplier (27.325) on the right-hand side of the table, secondly the smallī, which shows the place of one hundredth (1/100) for the second multiplier (3.11) is found at the bottom of the table, the intersection point on the table is the haubātī, which shows the place of one hundred thousandth (1/1000) that gives the name of the first place of the fractional part of the product (84,98075) and other places found in this way, the fractional part of the number is separated from the whole.

If we want to separate the fractional part from the whole of 27.325, obtained by dividing 84,98075 by 3.11, we first find the haubātī, which shows the place of one hundred thousandth (1/1000) for the dividend (84,98075) from the side of "kind of dividend" on the tables, then find the sefnātā, which shows the place of one hundredth (1/100) for the divisor (3.11) on the side of "kind of divisor" on the tables, the intersection point on the table is the smallī which shows the place of one thousandth (1/100) for the division (27.325), other places being found in this way the fractional part of the number is separated from the whole.

It is possible to determine the fractional parts of the square root of a whole number or fractional number using this table prepared by Taklıyüddin. For example, if we want to separate the fractional part from the whole of 1.6, that is square root of 2.56, first the number (2.56) is found on the side of "number of square root" at the upper left hand side of the table, then we go diagonally to the smallī, which shows the place of one hundredth (1/100) for 2.56, then we go down from this point to daksāḥī, which shows the place of one tenth (1/10) at the bottom, and it is seen that the name of first place of the fractional part of 1.6 is daksāḥī, or in other words, one hundredth (1/100).

CONCLUSION

The four tables prepared by Taklıyüddin have been discussed here, and the Makaddīmā (introduction) of Čerdī al-Dīnār have really provided a great ease for trigonometric, and consequently, astronomical operations, thus putting them on a level that can fulfill the needs of the mathematician and astronomer. But, when compared with tables that were improved in the West and were commonly used (and contemporaneous tables), it is seen that they are insufficient in two directions:

1. The contemporary tables were prepared in a form that showed all the values of sine, cosine, tangent, and cotangent of an arc.

2. The tables showing the minuses and secondly were not used, operations in degrees, minutes and seconds can be carried out using one table.

But, it must be noted that scientific information is the type of knowledge that can be improved on and extended, and because of this it is very natural for there to be a difference between the beginning of the improvement process and the end product. Taklıyüddin investigated the works of arithmetic and trigonometry, adding the results of his mental abilities and imaginative power, he prepared decimal trigonometric tables and used them for the first time, anywhere in the world. There will be some insufficiencies and mistakes in this period, when the knowledge began to bud. The important thing is that after the Ottoman mathematicians and astronomers perceived what insufficiencies and mistakes had been made they would try to fill in the missing information and to correct the mistakes.

During research in libraries where such books as these are kept, six copies of Sāheb Mīnāshīl al-İfākār, one copy of Tezīlī and eight copies of Čerdī al-Dīnār can be found. The oldest of these was copied out in manuscript form in the 16th century and the most recent was copied in manuscript form in the 19th century. This shows that, the zīf of Taklıyüddin were being read until recent times, and that the Čerdī al-Dīnār was more popular than the others. But, research carried out on both Taklıyüddin and his contributions; for example, his inventions concerning decimal fractions, were not satisfactorily carried out by Ottoman mathematicians and astronomers after the 17th century, and his name and his works were not frequently remembered. Thus, his effect became limited.

There are three important reasons for the zīf not being used after the 16th century by Ottoman astronomers or, in other words, why those of Zic-i Uluğ Bey were used and not those of Taklıyüddin.

1. The most important reason for this, with the exception of Sāheb Mīnāshīl al-İfākār, is the fact that he left the traditional lists of others zīf and based his work on new systems, the usage and preparation of trigonometric and consequently astronomical tables.

2. Arcs and trigonometric values of the arcs were shown in the decimal system instead of the sixty based system. That is to say, the change of the system forced the astronomers, time keepers and astrologers to learn the decimal system and to have to work both with the sixty based system and the decimal system in all arithmetical operations. It is not hard work to do this, according to Taklıyüddin, he frequently said that to make operations using decimal systems is easier than that of the sixty based systems. But, to leave a scientific tradition and the products of this tradition, that had continued for centuries, may have caused a feeling of panic, distracting these scientists from a new tradition and the formation of its products, or even to attempt to accept them. In that case, the problem does not originate from the difficulties of learning the new system, the problem originates from the difficulties of leaving the old system. Apart from this, the production of all scientific tools and necessary things for the sixty based system increased the dependence on this system.

b) Taklıyüddin had improved a new numeral system different from Beled Numeral System and Hindu Numeral System and had used this in the last two zīf. This made the present difficulties greater.

2. Also the fact that the astronomical tables, containing the observed values of Taklıyüddin, were distributed in three zīf, lead to the separation of the zīf. Sāheb Mīnāshīl al-İfākār and Čerdī al-Dīnār only have tables related to the observations of the sun and moon, Tezīlī is very rich in astronomical tables, having the tables that documented the planetary observations with the observations of the sun and moon. But the problem here is that some of these were not complete and were prepared in the decimal system. Zic-i Uluğ Bey is excellent and complete; it has both theoretical information and trigonometric and astronomical tables prepared using this information. In addition, commentaries were written on it by Ottoman scientists and it was corrected and completed.

3. The situation at the time were similar to that of Kāṭīb Celebi (1569 - 1659), the well known scientist and intellectual of the Ottomans, which he mentioned in his work, Mihāl al-Hākī al-Dīnār of Al-Abhāk (1656). In the middle of 16th century, that is to say, toward the end of the period of Kāṇized Sultan Süleyman (1520 - 1566), the relationship between philosophy and Islamic law had gone sour, in other words akīl science and nabl science, after the education of nabl science had been damaged, there remained neither akīl science nor nabl science. Because of this, it is not surprising that there were not any persons that recognized the worth of his works, and his contributions to science, nor that there was no one to improve the ideas in the work made in the period of Taklıyüddin, who lived and worked after Kāṭīb Celebi, in the first half of the 17th century. He had warned the Ottomans about the results of going this way, he had to defend akīl sciences and had to prove their usefulness in daily life.
THE BIRTH AND DEVELOPMENT OF MODERN BOTANY IN THE OTTOMAN TURKEY

PROF. DR. ASUMAN BAYTOP
ISTANBUL UNIVERSITY, FACULTY OF PHARMACY / ISTANBUL - TURKEY
PROF. DR. FEZA GÜNERGÜN
ISTANBUL UNIVERSITY, FACULTY OF LETTERS / ISTANBUL - TURKEY

The Ottomans' interest in botany resulted from carving for having detailed knowledge about the herbs used in medical treatment. Although the botany didn't take part within the curricula of the madrasa, the classical era Ottoman educational foundations, the Ottomans probably had attained an immense knowledge of medical herbs by means of the books and translations called "El-Mafradat" and "El-Mafradat: The Treatise of Ibn Baytar". In the nineteenth century, when the transfer of the disciplines developed in the Western World had gained a greater acceleration, the relationship between botany and the medicine continued. While the Turkish translations of the above-mentioned books continued to be used both by the folk and by the physicians applying the methods of traditional medicine, on the other hand the botany lessons began to take place in the curricula of the new schools founded to give modern medical education (such as Medik-i-Tibbiye-i Askeriye-i Şahane / the Imperial Military Medical College and Medik-i-Tibbiye-i Milliye-i Şahane / the Imperial Administrative Medical School). The lecturers of these schools prepared Turkish botany books by means of translating and compiling the botany books from Europe, and established botanical gardens in the above-mentioned medical colleges. We know that the students of the Veterinary Department of the Military Academy took the lessons of "The Pictures of the Plants" in their first year, and "The Plants" in their second year. Additionally, the students of the "Natural Sciences Department" of the Military Academy, that used to educate teachers for the military secondary and high schools, used to take the course named the "Science of Plants" in their first year. With the foundation of the first "Darsîfînames", Ottoman university in 1863, another institution happened to be added to the schools giving botany education. The natural sciences courses given in this first university contained the subjects of botany as well. In the regulations dated 1869, the botany course took place in the curricula of the Natural Sciences and Mathematics Faculty of "Darsîfîname", as a separate lesson, under the name of "the Science of Plants". However, the botany education in Darsîfîname attained a systematic structure only after the year 1900. In this article, we will study some of the most important professors and academicians, and also their works, who contributed to the introduction and development of the modern botany in Turkey, within a period of about a century from 1834 which is accepted as the year, when the first "Science of Plants' lesson was given, until the end of the first quarter of the 20th century.

THE IMPERIAL MEDICAL COLLEGE AND THE BOTANY

In the proposal once offered to Sultan Mahmud II in 1826 by the Chief Doctor Mustafa Bektas Effendi relating to the foundation of a school which would gi-
The Great
Ottoman-Turkish
Civilisation
The Great
Ottoman - Turkish Civilisation

3

PHILOSOPHY, SCIENCE AND INSTITUTIONS

Editor-in-chief
PROF. KEMAL ÇİÇEK

Co-editors
PROF. ERCÜMEN KURAN
PROF. NEJAT GÖYÜNCÜ
PROF. İLBİR ORTAYLI

Executive editor
GÜLER EREN

YENİ TÜRKİYE
The incredible fact that the Ottoman frontier beylik became an Empire over such a short period of time has attracted many Western researchers and scholars to delve into the history of the Ottoman State. It could be argued that there are miscellaneous determinants and dimensions that actually created the possibility for such an incredible feat to be accomplished. This volume has been edited with the aim of focussing on the main factors that gave rise to such a great civilisation. In the first place, the institutional character of the Ottoman State is of utmost importance. In order to understand the basis of Ottoman civilisation, the different patterns of its institutions should be studied, as the comprehensive analysis of the institutional structure of the Ottoman Empire might enable us to conceive how a small beylik was able to turn into one of the greatest Empires in the world. In this volume, the administrative, judiciary and military institutions of the Empire are set out as the main subject titles. In addition, there are various subjects which have been analysed, under such subrubies as bureaucracy, religion and law, shedding light on the main characteristics of Ottoman institutions.

In appreciation of the highly developed institutional structure of the Ottoman Empire, the ideational and philosophical sources cannot be underrated. Unless these sources are taken into consideration, it is impossible to grasp the various dynamics of Ottoman institutions. Therefore, this volume is entitled “Philosophy, Science and Institutions”, due to the close correlation and importance of these subjects to one another.

Contrary to conventional Euro-centric and Orientalist assumptions, which hold “science” as the peculiar praxis of the Renaissance and Enlightenment in
the West, in this volume it is generally argued that the Ottomans had a number of successes in scientific activities (ilm ü fen). The Ottoman State not only promoted the development of science within the borders of the Empire, but also facilitated several interactions with scientific activities outside of its territories. During this interaction, it both benefited from and contributed to the scientific improvements made in Europe.

Additionally, this volume dedicates an important place to the development of philosophy and thought in the Ottoman Empire; although in the Ottoman Empire such major philosophical schools as developed in Europe were not formed, rather the Ottomans focused mainly on Islamic philosophy. Yet this situation does not arise from the fact that the Ottomans lagged behind in speculative matters. On the contrary, they were not interested in philosophical issues that were outside the realm of Islamic tradition. From their point of view, Islam encompassed all ontological and epistemological matters, making any other philosophical concern dysfunctional.

Yeni Türkiye

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