Resumen del Tesis (eng)

1. Presentation

This work consists of a critical edition of the work entitled *Natā'iŷ al-afkār fī Sharḥ Rawḍat al-azhār* roughly translated as "Results of the thoughts in the comment of *Rawḍat al-azhār* (Flower Garden) ". The title, very literary, does not correspond, of course, with the content of the text, as it is a work-centered technical astronomical problems posed by Islamic worship, in which a series of rites and duties have some conditions clearly related to astronomy. The calendar is used, liturgical purposes, is Lunar of years 354 11/30 days and months that are alternately 29 and 30 days. The beginning of each month is determined by the sight of the new moon, which can be seen one or two days after conjunction moon-sun. Prayer is performed five times a day at specific times, which implies the need to know the time, which, in the Middle Ages, it was not as easy as now. Muslims, at the time of prayer, should be directed towards Mecca and determine this direction, from any place, is a problem of relatively complex spherical astronomy if you do not have a technician able to perform the calculation.

Responsible for solving these problems were, at first, the muezzin though, since the fourteenth century, arises both in the East and the West Islamic muwaqqit new profession, Arabic term which means something like "meter or controller of time. " The muwaqqits were astronomers, with more or less education, serving major mosques took care of all the problems associated with the *mīqāt* (astronomy related to the cult), to which I alluded above.

The *mīqāt* is a branch of astronomy that since its origin, is characteristically Islamic, as Greek astronomy was not raised, obviously, this kind of problem. Their study by historians of medieval astronomy is a relatively recent, has taken place since c. 1975 thanks to the work of a great English scholar, David A. King, who has coined the term *Astronomy in the service of Islam*, which is the title of one of his books (Aldershot, 1993). The lifelong work of David King has been the subject of a recent synthesis volume *In Synchrony with the Heavens. I. The Call of the Muezzin* (Leiden-Boston, 2004), in which we find references to some of the materials from *Natā'iŷ al-afkār*. Because the sources studied by this author have been, mostly, oriental, this thesis is a first attempt to analyze Magribi source.

2. Authors

One of these was muwaqqits Abū Zayd ʿAbd al-Raḥmān b. Muḥammad al-Ŷādirī, born in Meknes ca. 777/1375 and died in Fez in 818/1416, who served as the great mosque muwaqqit Qarawiyyīn of Fez and wrote at least three books on *mīqāt,* whose titles are:

- *Tanbīh al-anām 'alà ma yaḥduṯu fī ayyām al-'ām*: this is a work calculated for the latitude of Fez. It has not been edited or studied.
- *Rawḍat al-azhār fī ʿIlm waqt al-layl wa-l-nahār*: mnemonic poem consisting of 334 verses (subway more common, given its simplicity, for didactic poems). This is the published work in this thesis, together with the commentary of al-Ḥabbāk, to which I shall refer later. Preserved in many manuscripts, it is undoubtedly the most popular work of its author, who wrote in 794 H / 1391 to 1392 BC, when its author was only about eighteen.
- *Iqtiṭāf al-anwār min Rawḍat al-azhār*: it is a prose commentary of the procedures outlined in the *Rawḍat al-azhār*. It has been edited by Muḥammad al-ʿArabī al-Jaṭṭābī

in a volume published in Muḥammadiyya, 1986. The text has been the subject of a detailed study by Emilia Calvo published in *Suhayl* 4 (2004), 159-206.
One of the commentators on *Rawḍat al-azhār* was Abū ᶜAbd Allāh Muḥammad b. ʿAbd Allāh al-Ḥabbāk, the author of *Natā'iŷ al-afkār fī Sharḥ Rawḍat al-azhār*, as we have seen, is the underlying theme of this thesis. Polygraph is a native of Tlemcen, who served as faqih, an expert in applied mathematics succession partitions (*farā'iḍ*), mathematician and astronomer. Common sources attribute, date of death, 867/1462, which does not match the evidence found in *Natā'iŷ al-afkār*. In chapter 5 of this work (see below p. 47) we see that mentions the year 920/1514 to 1515 as annus presens. In this chapter (cf. p. 49-55) calculates a table of the length of the sun to the year 1514 BC. Somewhat strange find, in chapter 24 (cf. p. 265-266) a table that calculates the degree of the ecliptic crosses the meridian together with each of the 28 lunar mansions, calculated for two years: 794 / 1391 to 1392 (the date of writing *Rawḍat* al-Ŷādirī) and 970/1562-63, which should correspond to the time of al-Ḥabbāk. It should be noted that last year only appears in one of the two manuscripts (the London) that preserve this work, while missing in the manuscript of Cairo. If the reference to this year is not an error of the copyist's manuscript of London, would have to conclude that this table is a later interpolation due to the author or a copyist and, assuming that it is an interpolation of al-Ḥabbāk, that the date of his death can not be the year 867/1462 (possibly it is the date of death of his father) but after 970/1562-63.

3. Methodology used in editing and comment from *Natā'iŷ al-afkār fī Sharḥ Rawḍat al-azhār.*

Natā'iŷ al-afkār is preserved in two manuscripts:
- Ms. London, British Library 411/2, fols. 21r-55v, a font Magribi clear. In the explicit is the name of the copyist (Aḥmad b. Muḥammad al-Ḥasan b. Muḥriz) and copy date 1082/1670). It is much better than the manuscript of Cairo, as it has few gaps and plays 23 tables, in general, seem properly copied with the exception of Table 8 that contains numerous errors.
- Ms. Cairo, Maktaba Waṭaniyya 4311K, fols. 2r-48v. Copying in the year 1183/1769 with lyrics East. In the explicit name also appears copyist, but I have not been able to decipher. In this manuscript are omitted tables, with the exception of the table 22.

Although the manuscript of London is undoubtedly the best of the two, I used both my editing manuscripts, trying to reconstruct the original text of the author. I have standardized the spelling of hamza and corrected some syntax errors, as usual in the syntax of numerals, although note saving in the original text of the manuscripts.
In my edition I have introduced a division into introduction and thirty chapters, following the structure used by al-Ŷādirī in *Iqtiṭāf al-anwār*. Moreover, within each chapter, I have divided the text into paragraphs numbered in brackets. These sections provide, in many cases, the ur text of al-Ŷādirī *urŷūza*, followed by the commentary of al-Ḥabbāk, with the same number but followed by the initials RS (= Rachid Saidi), my own comment clarifying that often adds mathematical proofs of the exact procedures enunciated by al-Ŷādirī or al-Ḥabbāk, and attempts to explain the approximate procedures. He also edited the tables accompanied by a recalculation of the same that has allowed me, on occasion, suggest corrections to the numerical values of the same.

4. Previous studies on the work.

Natā'iŷ al-afkār contains extremely interesting materials related to the problem of the precession of the equinoxes, the various observed values of the obliquity of the ecliptic and negative estimates of the height of the sun at the time of the end of twilight (*šafaq*) and early morning (*faŷr*). The latter are important because they are two times when there are two canonical prayers rituals: the sunset (*maghrib*) and dawn (*faŷr*). Moreover, the references in the text to precession and obliquity of the ecliptic are a further indication of the crisis that occurred in astronomy Magribi from early fifteenth century in relation to the models designed by Azarquiel (Toledo, s. XI) to justify the precession using the theory of trepidation of the equinoxes and the idea that the obliquity of the ecliptic varied cyclically and had reached its peak shortly before Ptolemy, for whom ε = 23;51,20° and the Azarquiel minimum time (ε = 23;30º). According to this theory the value of ε should increase from the beginning of s. XII. These materials have been used in various works published by Mercè Comes and Julio Samso.
Azarquiel theories were followed, in al-Andalus, by his disciple Ibn al-Kammād (fl. 510/1116-17) and Ibn al-Hā'im al-Išbīlī (fl. 600 / 1204). Magribíes Astronomers also followed the same school of thought from the work of Ibn Isḥāq al-Tūnisī (fl. Tunis and Marrakech c. 588/1193-618/1222), followed by the anonymous compiler of the manuscript of Hyderabad (c. 678/1280-81), Ibn al-Bannā' al-Marrākušī (652/1256-721/1321) and Ibn al-Raqqām al-Mursī (Tunis and Granada / , m. 610/1215). All these authors are mentioned in the *Natā'iŷ*,, accompanied by notes criticism from al-Ḥabbāk who noted that the estimated value for the precession period far exceeded the maximum derivative shake tables Azarquiel and also that the obliquity of the ecliptic is stubbornly continue to decrease, rather than increase according to the Toledo astronomer cyclic model. This review, which we find both the *Natā'iŷ* as in other works produced from the early fifteenth century, led astronomers to abandon magribíes Andalusian school and introduce new astronomical tables (*zīy*es) developed in East . Among the latter the *Tāŷ al-azyāŷ* Ibn Abī l-Šukr al-Magribí (d. 681/1283) is the work that is cited frequently in the *Natā'iŷ*, where al-Ḥabbāk used profusely.

5. Content *Natā'iŷ al-afkār*.

I, then, a brief summary of the content of the work following the outline of the chapters in the edition used:
- Chapters 1-4 are concerned with chronology. Muslim lunar calendar, fair coincides with the first day of the year (1 Muḥarram) and the remaining months of the year. 30 months and 29 days. Leap years of 356 days. Solar Calendar, were used (mention the era of Alexander and the birth of Christ), show that corresponds to January 1 and the beginning of the remaining months. Calculation of *izdilāf*, which takes place in lunar years in which no day corresponding to January 1.

- Chapter 5: Correspondence between the months of the solar year and zodiacal signs. Rule to calculate approximately the length of the sun for each day of the solar year. Name a precession of 13;40° for its time (920/1514-15), calculated using constant Ibn Abī l-Šukr. Reference to a draw type sun almanac, calculated for a four-year cycle. Table that calculates the length of the sun for the year 1514. Procedure used in astronomical tables (*zīŷ*) to calculate the length of the sun. Correction to be applied if the calculation is done to a different place of Tlemcen. Table of geographical coordinates in the meridian using water as the source of lengths. Table of the mean motion of the sun derived from *Tāŷ al-azyāŷ* by Ibn Abī l-Šukr (except the table of hours). Table sun's equation is also derived from *Tāŷ* with a maximum of 2°. Approximate procedure to determine which lunar mansion is the sun. Throughout the chapter, continual references to Tlemcen.

- Chapter 6: declination of the sun, use ε = 23;30º, as the *Tāŷ*. Different historical estimates of the value of ε and allusion to Azarquiel cyclic model. Approximate procedure for calculating each degree of decline of the ecliptic without using tables. Solar declination table derived from *Tāŷ*.

- Chapter 7: ascensions. Approximate procedure for calculating "ortho times" (rising times) of the zodiacal signs, or the difference between the right ascension of the beginning and end of each sign. Since the ascension depends on the value of ε, brings up the criticism of Ibn al-Hā'im to the theory of Ibn al-Kammād which are supported by the periods of revolution used in the models that justify the obliquity of the ecliptic and trepidation of the equinoxes. Approximate Procedure al-Ŷādirī to calculate the right ascension of each grade by linear interpolation. Two exact procedures al-Ḥabbāk to obtain the same results. Ascensions table.

- Chapter 8: Oblique ascensions. Approximate procedure for oblique ascension after ascension applicable to the latitude of Tlemcen. Exact procedure also to Tlemcen. Oblique ascension table for Tlemcen, with a latitude of 34;30º (instead of 35º which uses in Chapter 10).

- Chapter 9: Calculating the latitude depending on the meridian altitude of the sun or of a star and its decline. Consider the case of areas south of the Ecuador. Calculation of latitude from the maximum and minimum height a circumpolar star.

- Chapter 10: meridian altitude of the sun in terms of its decline and the latitude. Table meridian altitude of the sun for each degree of longitude and latitude of Tlemcen (35º instead of 34;30º as in Chapter 8) and ε = 23;35º (instead of 23;30º as in Chapter 6).

- Chapter 11: trigonometric functions (sine, cosine, sine verse, string). Approximate procedure to calculate the sine and cosine without tables. Table of sines and cosines.

- Chapter 12: getting up in the shadow function (cotangent or tangent). Approximate procedures that do not require the use of shadow boards. Exact procedure, al-Ŷādirī, for within the height depending on its cotangent. Using a sine table but not a cotangents table.

- Chapter 13: two correct procedures exposed by al-Ŷādirī , to obtain the height of the sun, by observation, if the sky is covered with clouds.

- Chapter 14: Obtaining the shadow depending on the height. Exposes a approximate procedure (use inverse discussed in Chapter 12) and other exact using a sine table. Table tangential to a gnomon = 1 (called this function *ijtilāf ufuqī*). Two tables for a gnomon cotangents = 12 digit e = 6;40 feet.

- Chapter 15: transformation of tangent and cotangent values measured for different values of the gnomon.

- Chapter 16: ortiva and occidua amplitude depending on the declination of the sun and each other. Give an example of calculation which uses ε = 23;51,20º (the value of Ptolemy, instead of 23;30º and 23;35º).

- Chapter 17: Azimuth calculation based on height. The procedure, very elaborate, is already in al-Ŷādirī and appears in several Eastern sources, as well as on the *Zīŷ al-Mustawfī* by Ibn al-Raqqām that is probably the source of this passage. Give an example calculated for the latitude of Tlemcen (35º).

- Chapter 18: Arc day and night from the sun or a star. The calculation required to obtain the "equation of the arc semidiurnal" (*taʽdīl niṣf qaws al-nahār*) which is the product of the tangent of the latitude of the tangent of the declination of the sun or star. Obviously, a *muwaqqit* should know the tangent of the latitude of the place in which he lived, but to get the tangent of the declination should have a table of tangents. Apparently, this was not the case since al-Ŷādirī approximate discloses a method that does not require the use of a table. A second method, because al-Ŷādirī, and calculated for the latitude of Fez, is more than doubtful and al-Ḥabbāk presents a third method, for the latitude of Tlemcen, which is less disastrous. To this are added two procedures, accurate, using oblique ascension and the ascension of the degree of the ecliptic, or the oblique ascension of the extent and degree of diametrically opposed. A final method, approximate diurnal arc calculated according to the latitude of Tlemcen, the decline and the obliquity of the ecliptic.

- Chapter 19: Estimated number of hours equal to the arc corresponding day or night for correct procedure. Table semidiurnal arc for each degree of longitude of the sun for a latitude of 35°. Calculating the number of degrees corresponding to one hour of the day time or night. Grades table corresponding temporal an hour depending on the length of the sun for a latitude of 35º.

- Chapter 20: transformation of temporary hours equal hours and vice versa.

- Chapter 21: Estimated number of hours that have elapsed time of the day or night depending on the shade and the sun's altitude. In this section, al-Ŷādirī exposes two approximate rules with a clear Indian origin. Al-Ḥabbāk adds another procedure, but also more elaborate approximate, based on the meridian altitude of the sun, its height instantly, the latitude and the declination of the sun.

- Chapter 22: Determining when *ẓuhr* prayer and *ʽaṣr* . Exposed approximate rules that do not require to have a tangent table. Tables of the sun's altitude at the time of tha *ẓuhr* and *ʽaṣr* calculated for a latitude of 35º. Two tables that give the hour angle of the sun at the time of Thuhr and *ʽaṣr* tha for a latitude of 35º. Procedure for calculating the meridian altitude of the sun in terms of height and tha *ẓuhr* and *ʽaṣr*. Calculation *ʽaṣr* tha end.

- Chapter 23: dawn and dusk. Two approximate methods for calculating the number of hours temporary delay between sunset and the end of twilight, and between sunset and early morning. The methods derived from two rules, of Indian origin, discussed in Chapter 21. Another approximate approach, because al-Ŷādirī, and only valid for the latitude of Fez. Two approximate methods due to two authors.

- Chapter 24: two tables give the degree of the ecliptic crossing the meridian mansions simultaneously with 28 moles, calculated for 794H/1391-92 (al-Ŷādirī) and 970H/1562-63 (al-Ḥabbāk). Exact procedure to calculate the decline of a star based on their longitude and latitude: found in multiple sources in the eastern and *al-Zīŷ al-Mustawfī* Ibn al-Raqqām.

- Chapter 25: mediation and declination of fixed stars. Here al- Ḥabbāk revisits the theme of the precession of the equinoxes and the theory of trepidation. Table of 56 stars derived from Ibn al-Raqqām in which gives, for each, its longitude, latitude, mediation and declination. Exact procedure to calculate the mediation of a star derived from Ibn al-Raqqām.

- Chapter 26: degree of the ecliptic crosses the meridian at the time of sunset, sunset twilight and early dawn.

- Chapter 27 elapsed hours of the night and determination of the moments of the night prayers, non-binding, which are performed on the nights of the month of Ramaḍān (*tartīb awqāt al-suḥūr*). To calculate the passage of time using the right ascension of the midheaven degree. In one of the procedures set uses the first rule of Indian origin in Chapter 21.

- Chapter 28: height of the stars throughout the night. Re-use the first rule of Indian origin presented in Chapter 21: she gets the cotangent with the height of each star.

- Chapter 29: Up and Down.

- Chapter 30: Calculating the azimuth of the Qibla. The complex exact procedure described by al-Ŷādirī corresponds to the so-called "method of *zīŷ*es" described in the East at the end of the tenth century and introduced to the West by Ibn Muʿāḏ al-Ŷayyānī (m. 486/1093). The source is probably the to *al-Zīŷ al-Mustawfī* by Ibn al-Raqqām.

6. Conclusions

This paper is the first attempt to systematically analyze two treaties magribíes of *mīqāt*: the al-Ŷādirī *urŷūza* and commentary of the same due to al-Ḥabbāk. With them came into contact with the practices used by the centuries *muwaqqit*s between the XIV and XVI in Morocco (Fez) and in what is now Algeria (Tlemcen). It is interesting to note how often the rules set forth approximate more or less adjusted to the reality, which can obtain results using a simple calculation that, in many cases, completely ignore the use of tables. These rules are dominant in ur al-Ŷādirī *urŷūza*, usually calculated for the latitude of Fez when calculating the latitude variable involved, but also in the commentary of al-Ḥabbāk, who used the latitude of Tlemcen. We can see also as both al-Ŷādirī as al-Ḥabbāk *muwaqqit* assume that usually has a table of sines, but not in a tangent or cotangent table: it is common for all kinds of rules rodeos den to avoid the necessity of using these two functions, though easily avail breasts. Perhaps the reason for this restriction is because sine and cosine are calculated, usually to within 60 parts, while the tangent and cotangent are calculated for a gnomon of 12 digits, 6;40 feet or 7,

which implies that their use together with sine and cosine, requires few operations that transform these functions, so that all use the same order of units.
However, al-Ŷādirī is not always limited to stating the rules approximate but also introduces computational procedures far more complex, as can be seen in Chapter 17 (azimuth calculation based on height) and especially in Chapter 30 where the long and laborious exposes calculating the azimuth of the Qibla, using the "method of the *zīŷ*es".
Despite this, al-Ḥabbāk, which is a competent astronomer, tends to add to the approximate procedures, other accurate, in order to incite muwaqqit to improve your techniques and add to these rules a series of 24 tables that, in general, are not calculated with remarkable accuracy, as can be seen by examining the differences between the tabular values and recalculating them. The mathematical precision is obviously not one of the basic needs of muwaqqit who generally content with approximate values. Considering the tables to calculate the length of the sun (table mean motions and the solar equation) of Chapter 5, we can see that the source of these is the *Tāŷ al-azyāŷ* by Ibn Abī l-Šukr, where the tables above are approximate to the second, while in the version of al-Ḥabbāk, approximate values only to the minute, truncating or rounding the numbers of *Tāŷ*. It is obvious that al-Ḥabbāk has not calculated all its tables, but frequently, has copied from other sources and uses parameters that are not always compatible with each other, as evidenced by its use of 34;30º or 35º for the latitude of Tlemcen, or obliquity of the ecliptic of between 23;30º and 23;35º and, on one occasion, get to use the Ptolemaic value 23;51;20º.
It can be seen also that the purpose of both the *Rawḍa* as the *Natā'iŷ* muwaqqit is to provide all information necessary to ply their trade. Some of this information is general in nature, as we see in Chapters 1-4 which describes the main calendars in use, calculating the position of the sun (chapter 5) and its decline (Chapter 6), ascensions and oblique (Chapters 7 and 8), trigonometric functions (Chapter 11) and so on. Other notions, however, and relate to matters of direct application and the determination of the time and, in particular, hours of prayers *ẓuhr* and tha *ʿaṣr*, as well as the *maghrib* and *faŷr*. It is also directly applicable chapter 30, on the determination of the azimuth of the Qibla, though in the latter case it is doubtful that a competent excessively muwaqqit could not apply because of its complexity. Particularly striking is the omission of a theme: the already developed methods to predict the visibility of the new moon at the beginning of each month, which is the basis for the organization of the calendar and it is essential to determine the day of begins and ends the obligation of fasting the month of Ramaḍān.
To this should be added the interest our text as evidence of the shift that has occurred in astronomy Magribi since the early fifteenth century, the Andalusian school leaving for switching to Eastern tradition astronomical tables that match much better with observed reality. This was the origin of curiosity aroused by the *Natā'iŷ* in some scholars and motivated me to study this text. The results showed, however, that the work is also interesting for many other reasons.