Pre-Modern Astronomical and Astrological Data in Tabular Form: Storage, Edition and Mathematical Analysis

PAL & ALFA Workshop 2018

in cooperation with the projects TAMAS and HAMSI, centred around the development of the DISHAS database

Organisers

Benno van Dalen (Ptolemaeus Arabus et Latinus, Munich)
Matthieu Husson (ALFA, l'Observatoire de Paris)

Dates

Actual Workshop:
Monday 19 and Tuesday morning 20 November 2018
Practical sessions for students and researchers:
Tuesday afternoon 20 and Wednesday morning 21 November 2018

Location

Bayerische Akademie der Wissenschaften (Munich), Sitzungssaal 2 (1st floor)

Topic

This workshop will bring together scholars from all over the world who work on tables in the pre-modern astral sciences. They may discuss any aspects of their work with such tables, e.g. critical edition, storage and mathematical analysis. Overviews of types of tables found in hitherto lesser known categories of sources are just as welcome as proposals for entirely new types of analysis. Contributions on horoscopes and astrological tables are especially welcome, since they have generally not yet received the treatment they deserve. Although tables from the Ptolemaic traditions (Greek, Islamic, late-Indian and European) will be at the centre, we will also invite a speaker on Chinese astronomical tables in order to provide the database discussions with more background.

Special attention will be paid to the newly developed "Digital Information System for the History of the Astral Sciences" (DISHAS, cooperative undertaking of the projects TAMAS, ALFA, HAMSI and PAL), whose first part under implementation is a database of tables, the parameters on which they are based, and the sources in which they occur. Discussions of possible tools that access data from DISHAS for more efficiently carrying out tasks related to the edition and analysis of tables are particularly welcome. One or two IT specialists will be invited to speak about technical issues and possibilities related to the programming of further tools to be used with DISHAS.

We plan to add two practical sessions in which students and researchers can learn how to work with DISHAS (or, for certain functions that have not yet been implemented, with some of the DOS and Windows precursors programmed by Benno van Dalen and the editing tool CATE developed by HAMSI). The students and researchers will thus be introduced to the study and analysis of tables in a pragmatic way that complements the more theoretical approaches to be introduced in the first three sessions of the workshop. The practical sessions will give an opportunity for students and researchers to experiment with these tools using their own sources. The feedback gained from these sessions will be especially important for shaping the future development of DISHAS. The practical sessions will be organised by Matthieu Husson and the DISHAS development team.

Program

Monday, 19 November 2018

9.00– 9.15 **Opening words**
BENNO VAN DALEN (PAL, Bavarian Academy of Sciences and Humanities)
MATTHIEU HUSSON (ALFA, Observatoire de Paris)

9.15–10.15 **Giovanni Bianchini on Spherical Astronomy**
GLEN VAN BRUMMELEN (Quest University, Squamish BC, Canada)

10.15–11.00 **Ephemerides and Almanacs: Extraction of Underlying Parameters, Dating of Fragments, and Reconstruction of Transits**
JOHANNES THOMANN (Asien-Orient-Institut, Universität Zürich UZH)

11.00–11.30 Coffee break

11.30–12.30 *Four short presentations*:
John of Genoa's Table of Lunar and Solar Velocities
LAURE MIOLO (ALFA, Observatoire de Paris)
The Tables of S. Belle: Between Astronomical Tool and Astrological Diary
HELENA AVELAR DE CARVALHO (Warburg Institute, London)
Practices of Astrology in 15th century Nuremberg and the *Almanac Nova*
STEFAN ZIEME ("Image Knowledge Gestaltung", Humboldt-Universität, Berlin)
(Re-)presenting Arabo-Persian Astronomical Knowledge in China
DROR WEIL (Max Planck Institute for the History of Science, Berlin)

12.30–13.30 Lunch break

13.30–14.30 **Calculating Planetary Equations in Alfonsine Astronomy**
RICHARD KREMER (Dartmouth College)

14.30–15.15 **Testing for Table Dependencies: What Tools Can We Use?**
ANUJ MISRA (Max Planck Institute for the History of Science, Berlin)

15.15–15.45 Tea break

15.45–16.30 **Why and How Do We Build DISHAS?**
MATTHIEU HUSSON (Observatoire de Paris)

16.30–17.30 *Four short presentations*:
Isaak Argyros and the Transmission of the *Paradosis of the Persian Tables*
EMANUELE ROVATI (UZH / LMU / Ptolemaeus Arabus et Latinus)
Determining the Sine Tables Underlying Early European Tangent Tables
KAILYN BROOKE PRITCHARD (Quest University, Squamish BC, Canada)
On a Medieval Sine and Solar Declination Table
CAMILLE BUI (École Nationale des Chartes, Paris)
Solar Tables in Pedro Nunes' *Tratado da sphera*
ANÍBAL SZAPIRO (University of Buenos Aires)

Monday, 19 November 2018 (continued)

19.00 Workshop dinner at the restaurant
HOFER. Der Stadtwirt
Burgstraße 5 (close to Marienplatz, entrance also Dienerstraße 20)
80331 München
Tel. +49 89 24210444
https://www.hofer-der-stadtwirt.de/

Tuesday, 20 November 2018

9.00–10.00 **Algorithms and Tables in Early Chinese Mathematical Astronomy**
CHRISTOPHER CULLEN (Needham Research Institute)

10.00–10.45 **A Horoscope is also a Table!**
DAVID JUSTE (Ptolemaeus Arabus et Latinus, Bavarian Academy of Sciences)

10.45–11.15 Coffee break

11.15–12.15 *Four short presentations*:
Latitudes of the Planets in al-Farghani's *Elements of Astronomy*
RAZIEH-SADAT MOUSAVI (Max Planck Institute for the History of Science, Berlin)

The Study of the Tabular Corpus of al-Battānī's *al-Zīj al-Ṣābi'*
MÒNICA MONT (Filologia Semítica, Barcelona University)

The Astrological Tables in al-Battānī's Treatises
NADINE LÖHR (LMU Munich / Ptolemaeus Arabus et Latinus)

Reports of a Mamluk Battle Scattered Across an Astrological Handbook: The Case of Manuscript MM 13 (Cairo, Dār al-Kutub)
FIEN DE BLOCK (Oriental Languages and Cultures, Ghent University)

12.15–13.15 Lunch break

13.15–14.00 **DISHAS, an Innovative Solution to Share Data, Tools and Methods of Historical Astronomy**
GALLA TOPALIAN AND ANTONIN PENON

14.00–15.00 Practical session with DISHAS
15.00–15.30 Tea break
15.30–17.15 Practical session with DISHAS

Wednesday, 21 November 2018

9.00–10.45 Practical session with DISHAS
10.45–11.15 Coffee break
11.15–13.00 Practical session with DISHAS

Abstracts

The Tables of S. Belle: Between Astronomical Tool and Astrological Diary

HELENA AVELAR DE CARVALHO

The workbooks of the late fifteenth-century astrologer S. Belle, which I studied in my recently-submitted PhD, are a good example of the use of astronomical tables in the daily practice of astrology. Using this case study, this presentation will show that apart from their obvious utility to calculate horoscopes, tables could also serve as a diary, thus offering an inner view of the practice of astrology, and the astrologer's interests and main concerns.

Determining the Sine Tables Underlying Early European Tangent Tables

KAILYN BROOKE PRITCHARD

Since the 1400's, the tangent function has evolved from a useful auxiliary function into one of the central functions in trigonometry. This presentation will discuss my analysis of some of the earliest tangent tables known to have been produced in Europe, including works by historical actors such as Giovanni Bianchini, Regiomontanus, and Georg Rheticus. By working from the tangent tables themselves, I have been able to reproduce the underlying sine and cosine values of the tangents which appear, as well as the radii of the underlying tables. The results are surprising; the underlying tables aren't tables we have seen before.

On a Medieval Sine and Solar Declination Table

CAMILLE BUI

Paris, Bibliothèque nationale de France, latin 14481 is a manuscript from the 15th century in which we can find many astronomical tables. This presentation will focus on a solar declination table from this manuscript. The first goal is to have a better understanding of how this particular table functions and a way to compute it with programming tools. The second is to compare the results we have computed to the historical ones and eventually try to understand the differences that occur between them. Finally, using the statistical method of G. Van Brummelen and K. Butler, we attempt to establish, if possible, a dependency between the Sine table and the solar declination table in this manuscript. This gives a possibility to develop an algorithmic and a computational approach and is a start to learn how to use the tools and the methods exploited in this research field.

Algorithms and Tables in Early Chinese Mathematical Astronomy

CHRISTOPHER CULLEN

Not long after the beginning of the Chinese imperial state in the third century BCE, we begin to find a series of documents describing *li* 曆 'astronomical systems'. These contain detailed instructions for use by imperial astronomical officials in calculating the positions and movements of the sun, moon and five visible planets at any given moment. The primary purpose such documents served was to enable a complex luni-solar calendar to be prepared and issued on the emperor's behalf, thus actualising and symbolising his successful harmonisation of human activity with the cosmos. By using this calendar it was possible to ensure that many activities, ranging from state rituals to the business of everyday life, were performed at the correct and therefore propitious moment.

The value of the earliest Chinese documents of this type is not their degree of sophistication, but their lack of it compared to the earliest related texts preserved from other cultures, whose content already represents a relatively advanced stage of development. We are thus enabled, for instance,

to see precisely how Chinese astronomers adapted their work to the realisation that the ecliptic rather than the equator was the more appropriate reference frame for solar, lunar and planetary motion, and how the complexities of lunar motion were eventually built into schemes of calculation. In the earliest systems known to us, only planetary motions involve the use of tables (or rather lists) of data. But as levels of sophistication increased, tables became more important.

This talk will illustrate these points using as examples three early astronomical systems, of which I have published annotated translations in *The Foundations of Celestial Reckoning: Three Ancient Chinese Astronomical Systems*: Routledge, 2017. I shall discuss how these systems work by explaining the structure of Excel spreadsheets that repeat as closely as possible the steps they specify.

Reports of a Mamluk battle scattered across an astrological handbook: the case of manuscript MM 13 (Cairo, Dār al-Kutub)

FIEN DE BLOCK

In my presentation I will discuss my research on a late fifteenth century astrological report discussing several important campaigns in the Mamlūk-Ottoman conflict, of which the most important one is the campaign of amīr Yashbak min Mahdī (dawādār at the court of sultan Qāytbāy) against Shāh Sūwār. This report is a copy written in Mamluk Cairo shortly after the events and contains several horoscopes. The folia of this report are spread across a contemporary copy of an astrological handbook of Ibn Abī al-Rijāl (d. ca. 454/1062), written in the same hand. In my future research, I would like to link the horoscopes in this report to zījes in circulation in this period and related tables on timekeeping.

Why and How Do We Build DISHAS?

MATTHIEU HUSSON

Digital humanities transform the availability of historical sources gradually, along with the means to analyse, edit, and relate them. These changes should be addressed, anticipated, and fostered by various research communities in history. DISHAS (Digital Information System for the History of Astral Sciences) is a collective enterprise supported by CHAMA (Commission for the History of Ancient and Medieval Astronomy) that addresses changes in the field of the history of astral sciences. DISHAS relies on a network of international projects in Chinese, Sanskrit, Arabic, Latin and Hebrew sources.In the long run, it aims, in collaboration with partner projects, at providing tools to the community to edit and analyse the different types of sources usually treated in the history of astral sciences, namely, prose and versified texts, iconography and technical/geometrical diagrams, and astronomical tables. As a pilot attempt, DISHAS focuses on astronomical tables. This enterprise induces fundamental research questions about our historiographical practices and about our sources and the way we shape a corpus with them. In this presentation I want to introduce these general question, the methodology we are collectively following to address them in the project and some of the main directions we take in concretely implementing tools to treat them.

A Horoscope Is Also a Table!

DAVID JUSTE

The first part of this paper will be a general introduction to horoscopes, including definition, types and historical overview. The second part will lay the groundwork towards the making of a computer program for historians dealing with horoscopes, a program that would allow storage, edition and mathematical analysis. It will be indicated how such a program could be implemented as part of the DISHAS data system.

Calculating Planetary Equations in Alfonsine Astronomy
RICHARD L. KREMER

Among the many achievements of the *Almagest* is Ptolemy's demonstration of how the parameters for his planetary models can be established from a small number of selected observations. Given these models and parameters, Ptolemaic mathematical astronomy then offers a simple algorithm: mean motions plus corrections (or equations) = true positions. The equations are presented in tables so users need only interpolate, add and multiply sexagesimal numbers to operate the algorithms. As discovered by Poulle and Gingerich back in 1968, the equations in the Parisian *Alfonsine Tables* contain several inconsistencies and do not always accurately follow the Ptolemaic models. In this talk, I shall examine these inconsistencies, consider how the Alfonsine equations may have been computed, and shall report a preliminary study of how the inconsistencies are preserved in Alfonsine manuscripts.

The Astrological Tables in al-Battānī's Treatises
NADINE LÖHR

The fame of the Arabic astronomer al-Battānī rests mainly in his book on astronomical tables (*Kitāb al-Zīj*). His rather short commentary on Ptolemy's *Tetrabiblos*, on the other hand, is apparently extant in only two Arabic manuscripts. The end of the text in one of these manuscripts (Escorial, árabe 969) displays a table for the calculation of lots of transfers, consisting of a table for the revolution of the months and a table for the daily progress of the Moon in the zodiacal circle. Another table lists the terms of planets, decans and triplicities according to the practice of Ptolemy. Interestingly enough, a table on the same topic can also be found in some manuscripts of al-Battānī's *Zīj*. Nallino lists this table in his chapter of "tabulae spuriae" ("wrongly/mistakenly attributed tables"). A reader's note "And this is not in the archetype" confirmed Nallino in his assumptions. This, however, makes the question about the relation between tables and text in al-Battānī's commentary on the *Tetrabiblos* even more interesting. A mention of the table and some instructions on it's application in the last chapters of the text may lead to the assumption that it was part of the original treatise; a first impression which is still awaiting further examination.

John of Genoa's Table of Lunar and Solar Velocities
LAURE MIOLO

John of Genoa was active in Paris in the 1330's. He is the author of eclipse canons – *Canones eclipsium* – he wrote in 1332, and of a detailed computation – based on the *Alfonsine tables* adapted to the meridian of Paris – of the solar eclipse of the 3rd of March 1337. The starting point of these works is the table of lunar and solar hourly velocities displayed together with the radii of the Sun, the Moon and the shadow of the earth, including a column for the variation of the shadow of the earth. This table is often associated with a short canon beginning *Verum motum Solis et Lune in una hora*, that John of Genoa wrote shortly before 1332, at the same time he composed his table. Indeed, he refers to the table and the short canon in his *Canones eclipsium* and in his computation of 1337. John of Genoa's table is contained in twelve witnesses, and is often inserted between John of Lignères's set of tables (1322). The originality of John of Genoa's astronomical works mainly lies in his table of velocity and radii. All his texts have a link to this table. He composed it, perhaps for renewing the old table of lunar and solar velocities inserted by John of Lignères in his set of tables.

Testing for Table Dependencies: What Tools Can We Use?
ANUJ MISRA

To test the computative dependency between astronomical tables, a range of statistical tools and techniques can be applied. For example, to check if a particular sine table (from a set of historically possible sine tables) generates a particular solar declination table (attested in a historical work), one can employ a nonparametric statistical test like Wilcoxson signed-rank test. This has been proposed by Glen Van Brummelen and Kenneth Butler in their paper 'Determining the Interdependence of Historical Astronomical Tables' (1997, JSTOR: 2291448).

In this talk, I will review some of the methods that have been proposed to study table dependencies. In describing their merits and limitations, I will attempt to motivate the techniques currently being conceived, designed, and tested in collaboration with Dr Giulio Dalla Riva (University of Canterbury, New Zealand) to ascertain table dependencies.

The Study of the Tabular Corpus of al-Battānī's *al-Zīj al-Ṣābiʿ*
MÒNICA MONT

The object of my doctoral thesis is the analysis of the tables in al-Battani's *al-Zij al-Sabi*. Between 1899 and 1909 Carlo Alfonso Nallino published his study of the *Sabi Zij* with a unique source: the Escorial Manuscript Ms 908, copied in western Arabic. Around 1260 the zij was translated into Castilian under the patronage of Alfonso X. There is a copy of this translation preserved in the Bibliothèque Nationale de France (Arsenal, Ms. 8322). These two manuscripts together with Nallino's edition are the sources I'm using to analyse al-Battani's tables. My aim is to study them and to detect the errors by comparing the values with the recomputed values found using Benno van Dalen's Mean Motion Program. In my presentation I will show some tables wich have given me problems while recomputing the values, for example: "Mean Motion planets in the months" and "Conjunctions and oppositions of the moon and the sun in collected Egyptian years".

Latitudes of the Planets in al-Farghani's *Elements of Astronomy*
RAZIEH-SADAT MOUSAVI

In the *Almagest*, Ptolemy assigns different parameters for inferior and superior planets in latitude. For the inferior planets, he proposed three values called inclination, slant and deviation. During the Islamicate period the structures and tables for these parameters experienced differences. Even though al-Farghani's *Jawāmiʿ ʿilm al-Nujum* (*Elements of Astronomy*) is presented descriptively devoid of any tabular format, he gives information on the values of the latitudes for the moon and the planets. In order to open up discussion on al-Farghani's numerical data, I will start with a short introduction on Ptolemy's method in the *Almagest*, by putting focus on Venus as an example. Then, historically following the chain in Islamic tradition, two early Arabic texts will be approached: the *Zij* of al-Battānī and *al-Zij al-Mumtaḥan*. Employing comparison, the talk will end up in analysing briefly al-Farghani's method in exposing latitude values for the planets in his non-tabular format.

Isaak Argyros' Role in the Transmission of the *Paradosis of the Persian Tables*
EMANUELE ROVATI

A considerable number of Persian and Arabic zījes made their way into Greek-speaking milieus in the beginning of the 14th century. There is evidence that Byzantine astronomers reworked and combined the tables during at least one century, but it is hard to trace this adaptation process due to lack of critical editions. In my talk, I shall focus on the *Paradosis of the Persian Tables* by Isaak Argyros (d. 1375), a work which can be described as 'instructions for use' of widely spread Persian tables. A recent edition of the *Paradosis* shed light on its origin and transmission, but codicological

evidence was not fully exploited during the inquiry. By examining horoscopes and contrasting the textual tradition of the *Paradosis* with that of other recensions connected with Argyros, I hope to assess more carefully his modus operandi as a redactor of astronomical works. Also, a new dating of the *Paradosis* is discussed.

Solar Tables in Pedro Nunes' *Tratado da sphera*

ANÍBAL SZAPIRO

The Portuguese mathematician and cosmographer Pedro Nunes (1502-1578) published in 1537 the *Tratado da sphera com a Theorica do Sol e da Lua*, where he provided three methods for navigators to determine the geographical latitude using the declination of the Sun and two necessary tables to calculate it: a declination table for every degree of the ecliptic and a longitude table for every day of a 4-year cycle. I will present the characteristics and intended uses of these tables and the connections with two topics of my interest: relations between optics and astronomy and the use of astronomical instruments.

Ephemerides and Almanacs: Extraction of Underlying Parameters, Dating of Fragments, and Reconstruction of Transits

JOHANNES THOMANN

Ephemerides and almanacs are the most important sources for the practical use of primary astronomical tables. The underlying parameters of the tables used for their calculation can be extracted, and help to identify them, or lead to a reconstruction of hitherto unknown tables. Procedures for doing that will be demonstrated. All ephemerides before the end of the 13th century CE are only extant as fragments, often without containing the year for which they were made. In such cases the calendrical part helps to date them. If such information is not preserved, the positions of the planets are used for dating. The program "planetsearch", designed for that purpose, will be shown. Almanacs and later also ephemerides contain information on the astrological transits, often with the hours at which they occur. The program "transits" helps to calculate the transits and their times, which is helpful for reconstructing fragmentary or damaged texts.

DISHAS, an Innovative Solution to Share Data, Tools and Methods of Historical Astronomy

GALLA TOPALIAN and ANTONIN PENON

The DISHAS application is being built to match three main targets:
(1) publicize data - understood both as bibliographic references, documentation on historical astronomical science, but also research data for research reproductibility;
(2) common publication, in order to ease and group together the edition of the sources of the discipline, and
(3) scientific exploration, through dedicated common tools.

As the targets are defined, new challenges arise, not only technical, but also intellectual and epistemological:

- Why and how to bring together a scholarly community based on a type of source rather than on a specific field of study, a time or geographical frame?
- What do we include and what does the "digitized turn" imply for our object of research definition?
- How do we train the computer to expose new results, and how do we treat these results?

Halfway between scientific question and technical realization, these questions were addressed at the starting point of the DISHAS project and are still guiding us in the building of our information system, a sharp engineering project that will be presented during this talk.

Giovanni Bianchini on Spherical Astronomy
GLEN VAN BRUMMELEN

Spherical astronomy as a creative discipline saw a resurgence in the mid-15th century. The revival has often been associated with Regiomontanus, but at least some of his contributions were in fact due to his lesser-known older colleague, Giovanni Bianchini. In particular, the problem of converting stellar coordinates from ecliptic to equatorial coordinates, whose earlier solutions in Latin Europe had contained a significant error, was finally addressed properly by Bianchini in his *Tabulae primi mobilis*. Regiomontanus's own solution in his *Tabulae directionum* is a copy of this work, save for a change in the value of a parameter. We shall survey the remaining tables in Bianchini's work and outline some of the uses to which they were put in the canons. Finally, we will consider how DISHAS might have aided this research, and how it might be of assistance in exploring the remainder of the tables of spherical astronomy in Bianchini's and other 15th-century authors' tables.

(Re-)presenting Arabo-Persian Astronomical Knowledge in China
DROR WEIL

The Mongol conquest of China in the mid-13th century and the subsequent century of the Yuan rule introduced to China Islamicate methods of astronomical calculations and models of representing astronomical knowledge. With the fall of the Yuan and the establishment of the Ming and later dynasties, the vestiges of Arabo-Persian astronomical knowledge continued to circulate in different official and civil institutions. Astronomical tables, as a practical method to represent and manipulate astronomical knowledge that was imported from the Islamicate world, continued to be utilized in court and in mosques throughout the Ming and Qing periods. As part of my project that aims to chart the movement of Arabic and Persian texts to China and the accommodation of Islamicate knowledge on the natural world, I examine the forms by which knowledge was received and reproduced. In that context, astronomical tables, being one of these methods, recorded data related to the compilations of the *Huihui li* (*Arabo-Persian Calendar*) calendars, shadow measurement, and other applications. In my short presentation, I will give an overview of the use of astronomical and astrological tables among experts of Arabo-Persian astronomy and in Chinese Muslim communities.

Practices of Astrology in 15th century Nuremberg and the *Almanac Nova*
STEFAN ZIEME

In 1506, a group of astrologers and humanists around Nuremberg exchanged a few letters in which they discussed a set of celestial configurations that heralded menacing times for the people of Nuremberg. One of them, Lorenz Beheim, most likely made use of the ephemeris in Stöffler and Pflaum's *Almanac Nova* for his prognostications. The uncertainty that he phrased in his letters arose from the difference of predictions against the actual configurations that fit the *Almanac* quite well. Were practitioners of astrology aware of the discrepancies of almanacs through observation or mathematical understanding of the underlying principles? The *Almanac* contains ephemeris from 1499 to 1506, computed by Regiomontanus, and an extension to the year 1531 computed by Stöffler and Pflaum. Did they employ other computational tools than Regiomontanus and does the data allow for such questions by "reverse-engineering"?