Analysing and editing numerical tables from ancient astral sciences

22-26 june 2015

CNRS-Syrte, Observatoire de Paris/HAMSI, Canterbury University New Zealand

Organisation :

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Location

Salle du Conseil du bâtiment Perrault, Observatoire de Paris

(Entrée au 77 avenue Denfert-Rochereau, 75014).

Rationale:

The history of ancient astronomy undergoes now, as other domains in the history of sciences, a profound and important evolution: new approaches, borrowed essentially from the history of mathematics[1], paired with "digital humanities" tools and leads to the emergence of new questions, to the building of new tools and original international research project.

Research now is aiming not only at studying abstract astronomical theories expressible by the values of a few numerical parameters, but at recovering intellectual practices in their epistemological, social and material dimensions. It is then essential, relying on the sources themselves, to understand the precise computation techniques which led to the different tabular corpuses and the relation of these tables to the texts and diagrams that surround them. These questions require an elaboration of new tools in the context of the "digital humanities". For instance we need to handle large corpuses of tables, generally built other centuries, in their astronomical dimensions (underlying models, parameters) mathematical dimensions (type of numbers, layout of tables, procedures for use or generation), historical dimensions (date, place and milieu of production) and material dimensions (which supports for the tables, what association of tables in sources). These new questions underlies a number of projects concerning ancient astral sciences sources in Chinese, Sanskrit, Arabic, Cuneiform and Latin supported by European, Indian, Chinese and American institutions. Each of these projects has its own specificities and purposes but all would benefit from a collective reflexion arena and the impact of these on the field of history of sciences as a whole would be great.

However this new researches are emerging not in opposition to, but as an extension of previous scholarship. Thus a central aspect of this workshop is to gather younger and more senior scholars in order, not only to allow the transmission of know-how which generally isn't found in scholarly

[1]cf. History of numerical tables (ANR, dir. Dominique Tournès) and Mathematical Sciences in the Ancient World (ERC, dir. Karine Chemla)

publication, but also to set up an innovative and challenging discussion on these fundamental questions for the discipline. The work will be essentially devoted to the following questions:

- What type of database should we design in order to "edit" the sources of ancient astronomy in the context of the digital humanities: how to account for the table layouts, the different types of numbers, the different types of errors and variants between copies, how to articulate the paper and digital format of the publication?

- What type of tools should we elaborate to explore these databases and analyse these sources? How to articulate the modern computation power with the necessary attention to the actual computation practices of the actors? How to articulate the description of the algorithms in texts and their eventual effectives uses in tables.

These two groups of questions are obviously closely related and need to be treated together in order to guaranty the compatibility of the exploration and analysis tools with the database on which they should operate. Common and transversal work on these questions is thus essential to allow for the sharing of results produced by the different projects concerned with astral sciences tables around the world.

These pragmatic questions will allow work on specific case studies of tables in the astral sciences, which each participant will bring from their own field. However they will also be the occasion of broader reflection on the different elements of this new approach to the history of astronomy.

We are planning the organisation of two such workshops (June 2015 and 2016) in order to prepare a collection of essays to be published in a peer reviewed international journal. In this first workshop mornings will be devoted to presentation and discussion and afternoon are mostly kept free to allow for more in depth work in small group among the participants.

Program

Monday 22 June

Chair: Michela Malpangotto

9h15-11h15

Glen van Brummelen (Quest University, Canada)

Al-Kashi's Double-Argument Tables of Planetary Latitudes in the Khaqani Zij: Strengths and weaknesses of standardized statistical tools for analyzing historical astronomical tables

We present an unusual document from early 15th-century Iran: a set of double-argument tables for determining planetary latitudes from Jamshid al-Kashi's Khaqani Zij. Although Islamic tables of planetary latitudes generally simply copied from Ptolemy or some other source, these tables exhibit a unique structure and give rise to several possibilities for their computation. Intriguingly,

the tables are only partly completed in all available manuscripts, providing some insight into the patterns of computation. However, many mysteries remain; the tables have not been fully analyzed. To approach them, we also present several standardized statistical procedures that have been developed to analyze pre-modern astronomical tables: Benno van Dalen's method of parameter estimation (and a proposed improvement by David Bellhouse), as well as my table dependence test. This leads to an important methodological question: is it preferred to apply quantitative methods designed for specific tabular situations, or standardized tools that work with a wide variety of situations?

11h30-13h30

Kim Plofker (Union College, New York)

Integrating a table text into a corpus: the Grahanasarani of (pseudo-?) Gangadhara

Numerical tables in the pre-modern astral sciences are generally assigned to one of two broad categories. In the first are the (often anonymous) individual tables compiled and consulted as needed by astronomical practitioners (e.g., many of the surviving Babylonian astronomical tables). The other major genre is that of the "table text" or composed work containing a deliberately crafted sequence of tables with a set of instructions, written by an author seeking to provide astronomical practitioners with a complex algorithmic tool (such as the "Handy Tables" of Ptolemy or the zijes produced in Islamic astronomy).

In reality, of course, these categories represent part of a spectrum, and sometimes a hitherto-unknown text may fall somewhere in between them. This is the case with the subject of this seminar, a Sanskrit work called Grahanasarani with epoch date 1630 that seems substantially indebted but not identical to the known table text Grahasarani or Khecarasighrasiddhi of Gangadhara. We will discuss the problems of integrating such a work into the corpus of Sanskrit table texts, including identification of author and title, and the challenges they pose for classifying and representing tables in databases.

14h30-16h30

Internal working session

Tuesday 23 June

Chair: Kim Plofker

9h15-11h15

Seb Falk(Cambridge University, Phd Student)

Computing tables in monastic contexts

This presentation will focus on a manuscript that was produced at the Benedictine monastery of St Albans, probably in the early 1380s. It contains copies of the *Albion* and *Rectangulus* of Richard of Wallingford (Abbot of St Albans 1327-36), as well as a set of tables of astrological houses. It is unusual among astronomical manuscripts in that we can name the author: John Westwyk, a monk of St Albans, who spent some time at the priory of Tynemouth, a satellite of St Albans, before going on crusade to Flanders and later returning to St Albans, where he wrote the *Equatorie of the Planetis* equatorium treatise (which has previously been attributed to Geoffrey Chaucer).

The copies of *Albion* and *Rectangulus* are very faithful, perhaps reflecting the reverence felt at St Albans for their former abbot. However, one notable change made by John Westwyk was the addition of a new table of oblique ascensions, updated for the latitude of Tynemouth (55° instead of 51° 50'), probably in anticipation of his move north. Initial analysis of these tables using modern trigonometrical formulae in Microsoft Excel has shown that while the original table incorporated a consistent ecliptic obliquity of 23° 33' 30", the new table was created using a two-part method, with an obliquity of 23° 51' at one stage. In addition, further unexplained discrepancies suggest that Westwyk's calculation technique, or method of rounding, was different from his predecessor's. How can we reconstruct his methods? And why, when he was so faithful to Wallingford's work, did he use a different value for the obliquity when recomputing the table for the new location?

The table of astrological houses also presents some interesting challenges. It is laid out (starting in Capricorn) by ascendant on a given day, but the configuration of the houses is given at noon (when the day's ascendant is at the cusp of the 10th house); the days and months are only given for reference at the start of each sign. The table also gives units of time accumulating to 24 hours in a year, which allow the user to find the houses for any time of day. Analysis has shown that this table, too, was computed using a latitude of 51° 50' and obliquity of about 23° 33' 30", but it has also thrown up some interesting features of the computation. Deriving the houses from midheaven, rather than the ascendant, seems much more complicated, but could medieval scholars have had a simpler method? And can we use modern tools to explain the computational errors in the tables?

This presentation will discuss the interests and methods of monks who computed and updated astronomical (and astrological) tables for their changing contexts. It will also consider the benefits and drawbacks of using Microsoft Excel to analyse tables. Using modern trigonometry and rounding methods may lead to inaccuracy, but does it make the use of such programs unjustifiably anachronistic?

11h30-13h30

Li Liang (Beijing Institute for the History of Natural Science)

Computer-aided analysis of astronomical tables in Ming China

This presentation will introduce ways to explore and analyze the astronomical tables in ancient China with the help of computer software and databases. Several sets of numerical tables in the calendrical systems which were adopted between 13th century and 17th century will be discussed,

such as the Season granting system (used between 1281 and 1384) and Great concordance system (used between 1385 and 1644). The presentation will focus on the following questions. How to transform the historical tabular documents into digital databases? How to use computer programs to crack the tables and do the calculations according to the corresponding calendrical procedures? How to analyze their accuracy, when comparing to the modern computation? How to display the tables and their errors with graphical interfaces? And the problems what we faced in these process will also be presented, and discussed.

14h30-16h30

Internal working session

Wenesday 24 June

Chair: Richard Kremer

9h15-11h15

Anuj Misra (Canterbury University Phd, New Zealand)

Conceptual challenges in designing a document-oriented database for astronomical tables in Sanskrit Astral Sciences

The systemisation of numerical data into a structurally standardised and computationally amenable format is an important step in analysing and editing astronomical tables from ancient astral sciences in different traditions. The methods and practices employed in accommodating the polarity of the incoming numerical data in concordance with designing a formal document type standard help in understanding the challenges one faces in an endeavour to create a digital database of numerical tables. In our work with the planetary tables of the Brahmatulyasāraṇī we look at the issues of variability in input data types; formation of nested arrays with legal element-attribute structure; preservation of functional dependencies and correlations between element-arrays; sanity check standards for validation and default-value tokens; computational and numerical accessibility; and a multi-format output parsing ability ---in an attempt to define a document type with a set of markup declarations (for any SGML-family like XML).

11h30-13h30

Nathan Sidoli (Waseda University, Tokyo)

Round table

Editing astral sciences tables: articulating digital and paper publication in scientific Journals

14h30-16h30

Internal working session

Thursday 25 June

Chair: José Chabás

9h15-11h15

Richard Kremer (Darmouth College, USA)

Cracking the Tabulae permanentes *of John of Murs, Paris, c. 1321*

In their classic study of "Five centuries of finding true syzygy," J. Chabás and B.R. Goldstein identified as the earliest tabular solution to this difficult computational problem a double-entry table prepared in the twelfth century by Ibn al-Kammad. But al-Kammad's table requires users, before entering the table, to first compute the solar and lunar corrections as well as the solar and lunar velocities at the time of mean syzygy. In the early 1320s, John of Murs, possibly assisted by Firmin of Beauval, constructed a more "user friendly" (Chabás and Goldstein) double-entry table that requires knowing only the solar and lunar anomalies at the time of mean syzygy. Versions of this table were incorporated (without attribution, of course) into the subsequent eclipse tables of Immanuel ben Jacob Bonfils (1350s), John of Gmunden (1420s), and Georg Peurbach (1450s); the latter were printed in 1514 and widely used throughout the sixteenth century. In 2001, B. Porres and J. Chabás published an edition, with English translation, of the canons to the *Tabulae permanentes* but they did not ask how the tables were computed. In this paper, I shall offer a proposal for that algorithm and, if time allows, a proposal for Bonfil's algorithm, which differs slightly from that of John of Murs. And I shall discuss techniques for cracking double-entry tables more generally.

11h30-13h30

Clemency Montelle (Canterbury University, New Zeeland)

A tangle of tables and text: Editing Dinakara's Candrarki

A set of tables devoted to the sun and the moon, the Candrārki was compiled in Sanskrit by Indian astronomer Dinakara along with a short accompanying text, which incorporates additional smaller tables. The epoch is 31 March 1578 and the survive in at least a dozen manuscripts. Some manuscripts contain the text only, some the tables. Some contain both the tables and the texts. We explore some of the challenges related to editing and analysing these tables.

14h30-16h30

Matthieu Husson (CNRS-Syrte; Observatoire de Paris)

Meerhoot, John of Murs and the MS Brussels Royal 1086-1115: analysing and editing an astronomer "toolbox"

MS Brussels Royal 1086-1115 is a composite manuscript of the 15th century mostly from the hand of John van Merhoot. It contains mainly theological works of John Ruusbroec an important mystic writer of the 14th century. But as was recently pointed out by José Chabas and Bernard Goldstein (*JHA*, 2012) the manuscript also contains a unique copy of an early astronomical work on syzygies and eclipses by John of Murs which is of great importance in understanding the formation of the Parisian alfonsine tables. Moreover the folios containing this work are annotated in various ways by multiple hand, including Meerhoot's. Building on José Chabas and Bernard Goldstein elucidation of the tables in this Manuscript we would like to explore a different perspective: How can we analyse and edit this document as an element of the astronomical toolbox of Meerhoot? How can this help us understand the interplay between mathematics and astronomy in the European late medieval period? How can this help us contextualizing astronomical practices?

Friday 26 June

Chair: Clemency Montelle

9h15-11h15

José Chabás (Universitat Pompeu Fabra, Barcelona)

Analysis of several astronomical tables by Giovanni Bianchini

The fifteenth-century astronomer Giovanni Bianchini (d. after 1469) worked as administrator of the estate of the prominent d'Este family, based in Ferrara, in the central decades of the century. In 1463–1464, Bianchini corresponded with Regiomontanus (1436–1476) on astronomical and mathematical problems and their solutions. As a table-maker, Bianchini compiled towards 1442 a voluminous set of tables, mainly on planetary motions, which he computed in the framework of the Parisian Alfonsine Tables, but with a surprisingly innovative approach.

Bianchini is also the author of other much shorter sets of tables: one on the diurnal motion and another, called *Tabulae magistrales*, consisting of trigonometric tables to solve specific problems of spherical astronomy. In this presentation we focus on two or three of these tables and address some of the main problems found in the analysis of an astronomical table: 1) reveal the purpose of the table, that is, explain what its entries represent; 2) recompute it, that is, determine the underlying algorithm or function and the parameters used in the compilation of the table; and 3) produce evidence for the context and tradition to which the table belongs.

11h30-13h30

Daniel P. Morgan (Sphère, CNRS, SAW Project, post-doc)

Spreadsheets and First-millennium Chinese li *Procedure Texts*

In 2005, Christopher Cullen published a three-page note, 'Translating ancient Chinese astronomical systems with EXCEL' (JHA 36.3: 336-38), and uploaded partial spreadsheet translations of Han-era (206 BCE – 220 CE) procedure texts on the Needham Research Institute website (here). While there has been talk about the use of computers in the past, Cullen's stands as the first and only attempt to publicly detail the methodology and potential of automating *li* texts. In this talk, I will speak about my own experience with such translation and its pedagogical and research potential for first-millennium procedure texts. In 2011, I began my own series of spreadsheet-translations with the goal of exploring how we might gage the accuracy of these systems. The process of translating ancient Chinese into at once English and code, however, raised so many basic questions about what the texts are and are not saying that I was forced to set aside this goal indefinitely. In taking the audience through this morass of discovery, I will describe a number of important phenomena and ambiguities that such translation has revealed and offer ideas about how we might ultimately return to the discussion of accuracy.