

### *Thinking DISHAS's Mathematical tools*

Observatoire de Paris, February, 1-2

Salle du Conseil

**Organisation:** Matthieu Husson, Benno van Dalen, Clemency Montelle

#### **Rationale**

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 the 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 (HAMSI), Arabic (PAL), Latin (ALFA) 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, scientific instruments, prose and versified texts, iconography and technical/geometrical diagrams, and astronomical tables. As a pilot attempt, DISHAS focuses on astronomical tables. A first version of DISHAS is currently tested by various members of the team. However it does not include yet any mathematical tools.

The purpose of the workshop is to select and define those tools, to order them in working blocks in order to be able to schedule and distribute the development of DISHAS in the next month and years. We are now able to distinguish three types of mathematical tools to be integrated in DISHAS:

1. The first types of tool are the basic tool required for the web applications to interpret correctly as quantities the various historical form of numbers and units used in the history and currently implemented in DISHAS. This first type of tool will also offer a decent and simple interface to input table content in the database with for instance the possibility to compute first and second differences and use these to predict tabular values. Finally some fundamental tools such as a sexagesimal calculator or chronological conversion tools might be incorporated also at this stage.
2. The second type of tools will refine those of the first category with specific tools for each type of tables. For instance statistical tools will be implemented to allow for a parameter estimation which then can be used to predict table values or generate metadata for the table content. Some tools exploiting the symmetries of astronomical tables are also envisaged. Finally some non-parametrical test to explore computational relation between tables might also be incorporated at this stage. Tools of this kinds were developed locally and sometime systematically by various scholars in the field.
3. The third and last type of mathematical tools that we envision for DISHAS will help scholars explore the performative dimensions of astronomical tables i.e. restore them as much as possible as computational tools. This type of tools is, at present, mostly inexistent and it is a new domain to explore. Libraries implementing various arithmetics depending on the type of numbers and the astronomical traditions will have to be developed, tools to handle rounding and truncation as well. Interpolation libraries for tables are probably also required features. From these basic tools it will be possible to develop computations scenarios from and between the tables of the databases.

Based on case studies or on the presentation of currently existing tools the presentation of the workshop will explore these various level and help us define, with the cooperation of DISHAS IT's, the first steps and mid-term objectives with respect to the mathematical tools.

**Program****Thursday 1, February 2018****9h15-9h30***Welcome***9h30-10h45****Petr Hadrava (Academy of Sciences of the Czech Republic)***Mathematical Treatment of the Alfonsine tables***10h45-11h00***Coffee break***11h00-12h15****Benno van Dalen (Bavarian Academy of Sciences and Humanities, Germany)***Obsolete Precursors: Examples of Table Analysis with TA and ZijManager***12h15-13h30***Lunch break***13h30-14h45****Glen Van Brummelen (Quest University, Canada)***Dependence and Independence: Tables, How They Relate, and How They Don't***14h45-16h00***General discussion 1 (Allow to input table content, final validation)***16h00-16h15***Coffee break***16h15-17h15***General discussion 2 (Statistical analysis tools 1)*

**Friday 2, February 2018**

**9h15-9h30**

*Welcome*

**9h30-10h45**

**Richard Kremer (Dartmouth College)**

*Reproducing astronomical tabular computation by computer algorithms: 50 years of Alfonsine electronic computation*

**10h45-11h00**

*Coffee break*

**11h00-12h15**

**Matthieu Husson (CNRS, PSL-Observatoire de Paris-SYRTE, ALFA project)**

*Tools to explore elementary arithmetic and interpolation practices in the Parisian Alfonsine context*

**12h15-13h30**

*Lunch break*

**13h30-14h45**

**Anuj Misra (TAMAS postdoctoral Fellow, Observatoire de Paris, France)**

*Developing digital tools for sexagesimal arithmetics in recomputing astronomical tables.*

**14h45-16h00**

*General discussion 3 (statistical analysis tools 2)*

**16h00-16h15**

*Coffee break*

**16h15-17h15**

*General discussion 4 (toward historical tables as computational device)*

## Title and Abstracts

(Alphabetical order)

### **Benno van Dalen (Bavarian Academy of Sciences and Humanities, Germany)**

#### *Obsolete Precursors: Examples of Table Analysis with TA and ZijManager*

any historians of the pre-modern astral sciences have written their own programs for dealing with technical problems related to astronomical tables, starting with early attempts by Kennedy and Gingerich with punch cards on mainframe computers, through relatively straightforward DOS programs by North, Van Brummelen, Mielgo, myself and others, up to fancy Windows applications and extensively programmed Excel worksheets by several members of the TAMAS group. DISHAS has the promise of incorporating many of the functions of these individual programs. As an example of the types of functions that I think should be included, I will present two or three examples of the analysis of astronomical tables as I have carried them out with my own DOS program TA (Table Analysis) and its Windows successor ZijManager by Rafael Ziolkowski. These examples may be chosen by the organisers and the audience from the following possibilities:

- convenient input of tables
- flexible output of tables including a generic apparatus
- parameter estimation by means of least squares
- establishing the dependence of a tangent table on a sine table
- establishing the sine table from which another table was calculated by means of inverse interpolation

### **Matthieu Husson (CNRS, PSL-Observatoire de Paris-SYRTE, ALFA project)**

#### *Tools to explore elementary arithmetic and interpolation practices in the Parisian Alfonsine context*

I want to expose some results of a past and current research regarding how Parisian Alfonsine actors of the first half of the 14<sup>th</sup> century were handling basic arithmetical operation and interpolations in an astronomical context. Relying on these results I will try to explore what could be the type of tools that we could try to develop in order to restore astronomical tables as computational tools, faithfully to actors' local practices, and analyse their mathematical properties (robustness, error propagation, convergence of iterative procedures, etc.).

### **Petr Hadrava (Academy of Sciences of the Czech Republic)**

#### *Mathematical Treatment of the Alfonsine tables*

To collect the numerical data contained in various versions of Alfonsine tables, we use the method which we applied in the past to treat several topics from the history of astronomy (cf. e.g. JHA 38, 2007, 305). The method is rooted in transcribing of the tables and simultaneously, already in this stage, also in deciphering the algorithms used by the authors of the tables. We have debugged specialized computer codes (in Fortran) which, for a given set of free parameters, simulate on their output the data given in each type of a table. The codes can also fit (using the simplex method of optimization of least squares) the values of the free parameters to the input data in the same format. A transcription of a small part of the table can thus be used to find approximate values of the parameters and to produce a preliminary outline of the whole table which is then manually modified to correspond to its manuscript template. This procedure has been already applied to various types of astronomical tables and it proved to be more efficient and safer than a straightforward transcribing of extensive tables. Practical examples of this approach will be shown in the contribution.

**Richard Kremer (Dartmouth College)**

*Reproducing astronomical tabular computation by computer algorithms: 50 years of Alfonsine electronic computation*

In 1968, Poulle and Gingerich published the first research that brought together electronic computers and Alfonsine astronomy: "Les positions des planètes au moyen âge: Application du calcul électronique aux tables alphonsines", *Académie des inscriptions & belles-lettres, Comptes rendus*, pp. 531-48. Since then, many scholars have used Gingerich's FORTRAN programs and a few others built their own programs to replicate the computational steps and practices of mathematical astronomy in the Ptolemaic mode. Working with Lars Gislen, I have developed EXCEL spreadsheets that replicate computation of longitudes and latitudes of the Almagest, al-Battani's zij, al-Kharizmi's zij, the Toldean Tables, the Parisian Alfonsine Tables, the Copernican Prutenic Tables, Tycho's solar and lunar tables, Longomontanus's *Astronomia danica*, Kepler's Rudolphine Tables, and Thomas Streete's *New Theorie of the Coelestial Motions* (London 1665, only the luminaries). In this paper, I will demonstrate the basic features of Gislen's and my spreadsheets and, by showing some computational examples, shall reflect on the strengths and weaknesses of such tools for research on the history of mathematical astronomy, including Alfonsine astronomy. END

**Anuj Misra (TAMAS postdoctoral Fellow, Observatoire de Paris, France)**

*Developing digital tools for sexagesimal arithmetics in recomputing astronomical tables.*

Modern scholars often make tacit decisions on particular rounding schemes when recomputing astronomical tables to agree with the ones produced by historical actors. In some instances, a *systematic-rounding* method may be selected, e.g., calculating the final values up the fourth sexagesimal fraction and rounding it to the third sexagesimal fraction based on a significance-arithmetic rule. In other instances, a *truncation-without-rounding* method may be applied, e.g., reducing the final value, calculated up to the fourth sexagesimal fraction, to the third sexagesimal fraction by a simple truncation of digits. The selection of one, or both, of these two methods is typically done in a manner that minimises the differences between the recomputed and the historical values. Moreover, calculative decisions, e.g., rounding at each step of the recomputation as opposed to rounding the final value, also affects the precision, the accuracy, and the reliability of the recomputation.

In this talk, I will attempt to explore the mathematical challenges and decision-making algorithms in my study of select tables of Nityānanda's Amṛtalahaṛī (c. 1649/50 CE). The aim of this talk is to promote a collective attempt in designing and developing digital tools (via DISHAS) for Table Analysis Method for the history of Astral Sciences (TAMAS).

**Glen Van Brummelen (Quest University, Canada)**

*Dependence and Independence: Tables, How They Relate, and How They Don't*

About 20 years ago I developed a standard procedure for determining whether one historical astronomical table might have been calculated based on the values of another: for instance, were the values in a given declination table computed from a particular sine table? With it I was able to resolve several questions, and it remains a useful tool in a table cracker's arsenal. However, my work with this and other procedures led to several vexing questions regarding the application of statistical tools to our data. So, in addition to exploring the use of the table dependence test, we consider several additional questions: with this sort of data, to what extent can we trust the results of a significance test or confidence interval? Can we identify situations in advance that might cause problems, and is it possible to find ways to work around them? Finally, to what extent do we wish DISHAS to perform statistical procedures, as opposed to exporting the data to statistical software that already exists?