Taqi al-Din ibn Ma^{c}ruf (Takiyüddin) and his work on the astrolabe

Jan P. Hogendijk, joint work with Mrs. Eslem Günaydın (Istanbul).

Mathematics Department, Utrecht University

2022

This talk

1. Taqi al-Din ibn Ma^{c}ruf (1526-1585), (Takiyüddin)
2. What is an astrolabe?
3. Takiyüddin's work on the astrolabe

1. Taqi al-Din ibn Ma^{c}ruf (Takiyüddin)

Born 1526 CE, Damascus, Syria

qadi, astronomer, came in 1570 to Istanbul.

director of observatory in Istanbul under Sultan Murat III (destroyed 1580)

died 1585.

Wrote in Arabic

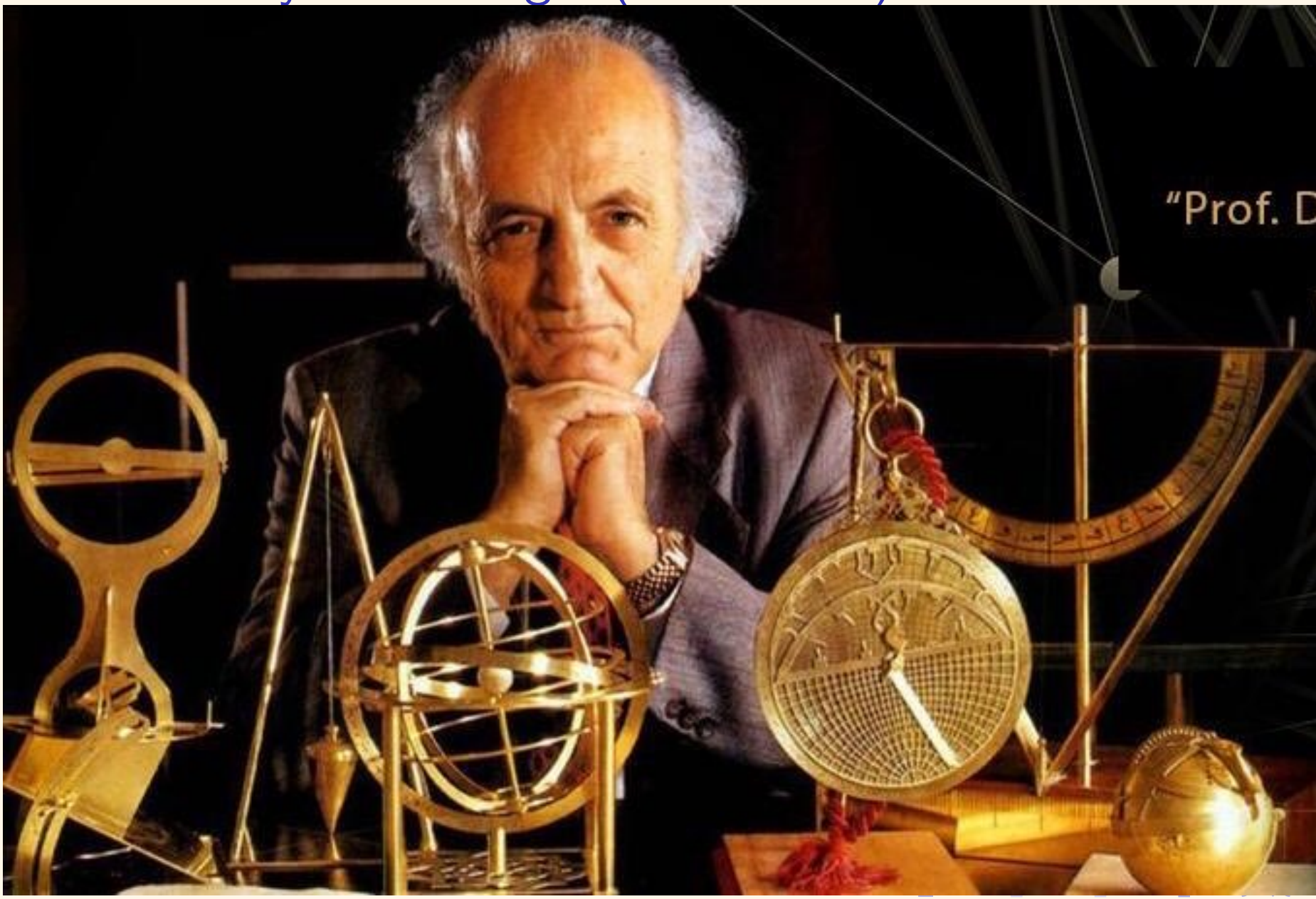
Taqi al-Din ibn Ma^{c}ruf (Takiyüddin), Biography

The greatest Ottoman astronomer, and one of the greatest astronomers in the entire Islamic tradition. Also a good mathematician.

Extremely accurate observations, for example of solar altitude,
(hence very accurate astronomical theories)

Some 30-40 works are extant, on astronomy, optics, arithmetics, sundials, clocks, mathematics, machines. Only few have been published

Many astronomical instruments by Takiyüddin were reconstructed by Fuat Sezgin (1925-2018)



Astronomical instrument by Takiyüddin, in Museum for Islamic Science in Gülhane Park, Istanbul, and in the exhibition on Turkish-Islamic Science in 100 instruments.

AN OBSERVATION INSTRUMENT INVENTED BY
TAQIYADDĪN FOR THE ISTANBUL OBSERVATORY:

07

ĀLĀ MUŠABBAHA BI-L-MANĀṬIQ

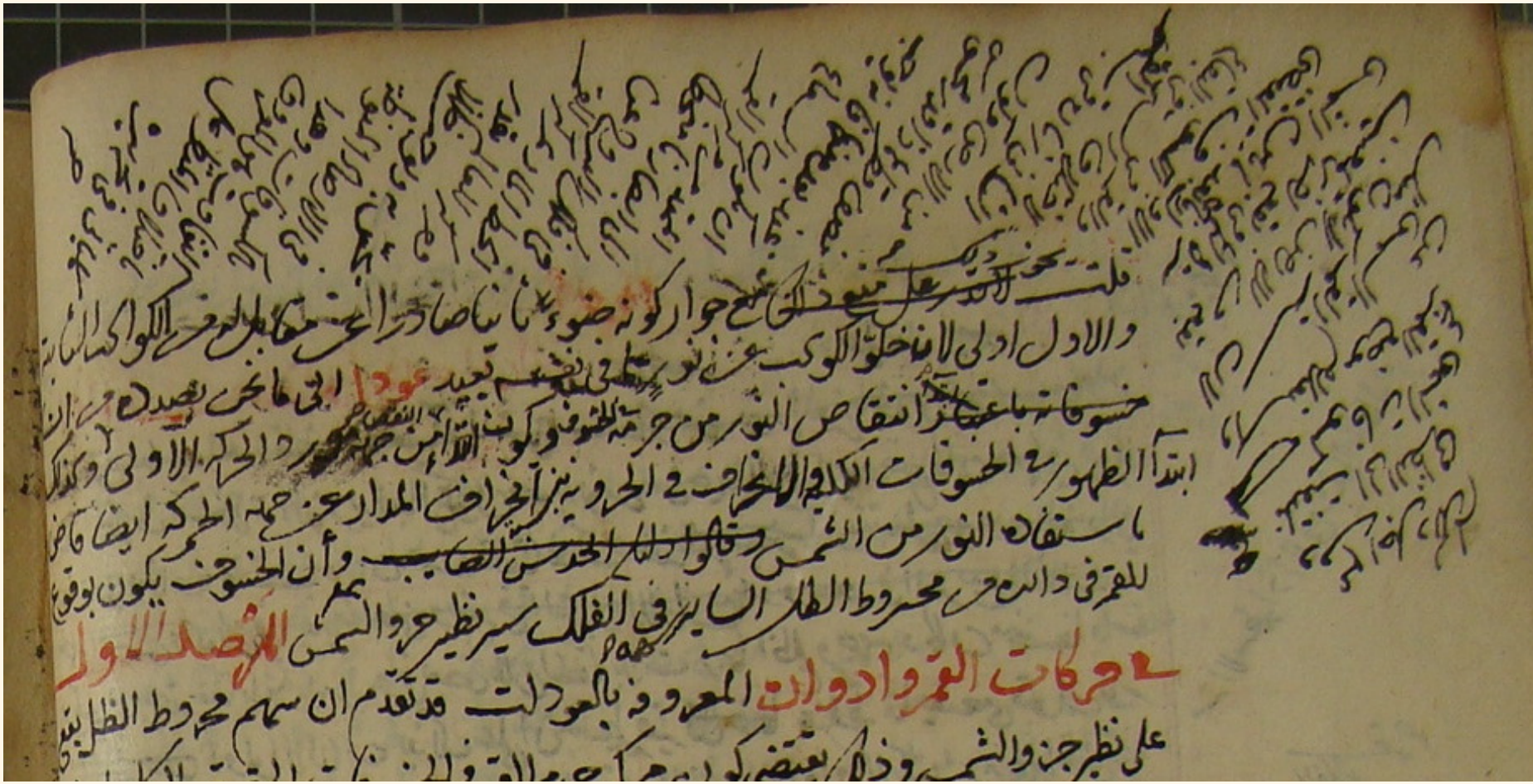
Ālāt al-raṣadīya li-zīǧ-i Šahinšāhīya written by the Ottoman historian and shahnameh author Seyyid Lokman in Turkish describes nine observation instruments used in the Istanbul Observatory with miniatures.[26] A study of the text describing the instruments reveals that the seventh, eighth and ninth instruments were invented by Taqīyaddīn.

The work specifically underlines that the eighth instrument called Ālā mušabbaha bi-l-manāṭiq had never been constructed before. It is reported that Taqiyaddīn built this instrument for the particular purpose of examining the planet Venus and measuring the radius of its epicycle by drawing upon chapter ten of Ptolemy's *Almagest*.[27]

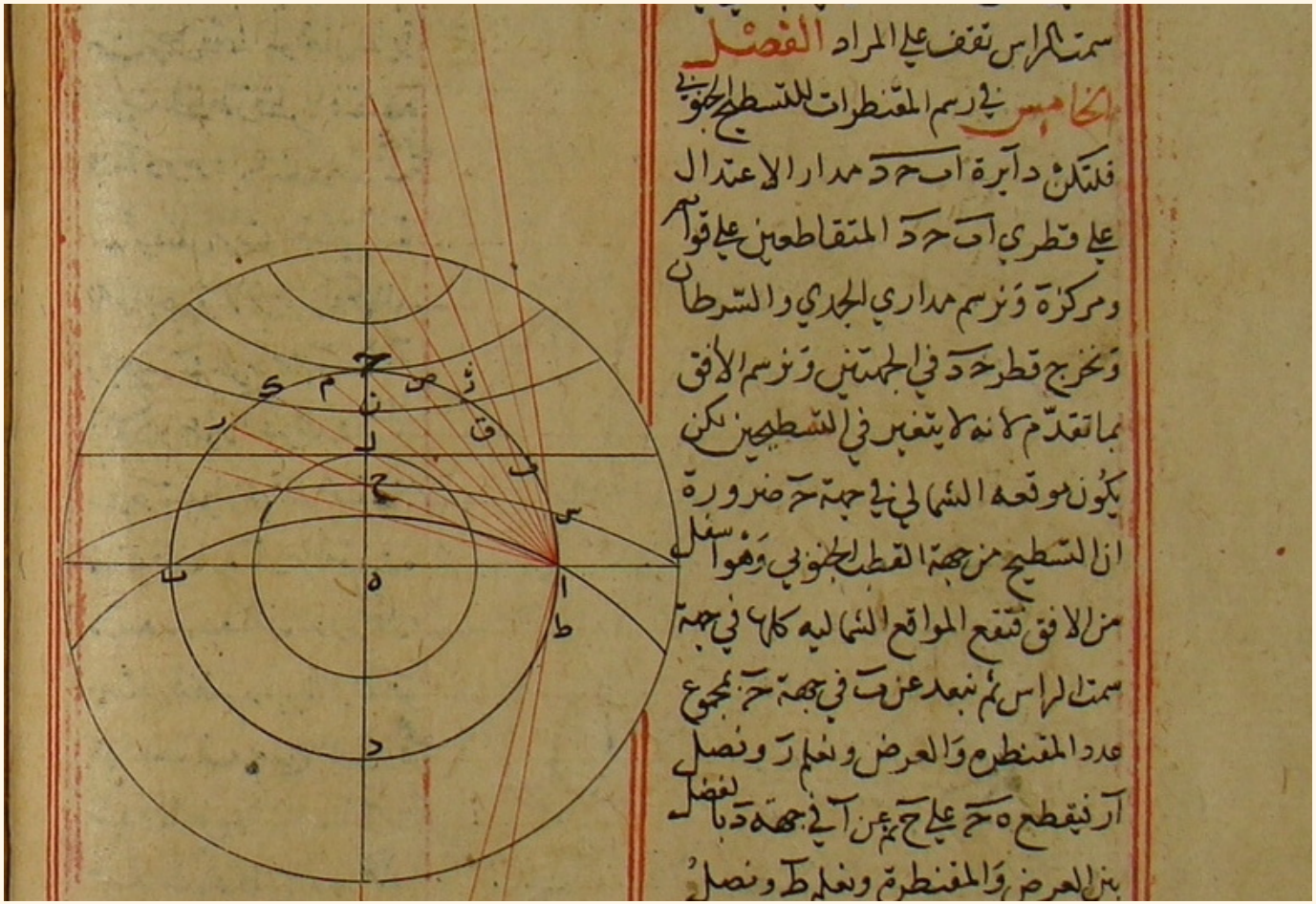
Our model was built according to the description and drawings in the work.[28]

Takiyüddin even built a mechanical clock!

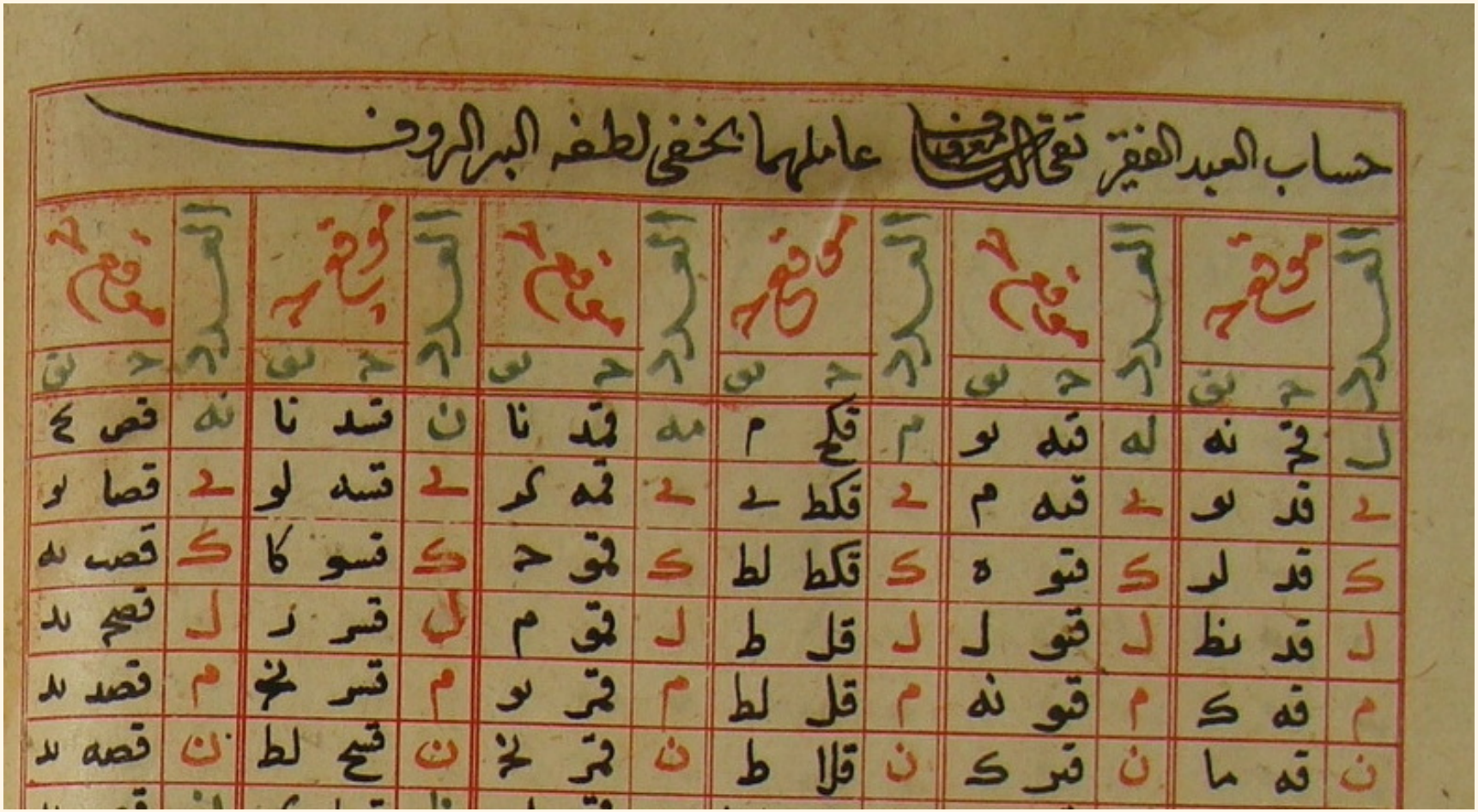
His work on astronomical observations, Sidrat al-Muntaha, is studied in the PhD thesis by Hüşeyin Sen, Utrecht University, on the basis of a manuscript in Kandilli Obsrvatory, which Takiyüddin wrote in his own hand!



The manuscript in Kandilli Obsrvatory also contains another work by Takiyüddin, on the astrolabe, entitled "The weighty rules on the basics of projection" (tasṭīḥ, flattening).



The work includes tables with numbers, and a few signatures by Takiyüddin, showing that it was also his own handwriting.



2. What is an astrolabe? Basicly a clock.

Turkish astrolabe (1706-7 CE)

Four important parts:
1. Scale on circumference to read off (sidereal) time

2. Network ("spider") with stars and sun which can rotate

3. Under the network a plate with a grid.

4. On the back: a rotating ruler with two sights.

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How to use the astrolabe (workshop this afternoon):

Input: Measure the altitude of a sun or star with the ruler on the back (alidade)

How to use the astrolabe (workshop this afternoon):

Then set the astrolabe (rotate the spider over the plate, so that the position agrees with the altitude of the sun or star)

Then you can read off the (sidereal) time on the scale.

You can transform this to solar time, and also determine time intervals

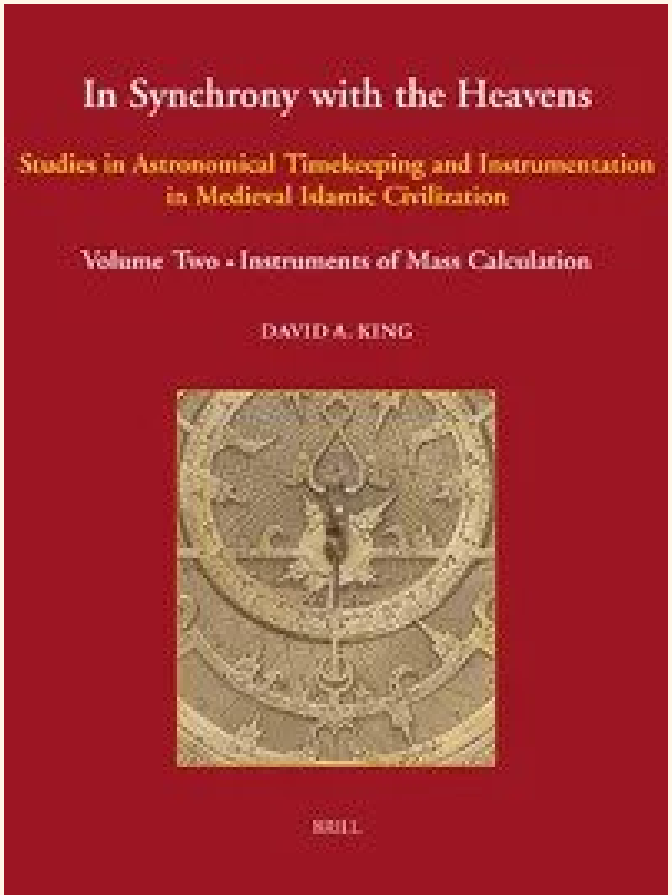
(for example: how much time it takes at night until the fajr prayer, or until sunrise)

you can even use it as a compass!

Hundreds of astrolabes made in the Islamic world between ca. 900 and 1800 exist today in museums and private collections.

Experts in this field include:

Prof David A. King (Frankfurt, Germany)



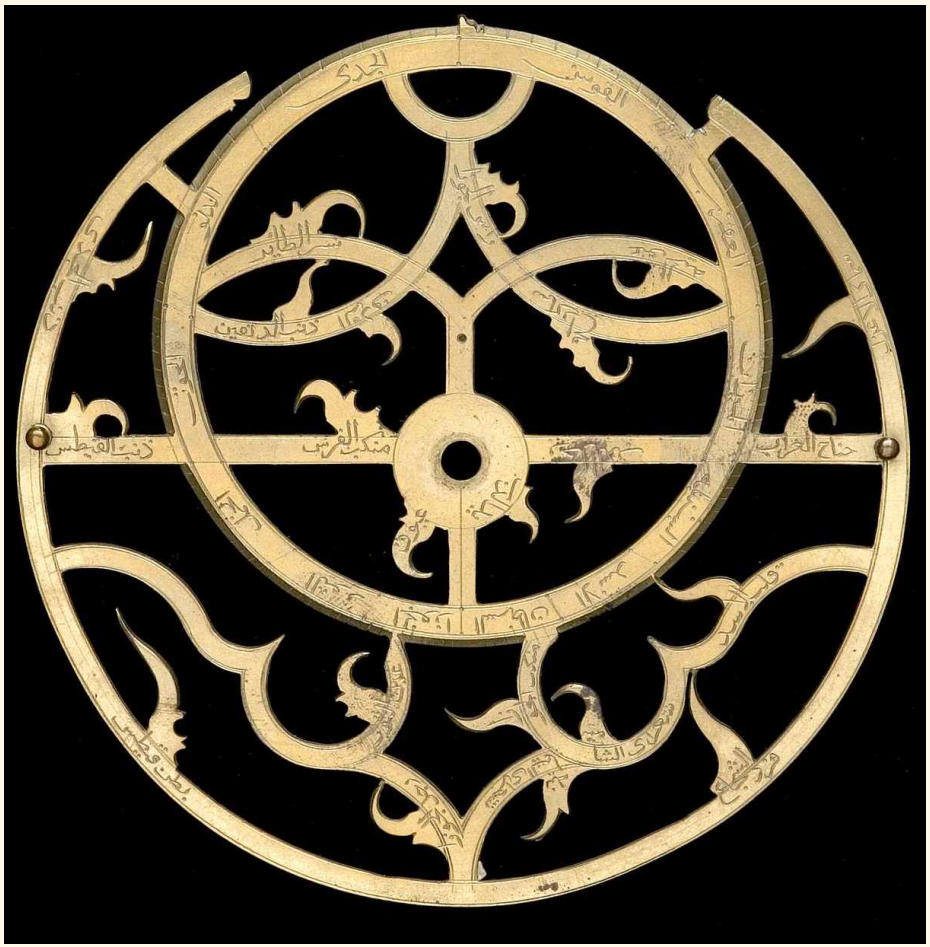
Dr Taha Yasin Arslan, Turkish astrolabe maker, Istanbul

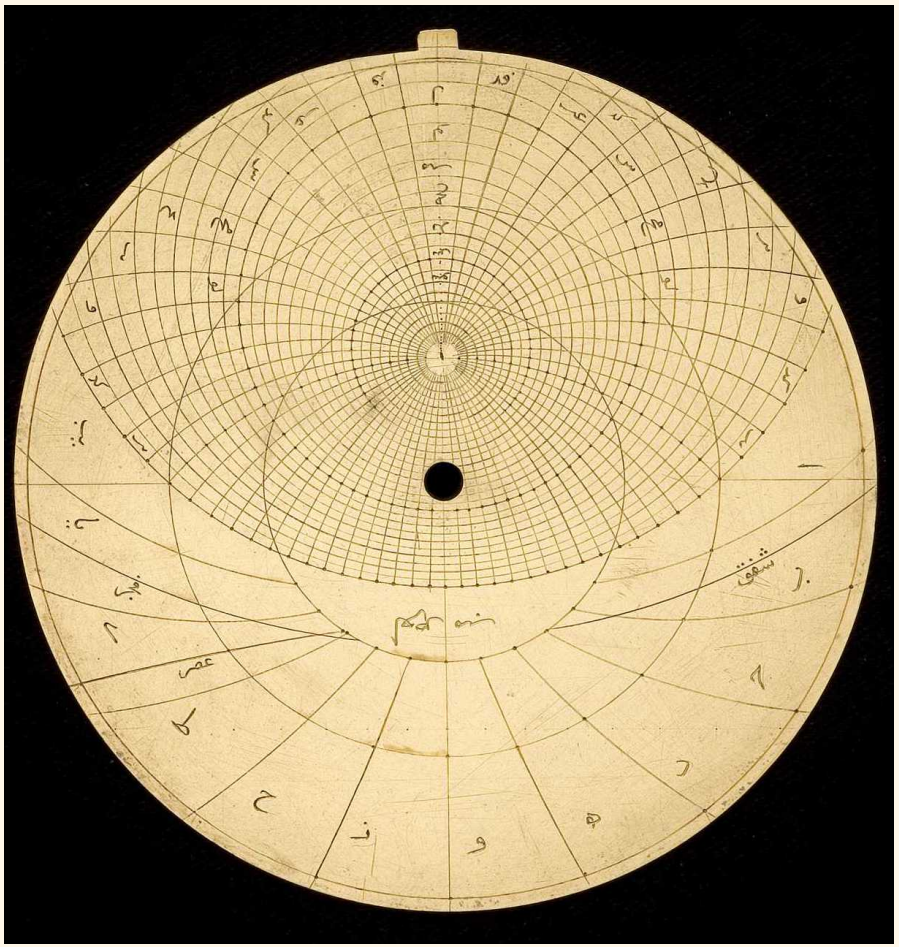
The astrolabe is also interesting for art history, and it has great potential for modern science education for a general audience

Bagdad, eca. 985 CE

Lahore, ca. 1570 CE

3. Takiyüddin's work is called "important rules on the basics of flattening" (Arabic: tasṭīḥ). We will now discuss the contents.

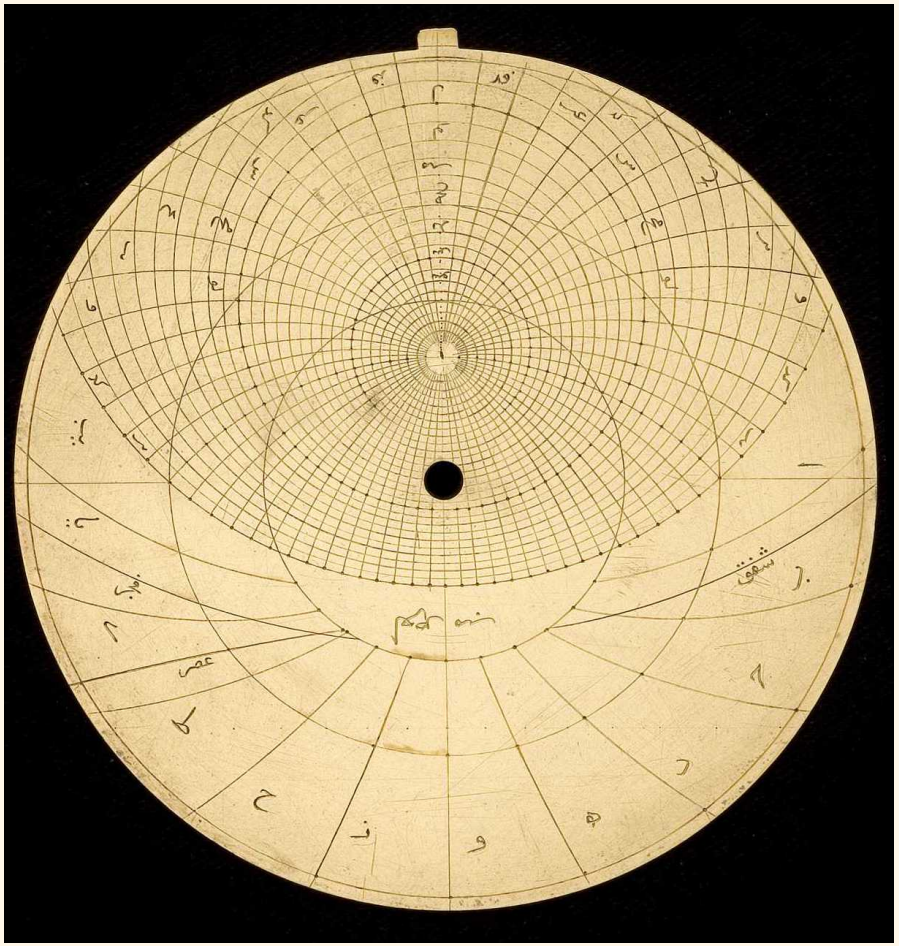




Takiyüddin's work is mostly about the design of the plate.

Spider of the same Turkish astrolabe

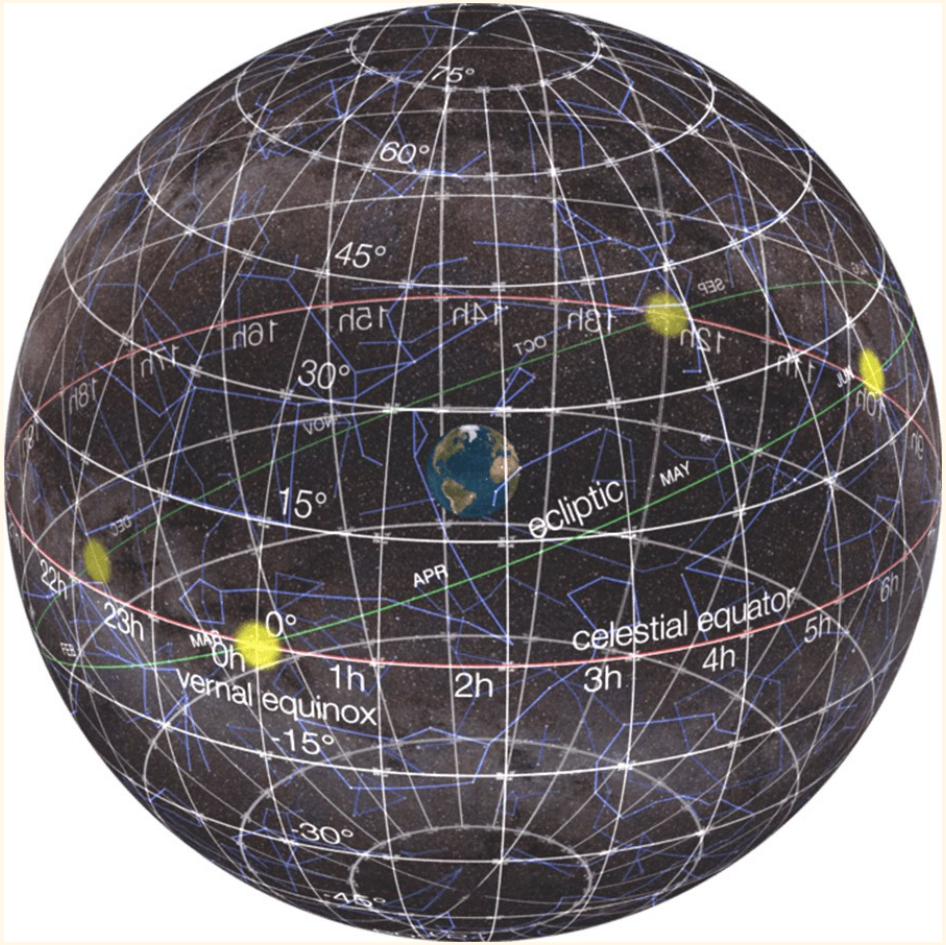
Plate for northern Turkey, 42°



What is the “ flattening” (Arabic: tasṭīḥ) that Takiyüddin writes about?

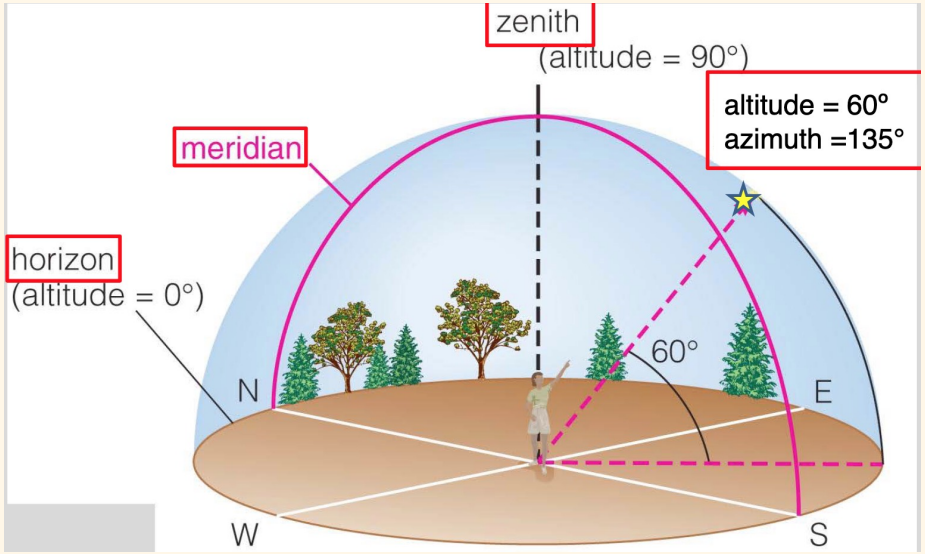
The celestial sphere (of the universe), with circles on it. is flattened two times.

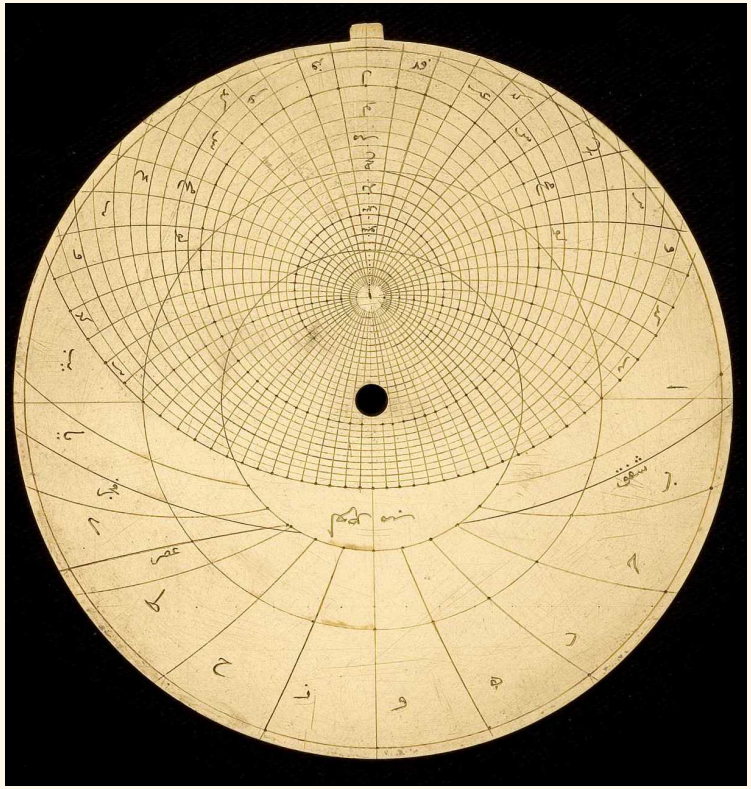
1. Stars are ‘flattened” on the spider, a map of the heavens.



What is the " flattening" (Arabic: tasṭīḥ) that Takiyüddin writes about?

Celestial sphere with Horizon, East, North, West, South, and zenit (point above your head), and horizon, and other coordinate circles, is flattened on the plate.





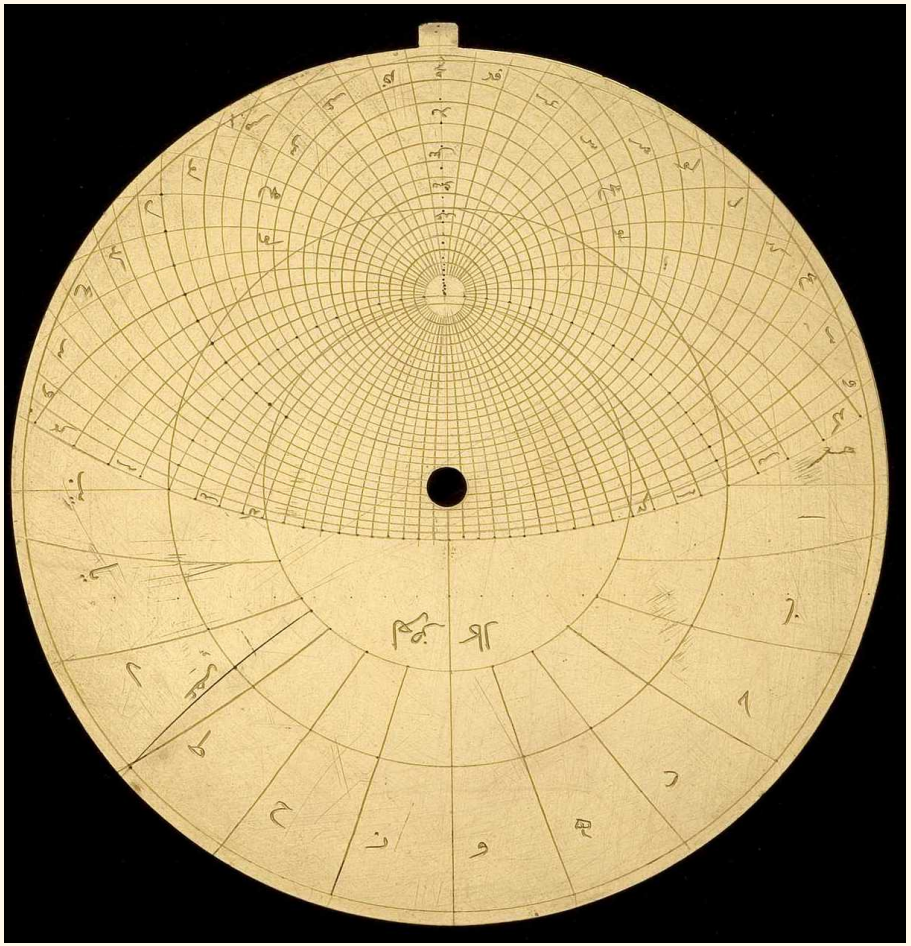
Why does the astrolabe work?

If the spider turns around the pole, the astrolabe imitates what happens in nature.

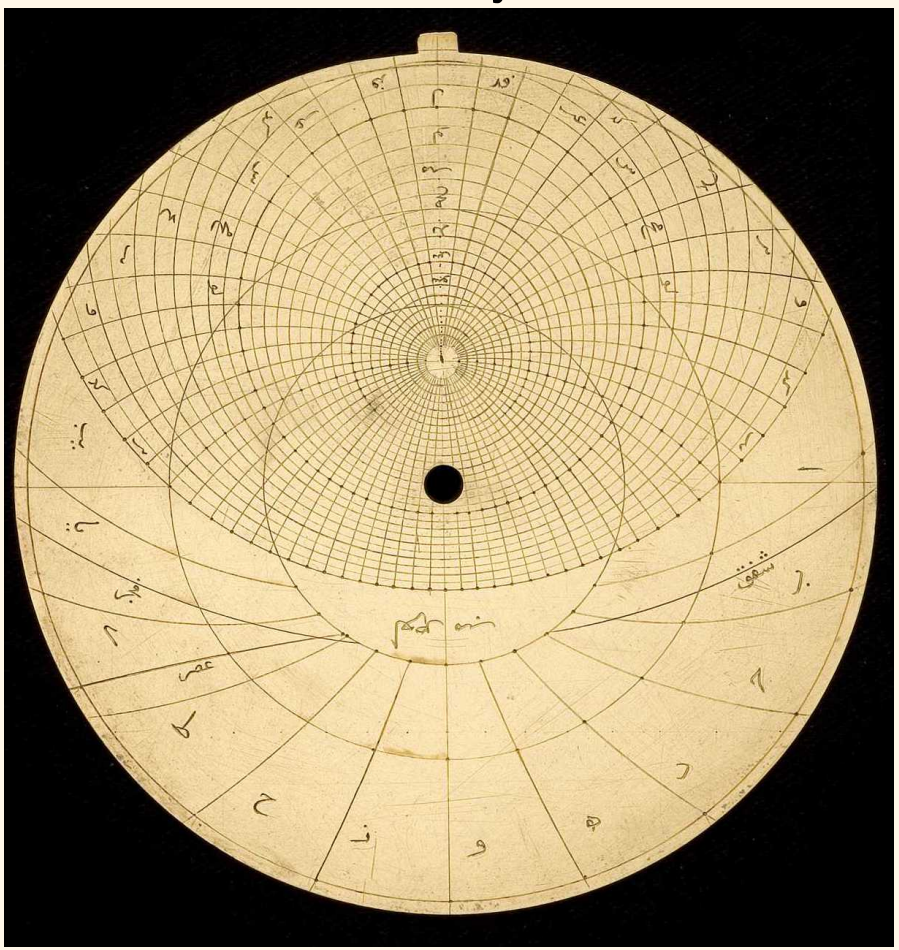
Therefore the astrolabe is a precision instrument.

The grid on the plate depends on geographical latitude. Examples:

Plate for Mecca, $21^o30'$

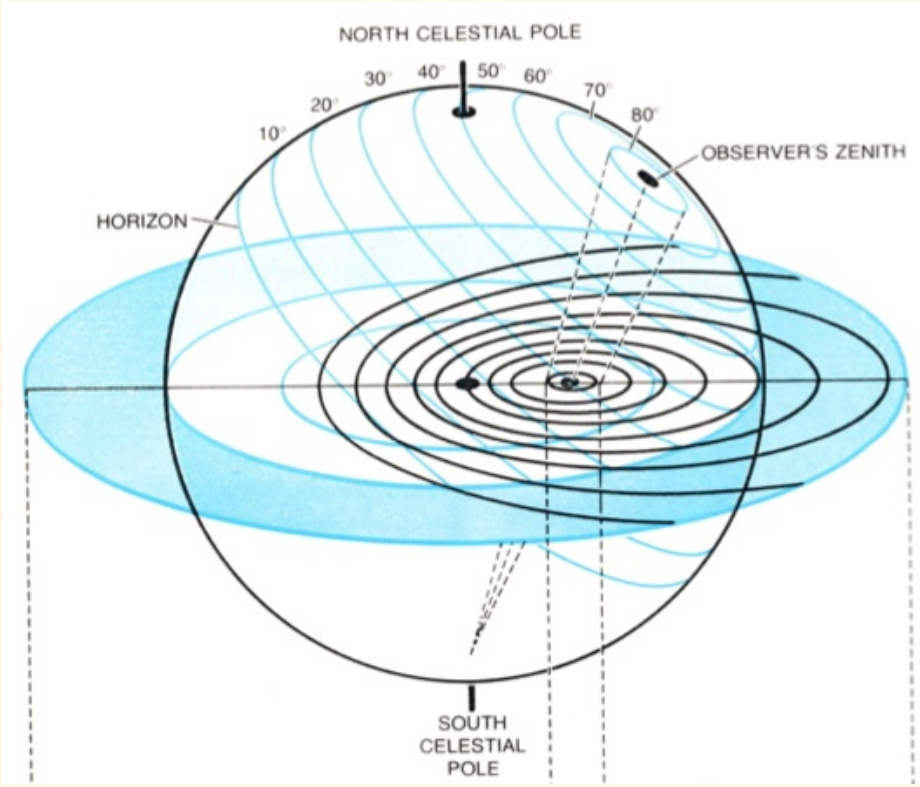


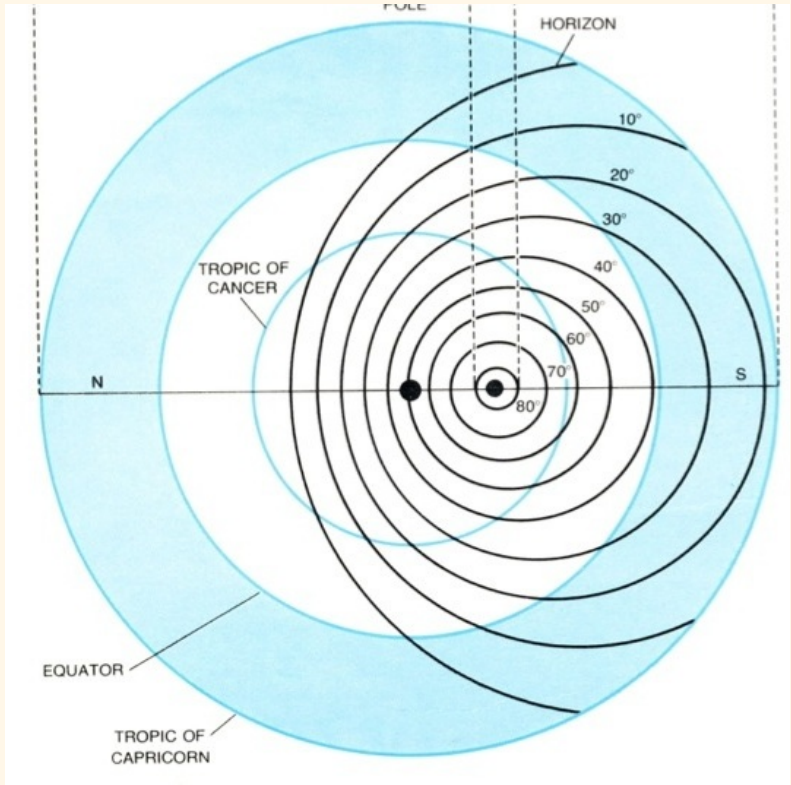
For Northern Turkey, 42^o



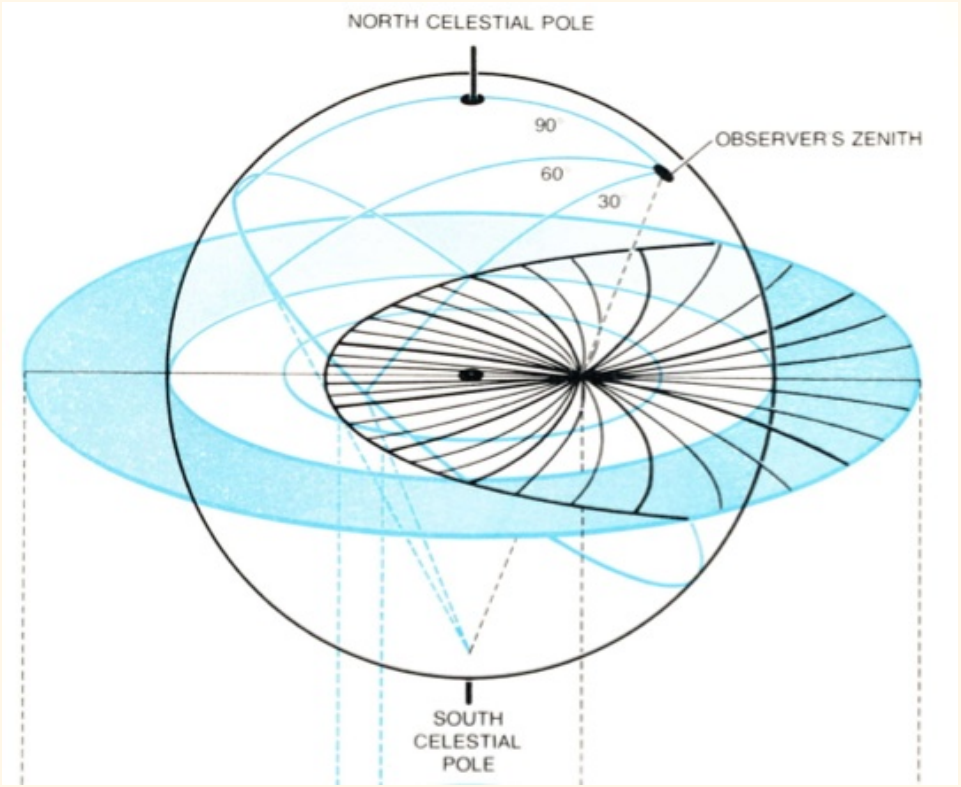
How does the flattening work for the plate? For circles around the zenith,called the almucantars

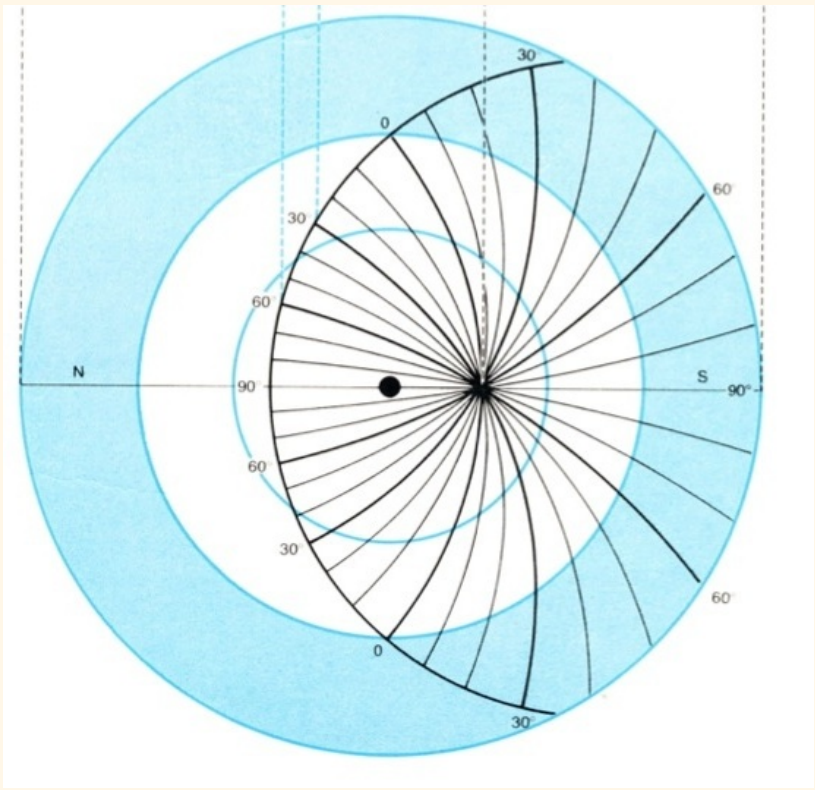
Stereographic projection





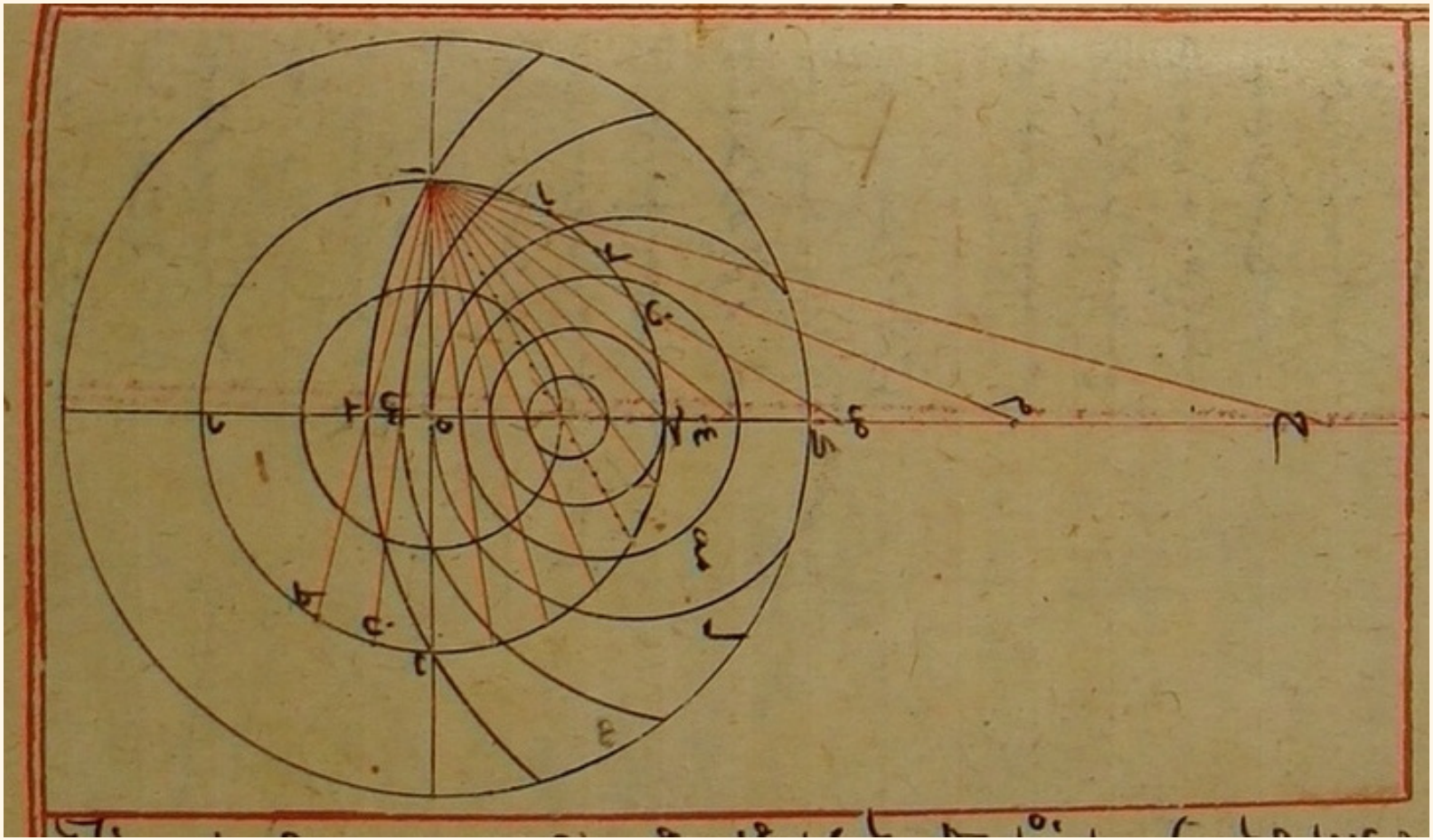
The "flattening" for the other type of circles (through the zenith), called the azimuthal circles





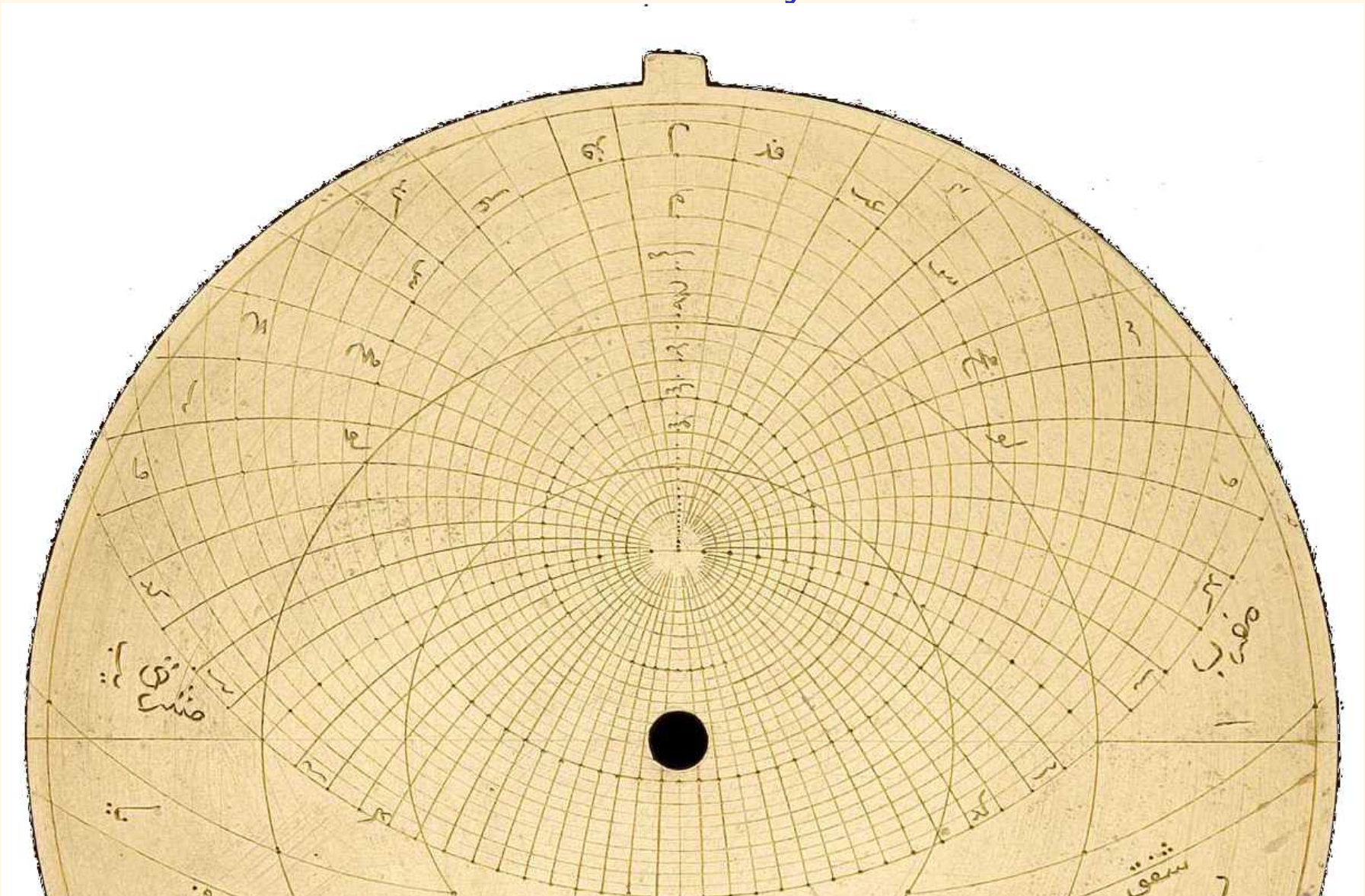
How to make a plate? By geometrical construction?

It can be done, and Takiyüddin mentions it; but it can never work (if you don't believe it, we have a workshop where you will experience this yourself).



One of Takiyüddin's figures.

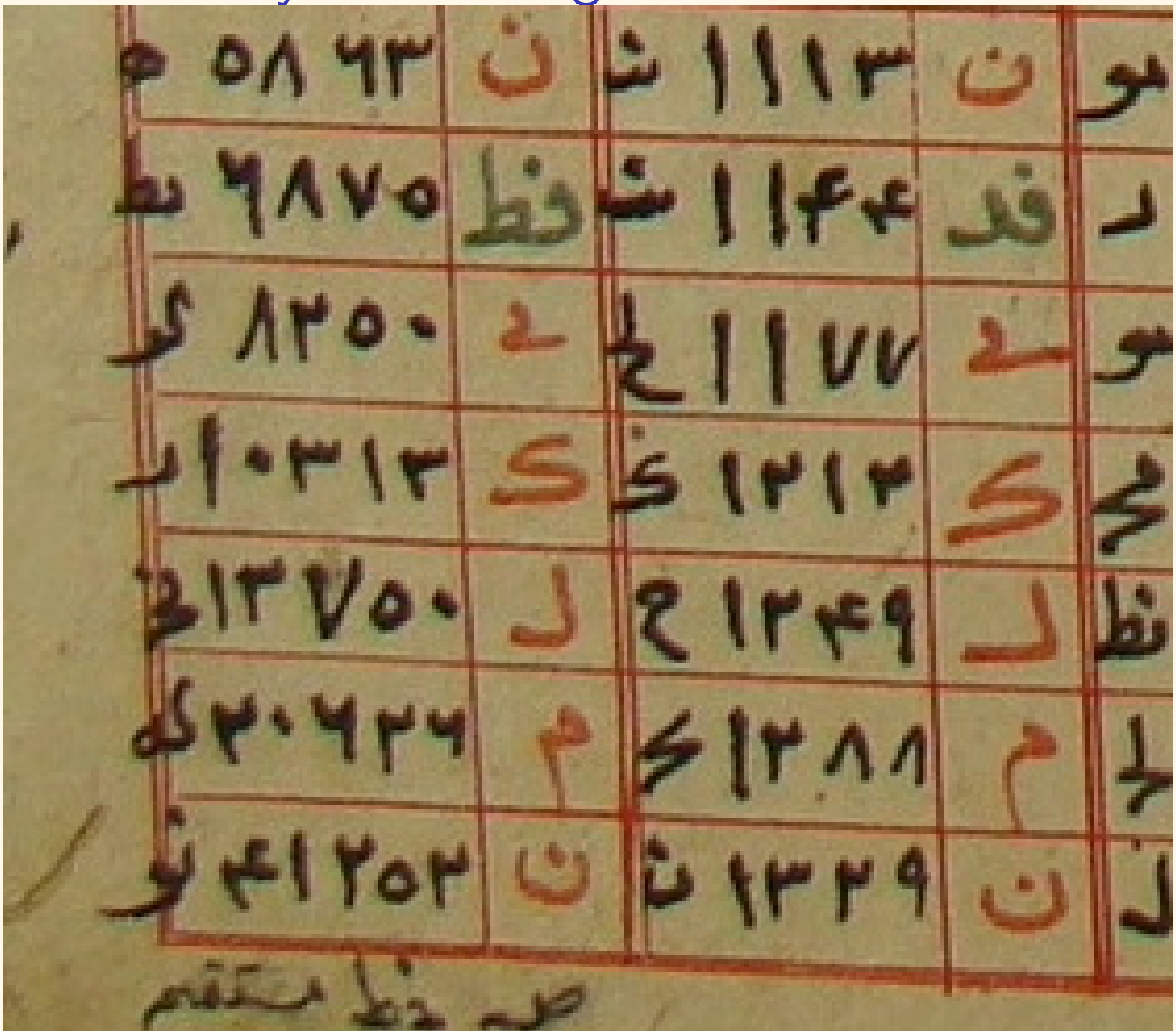
The plate has to be very accurate. The circles around the zenith are not really concentric, sometimes closer to one another, at other times further away



Takiyüddin's solution (really: the Islamic solution) is to compute everything. He first computed an accurate table of the tangent function $60 \tan \frac{x}{2}$ and $60 \tan(45^\circ + \frac{x}{2})$ for x between 0 and $89'50^\circ$ for intervals of 10 arc minutes; more than 1000 values.

Details of Takiyüddin's tangent table: 1.

Details of Takiyüddin's tangent table: 2.



Using his tangent tables, Takiyüddin computes more than 25 tables to construct the astrolabe plate for different geograpical latitudes. Here you see his tables for cities with geographical latitude 43° (left), 50° (right)

Takiyüddin's tables for plates: for which latitudes?

0^o (for theoretical purposes), he then uses this to find the azimuth (innovation!)

$21^o30'$ (Mecca), $23^o30'$, 30^o, $30^o20'$, 32^o, $33^o30'$, 34^o, 35^o, 36^o, 37^o, 38^o, 39^o, $40^o20'$ $41^o10'$ (Istanbul?), $41^o20'$,

42^o, 43^o, 44^o, 45^o, 46^o, 47^o, 48^o, 49^o, 50^o,

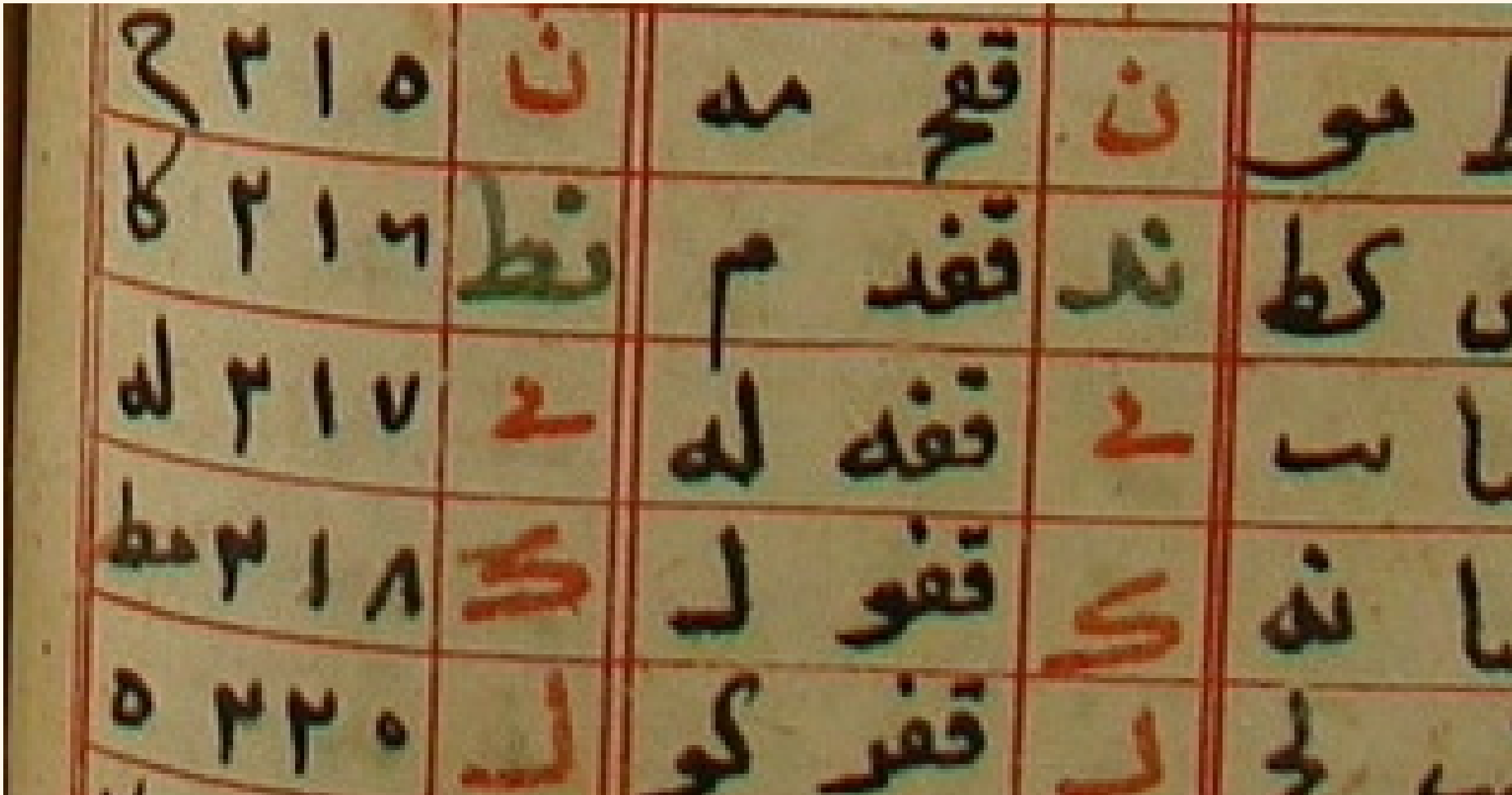
$66^o30'$ (for theoretical purposes related to the ecliptic and the stars)

Mystery question: Why did he compute tables for exactly these latitudes?

Takiyüddin's astrolabe text

Edition and translation are in preparation by Mrs Eslem Günadyin and Jan P. Hogendijk

You can learn his way of writing numbers in the Abjad workshop (tomorrow!)



Why is Takiyüddin interesting?

For many reasons! Three aspects:

The quality of his work: his power of concentration, his will power

His possible relations with, and influence on, science in Western Europe.

He was a great astronomer, with formidable mathematical skills.

Thanks for your attention! Download this presentation on www.jphogendijk.nl/taqi/pres.pdf