Středověké astronomické tabulky

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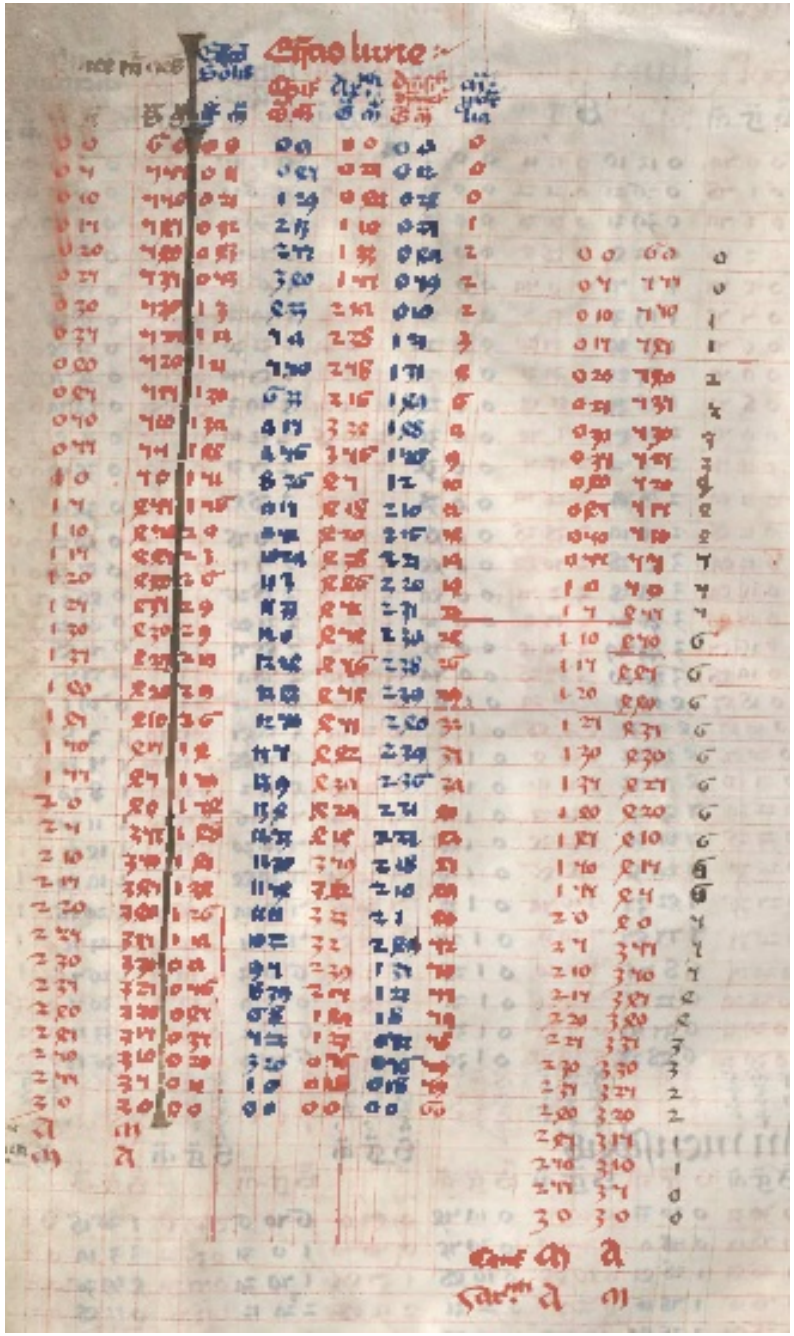
ALFA-Shaping a European scientific scene: Alfonsine astronomy, CoG agreement n°723085

Obsah

- Ekvace Slunce
- Ekvace Měsíce
- Časová rovnice
- Trepidace



Paulerinus - Liber viginti artium, BJ 257

JHA 38 (2007), 305; DVT 41 (2008), 65

Astronomie = pátá věda,
fol. 131ra-142vb, tabulky 143r-152v

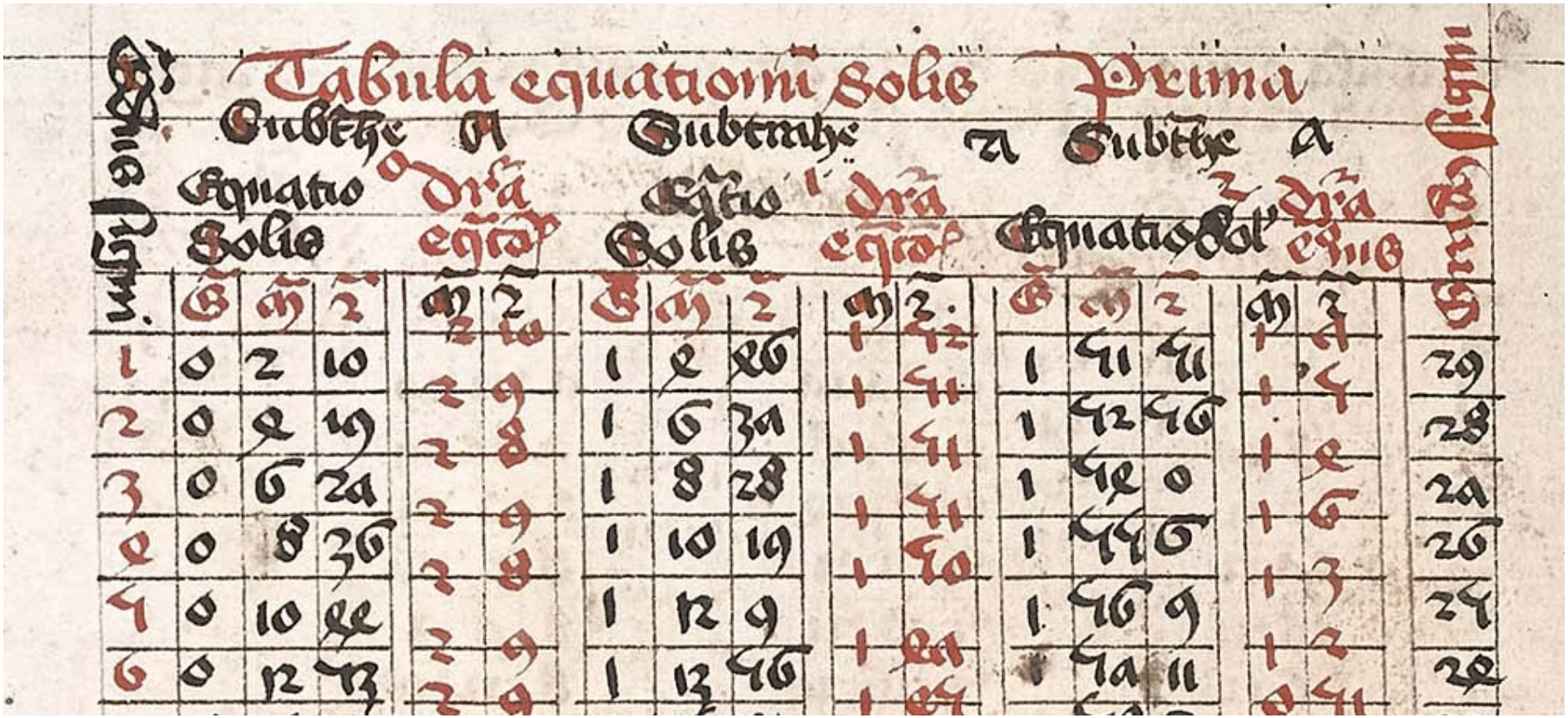
f. 131va: typy astronomie: přirozená, získaná, teoretická, ruční, **tabulková**, přístrojová, komputistická, kostelní

"**Tabulková astronomie** je založena na Alfonsinských nebo Lineriových tabulkách, na Anglických tabulkách nebo mých, které jsou velmi krátké a zabývají se během planet podle obecných či fyzických znamení"

f. 135 vb: "Abych však příliš nezlehčoval tuto přeslavnou vědu nebo ji dokonce nezlehčil natolik, že by ji mohli znevažovat i hlupáci: z žádné vědy jsem nebyl tak unaven a z žádné mne nebolela hlava a oči tolik, jako z této"

Ekvace Slunce

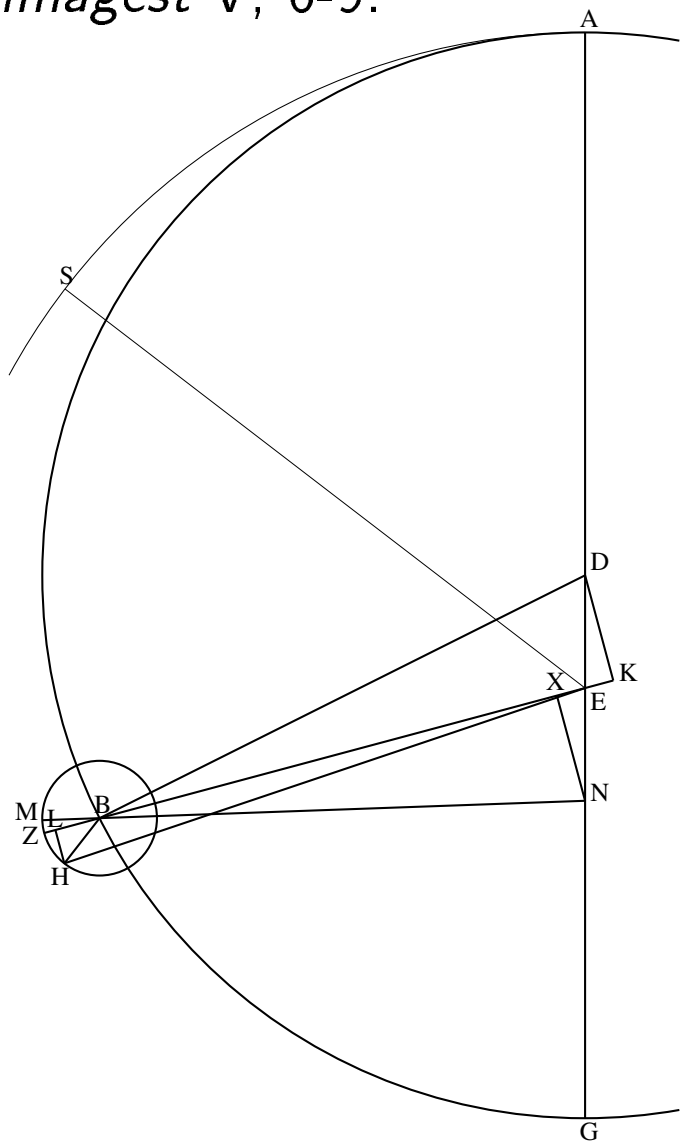
$$\epsilon = \arcsin\left(\frac{e \sin a}{\sqrt{1+2e\cos a+e^2}}\right)$$



X B 3 fol. 95v

Ekvace Měsíce

Almagest V, 6-9:



$$R \equiv DB,\ e \equiv DE,\ \eta \equiv \angle SEB = \angle DES$$

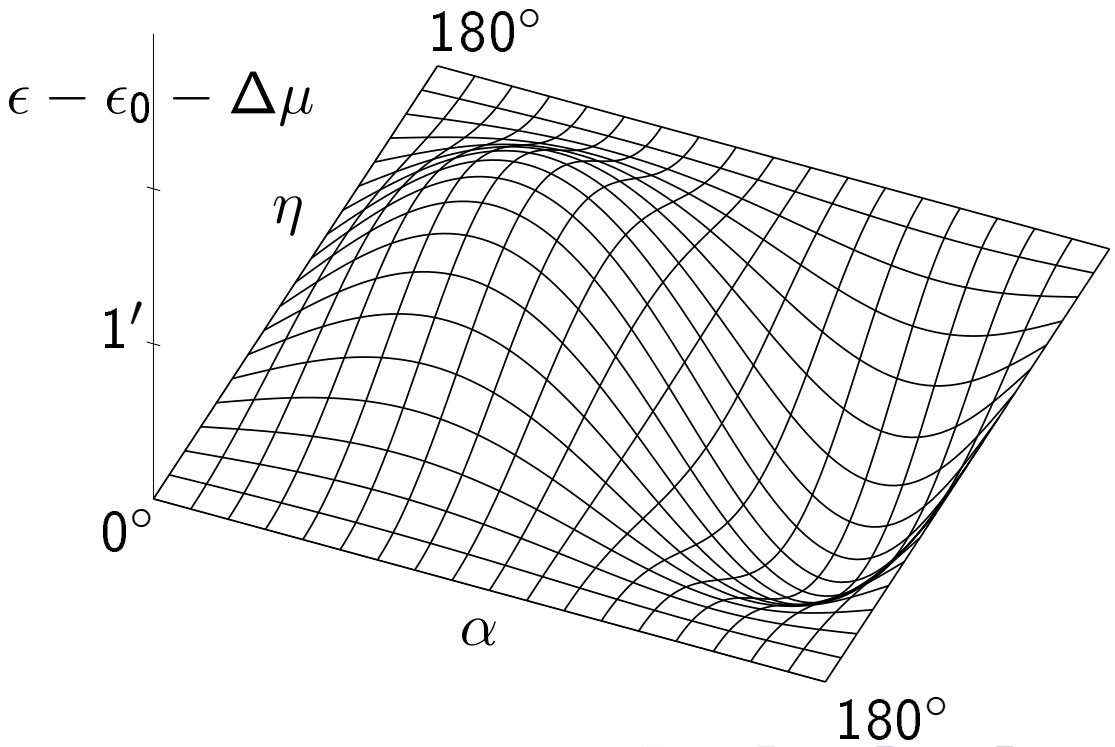
$$d(\eta) \equiv EB = \sqrt{R^2 - e^2 \sin^2 2\eta} + e\cos 2\eta$$

$$e \equiv DE,\ \alpha \equiv \angle ZBH$$

$$\theta \equiv \angle ZBM = \arctan \frac{e \sin 2\eta}{\sqrt{R^2 - e^2 \sin^2 2\eta} + 2e \cos 2\eta}$$

$$\epsilon(\eta, \alpha) \equiv \angle BEH = \arctan \frac{r \sin \alpha}{d(\eta) + r \cos \alpha}$$

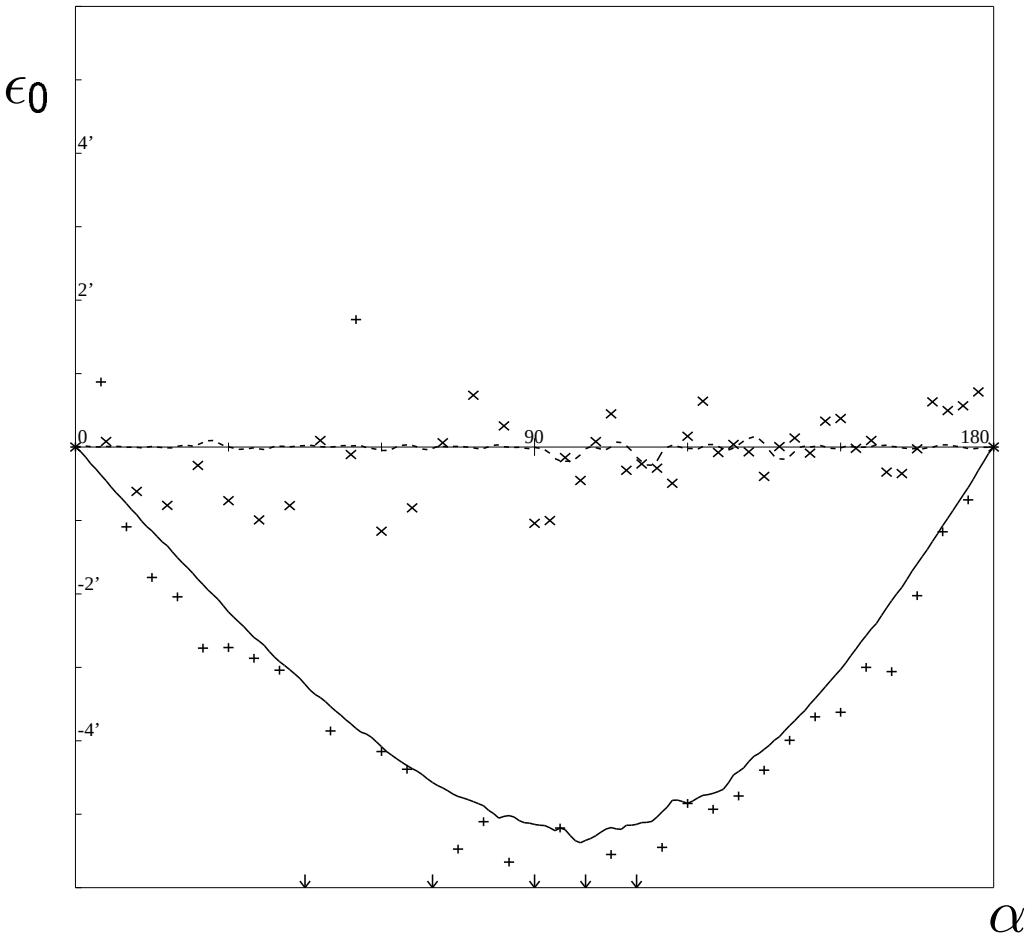
$$\simeq \epsilon_0(\alpha) + \Delta(\alpha)\mu(\eta)$$

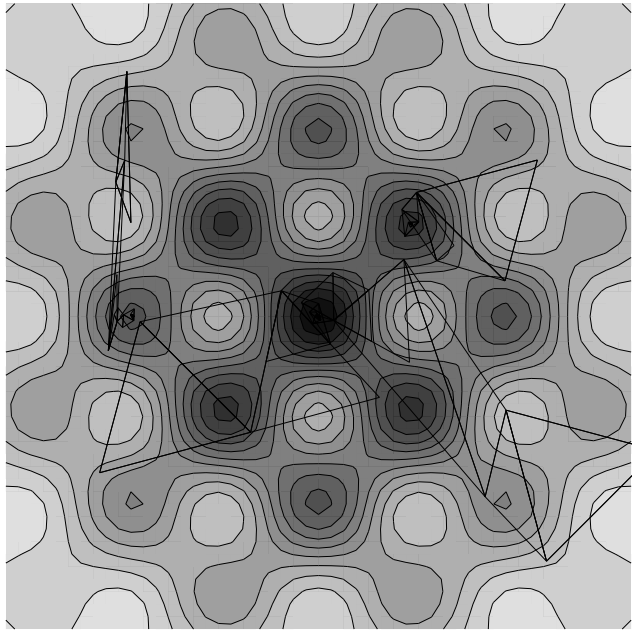


Metoda nejmenších čtverců

$$0 = \frac{\partial}{\partial p} \sum_i w_i (y_i - f(x_i; p))^2$$

Simplexová optimalizace





× *Almagest*

\+ Žídkovy tabulky

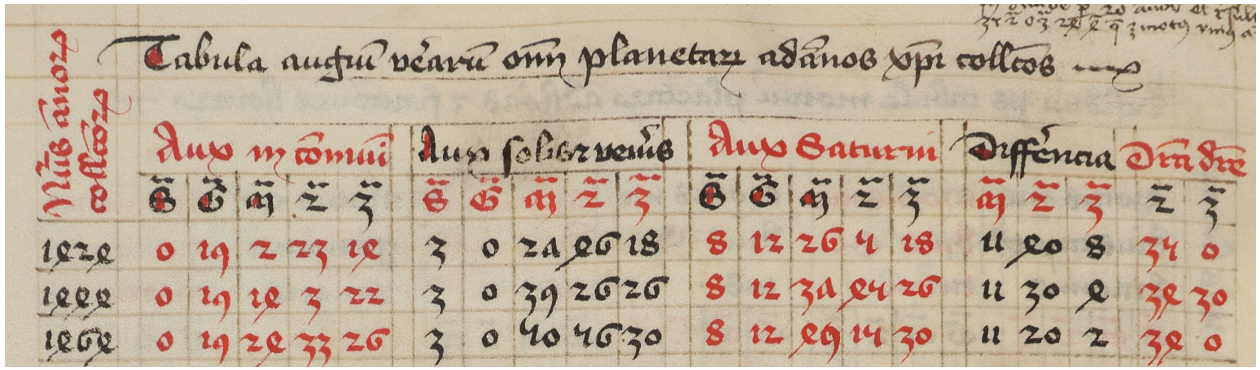
- - - - *Toledské tabulky*

—— *Alfonsinské tabulky*

quantity	parameter value	Almagest	Toledan tables	Alfonsine tables	Paulerinus' tables
$\theta(\eta)$	e/R	0.207865	0.207876	0.207881	0.207859
	0.207648	$\pm$.000056	$\pm$.000037	$\pm$.000029	$\pm$.000058
$\epsilon_0(\alpha)$	$r/(R+e)$	0.087441	0.0874928	0.0859937	0.085856
	0.0875	$\pm$.000028	$\pm$.0000017	$\pm$.0000010	$\pm$.000028
$\Delta(\alpha)$	e/R	0.2233	0.2294	0.2284	0.2392
	0.207648	$\pm$.0015	$\pm$.0013	$\pm$.0013	$\pm$.0022
	r/R	0.0986	0.0953	0.095804	0.0913
	0.105669	$\pm$.0007	$\pm$.0006	$\pm$.0006	$\pm$.0009
	cc	-0.9678	-0.9832	-0.9825	-0.91986
$\mu(\eta)$	e/R	0.18101	0.23005	0.23005	0.2504
	0.207648	$\pm$.0025	$\pm$.0025	$\pm$.0025	$\pm$.0042
	r/R	0.40741	0.0	0.0	0.59449
	0.105669	$\pm$.00125	$\pm$.00002	$\pm$.00005	$\pm$.007837
	cc	-0.7719	-0.11350	-0.11667	-0.61804

Interpolace dělením

Toruń BU 74 fol. 256v



fol. 269rb:
apogea k roku 1430... nejbližší nižší 1424... přebytek 6 let...
$[20/6] = 3$... 20=6*3+2... $D = 11'40''8''' = 42008'''$...

$$\Rightarrow \Delta \simeq D/k = 42008'''/3 = 14002'''...$$

$d \equiv D/N = 35''0''' = 2100'''$... 2100*2/3=4200/3=1400...

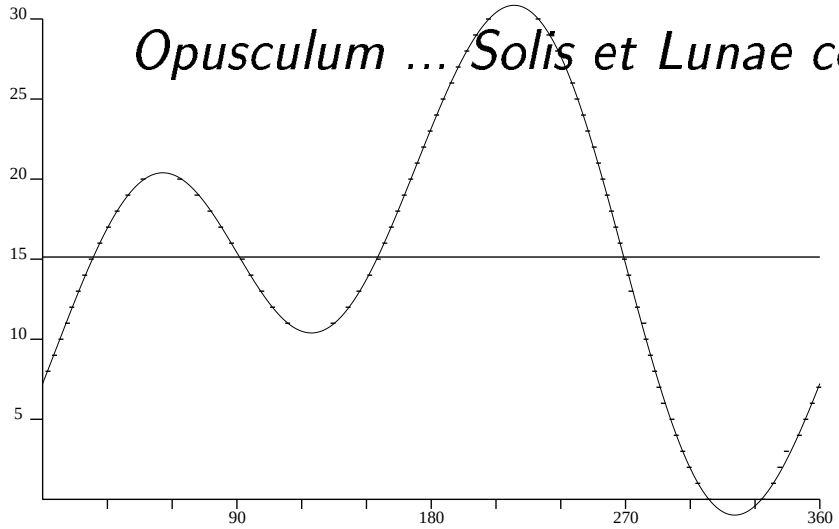
$$\Rightarrow \Delta = 14002''' - 1400''' = 12602''' = 3'30''2'''$$

alternativa násobením: $\Delta \simeq 6 * 2100''' = 12600''$

krok $N = 20$ let, diference $D = 42008'''$,
za l let přírůstek $\Delta = D * l/N = l * d$, kde $d \equiv D/N$

$\Delta = D * l/N = D * (1/k - (N - l * k)/N/k) = D/k - d * (N - l * k)/k$,
kde $k \equiv [N/l]$

Časová rovnice (Václav Faber z Budějovic)

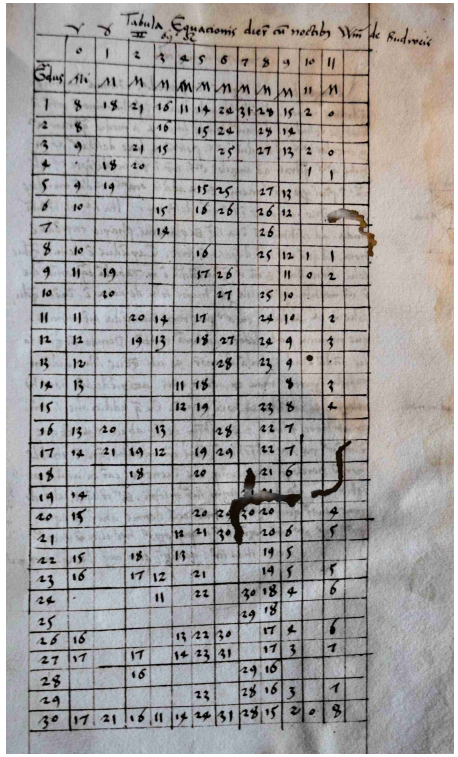


Opusculum ... Solis et Lunae coniunctionum..., 1494-5

DVT 50 (2017), 192

$$\tan\alpha = \cos\varepsilon \tan l$$

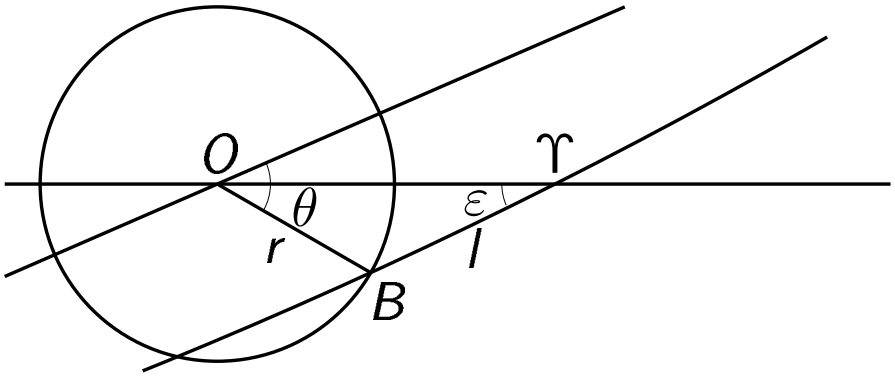
$$\tan(l - l_a) = \frac{\sin m}{\cos m + e}$$

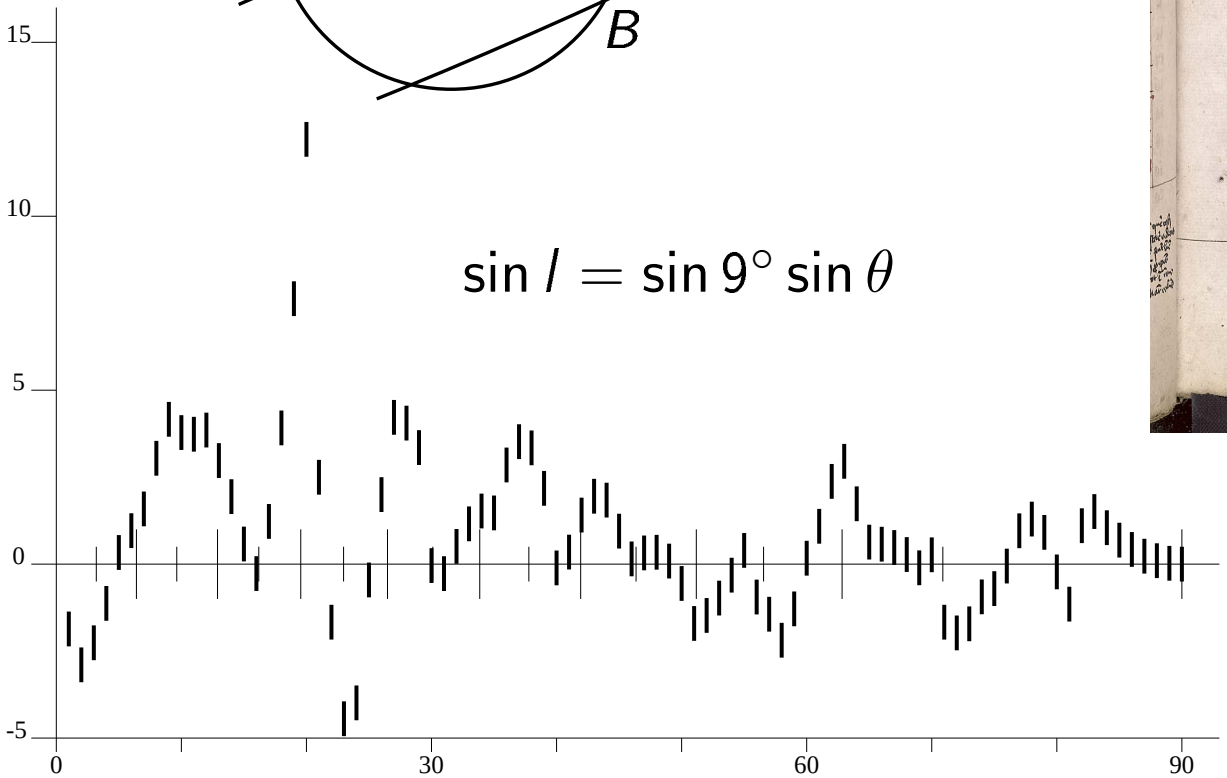


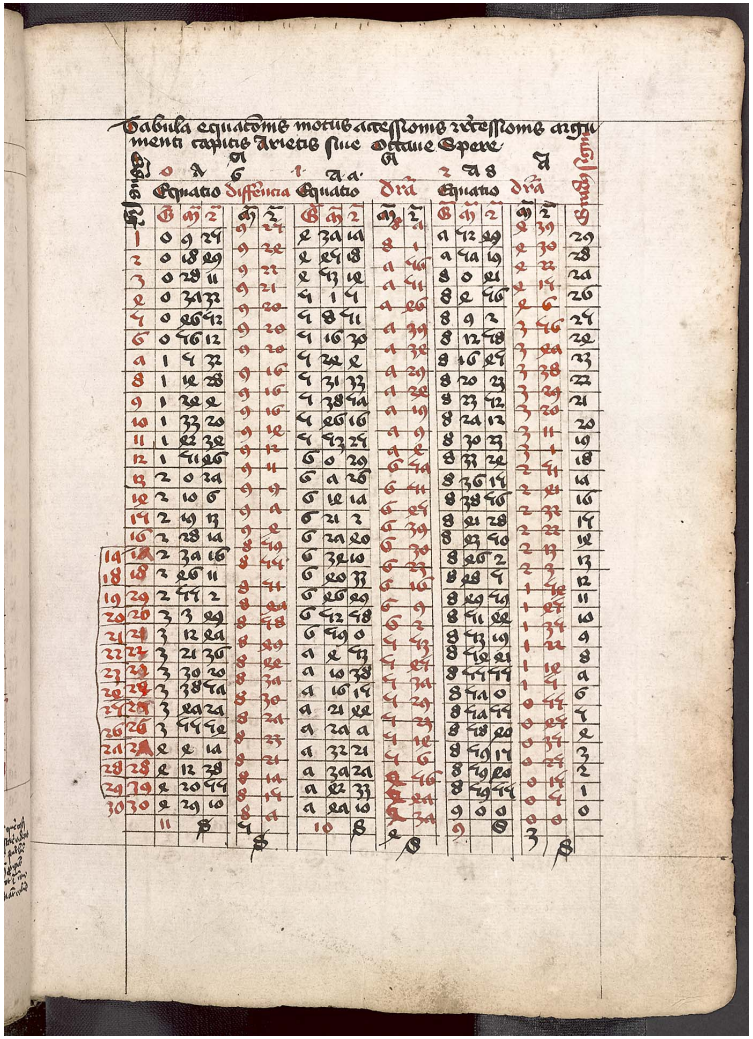
	Faber	tabula vetus	tabula moderna	Peuerbach	Handy tables	Toledské tabulky
	čas	úhel	čas	čas	čas	úhel
Δ_0	3.908°	4.014°	4.082°	4.099°	−3.428°	4.099°
l_0	−0.1997°	−0.2429°	0.0817°	0.0290°	0.0178°	−0.1486°
e	0.03480	0.03488	0.03785	0.03779	0.04164	0.03441
ε	23.642°	23.640°	23.597°	23.570°	23.712°	23.612°
l_a	87.734°	87.628°	90.635°	90.008°	66.088°	82.890°
error	0.0363°	0.0235°	0.0252°	0.0085°	0.0132°	0.0268°

Trepidace

NK XIV F 10, XIII C 17, I G 6, X A 3, X B 3
Ratdolt 1483, Santritter 1492







(Pseudo)Thabit's "De motu octave spere"

Thabit ibn Qurra, ∼830-901

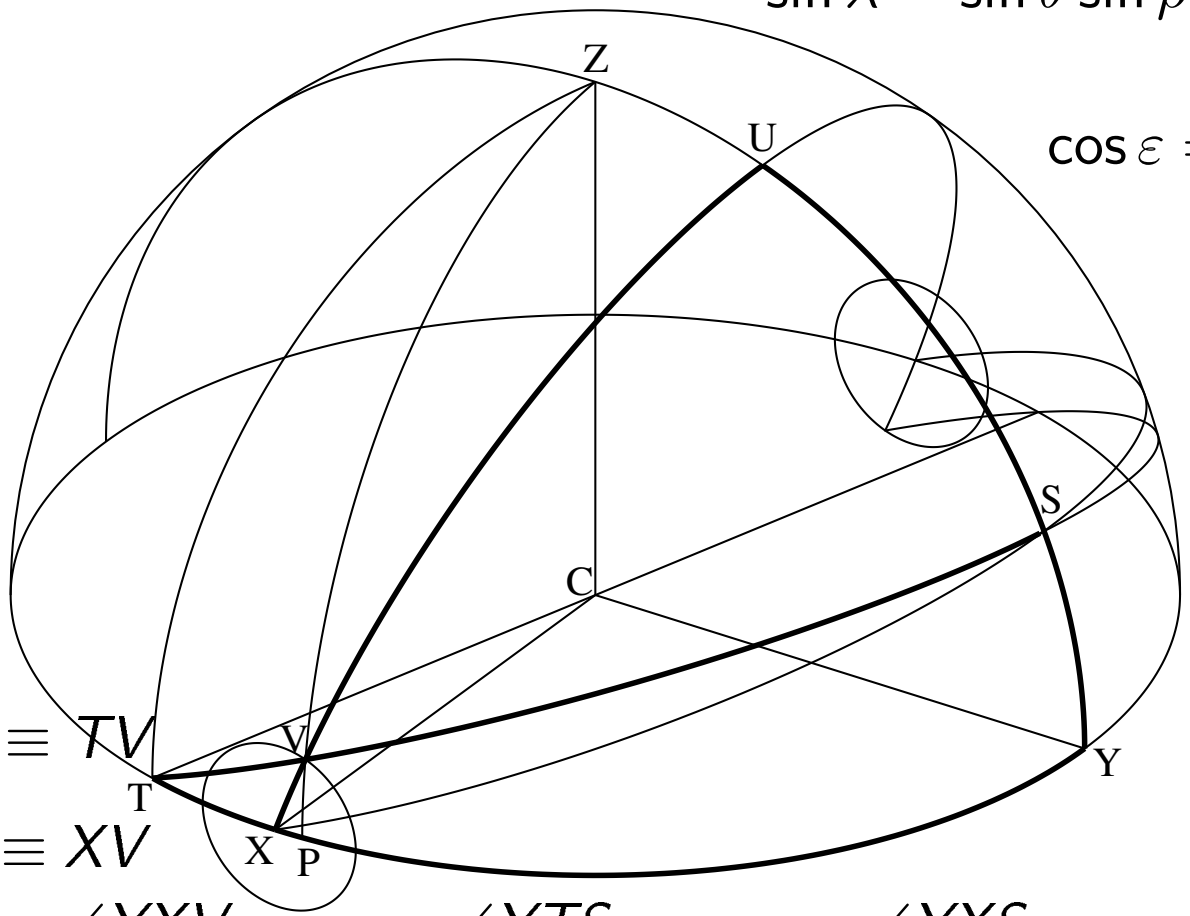
Gerard of Cremona, 1114-1187

$$\sin\lambda = \sin\theta \sin\rho \left\{ \frac{1+\tan^2\rho\sin^2(\theta-\varepsilon_0)}{\sin^2\varepsilon_0+\tan^2\rho\sin^2(\theta-\varepsilon_0)} \right\}^{1/2}$$

$$\cos\varepsilon = \frac{\cos\varepsilon_0}{[1+\tan^2\rho\sin^2(\theta-\varepsilon_0)]^{1/2}}$$

R. Mercier (1976-1977)

$$\lambda \simeq \lambda_{max}\sin\theta$$



$\lambda \equiv TV$

$\rho \equiv XV$

$\theta \equiv \angle YXV$ $\varepsilon \equiv \angle YTS$ $\varepsilon_0 \equiv \angle YXS$

Menelaos $\triangle UXY \times TVS$: $\quad \mathrm{tg}\alpha = \mathrm{tg}\rho \frac{\sin(\theta - \varepsilon_0)}{\sin \varepsilon_0}$

Cosine $\triangle TVX$: $\quad \cos\lambda = \cos\alpha \cos\rho - \sin\alpha \sin\rho \cos\theta$

Sine $\triangle TVX$: $\sin\varepsilon = \sin\rho \frac{\sin\theta}{\sin\lambda}$

Sine $\triangle XPV$, $\triangle TPV$:

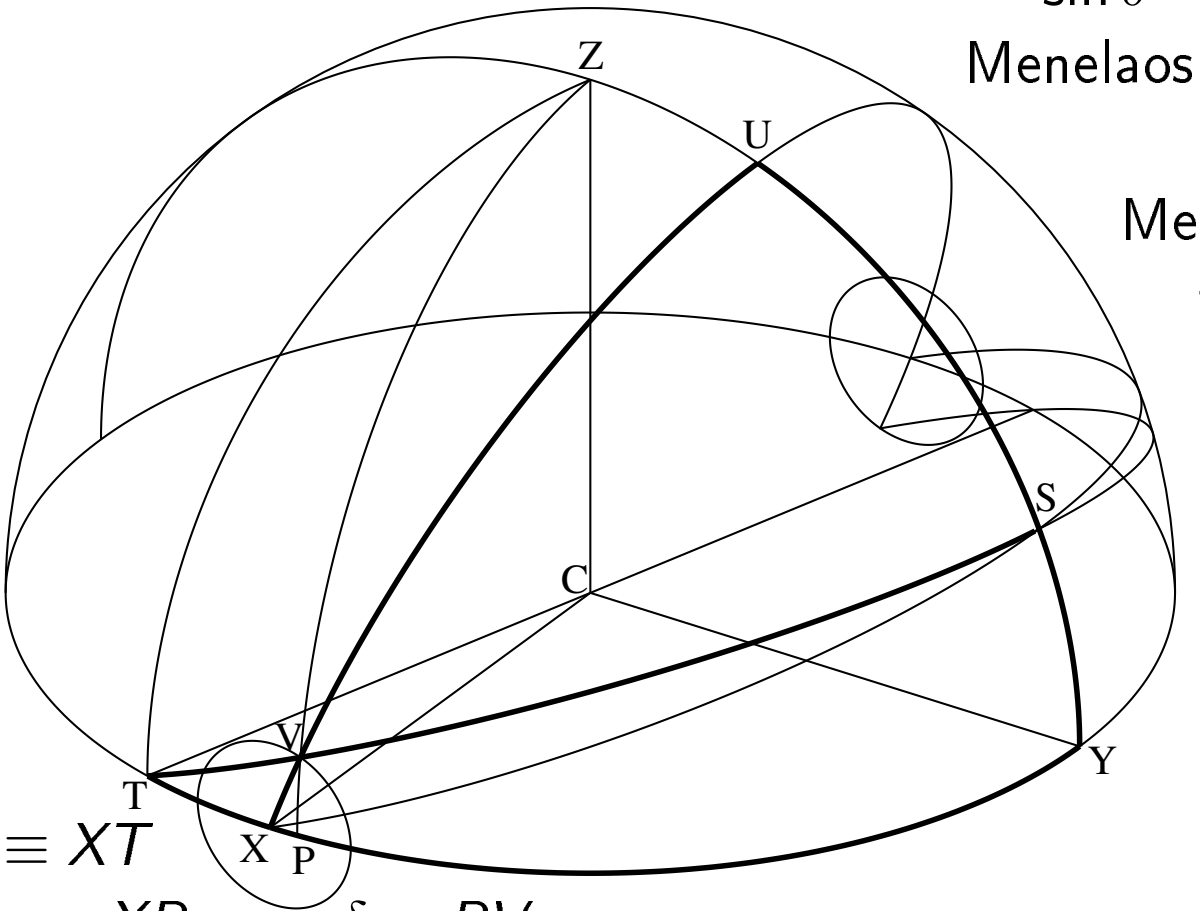
$$\sin\delta = \sin\theta \sin\rho = \sin\varepsilon \sin\lambda$$

Menelaos $\triangle PYZ \times XVU$:

$$\sin\alpha_V = \frac{\tan\delta}{\tan\theta}$$

Menelaos $\triangle PYZ \times TVS$:

$$\tan\varepsilon = \frac{\tan\delta}{\sin(\alpha + \alpha_V)}$$



Sine $\triangle TVZ$:

$$\sin\lambda = \sin(\alpha + \alpha_V) \frac{\cos\delta}{\cos\varepsilon}$$

$\alpha \equiv XT$

$\alpha_V \equiv XP$ $\qquad \delta \equiv PV$