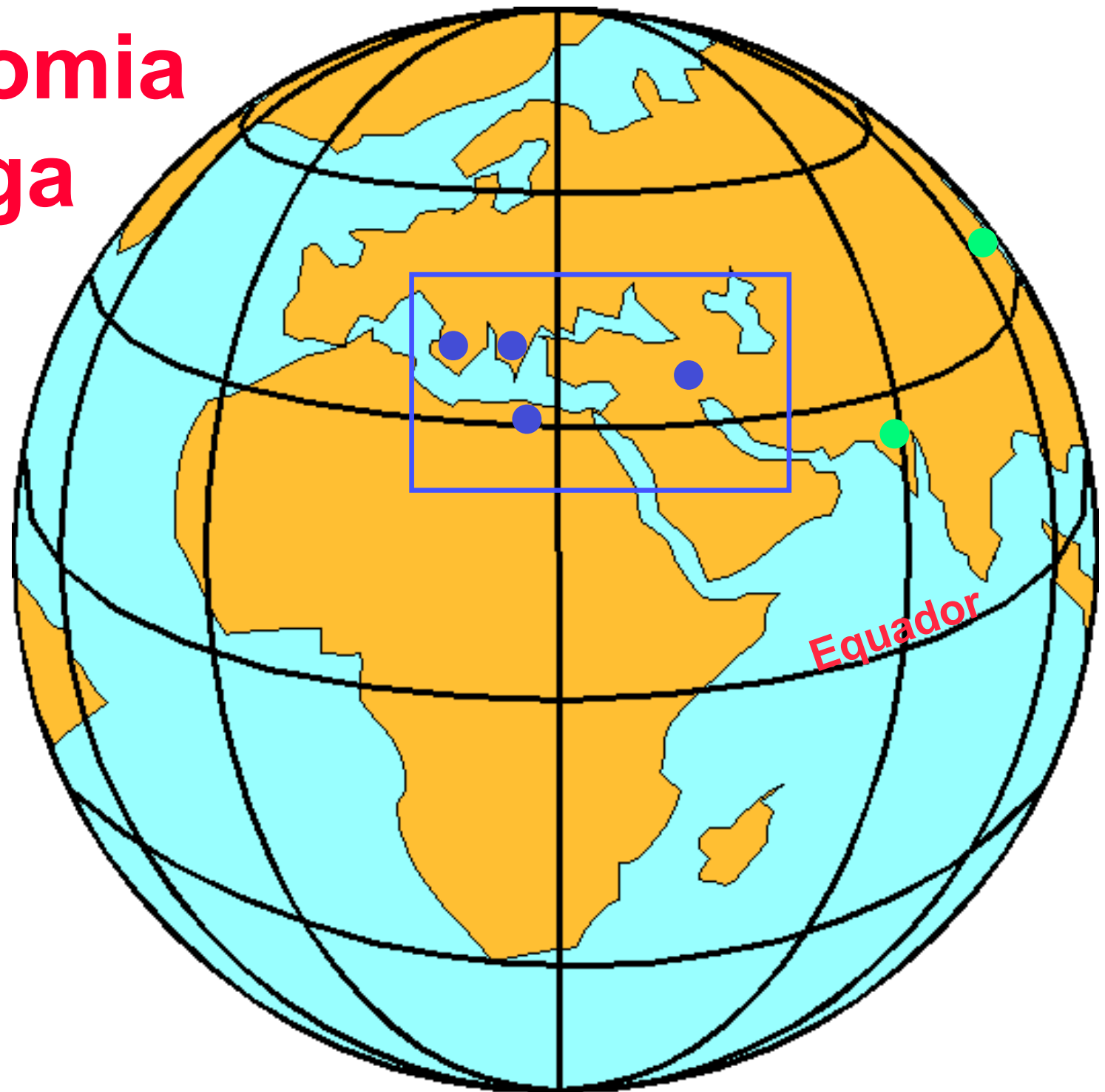


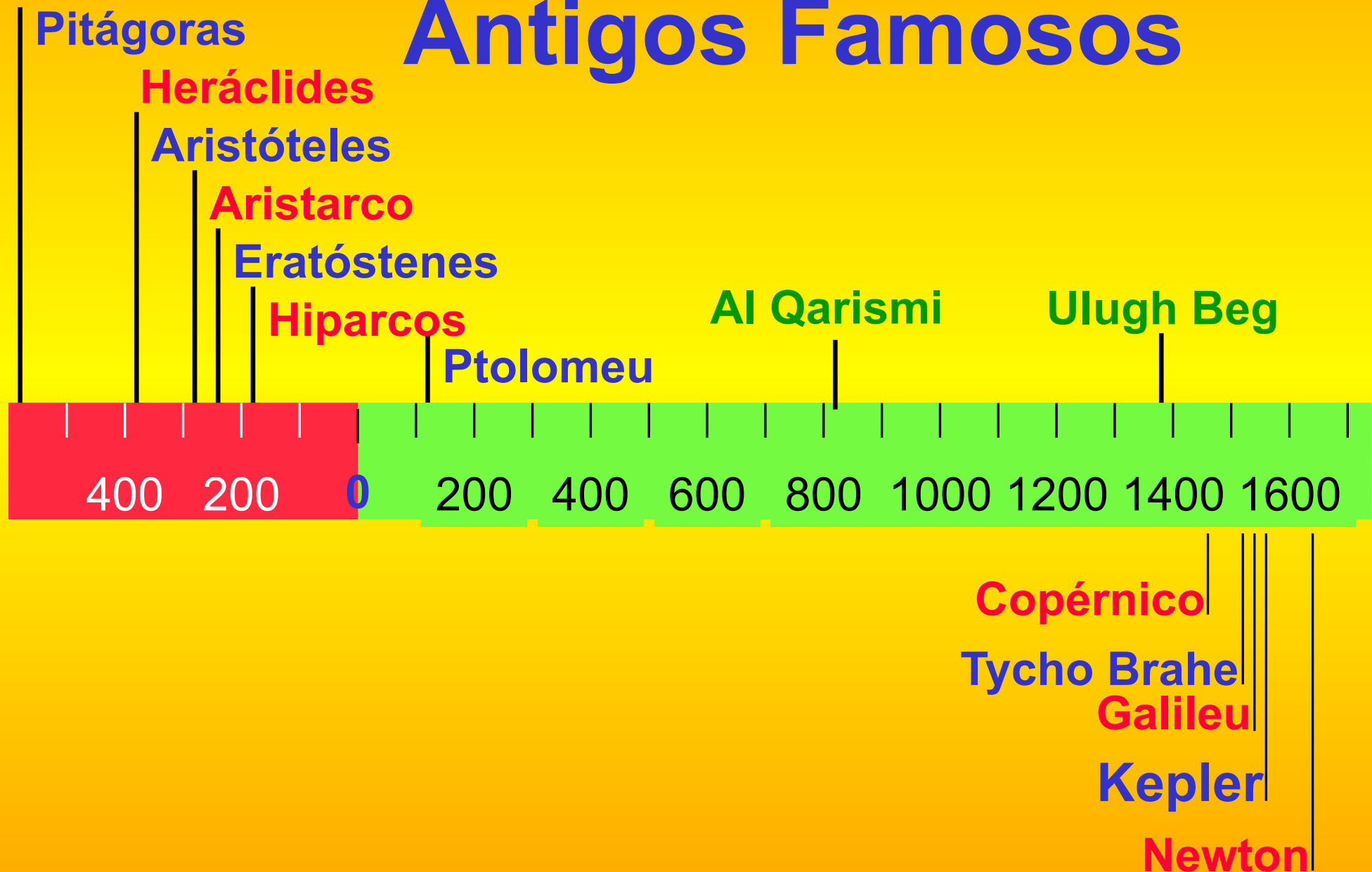
Início da Astronomia: História e Métodos

R. Boczko
(mod. R. Costa)
IAG-USP

Astronomia Antiga

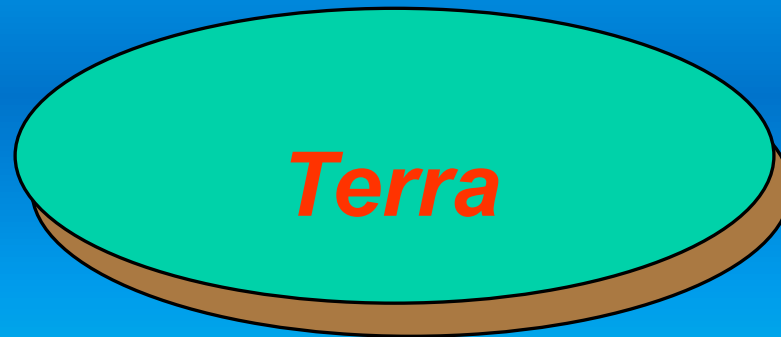


Filósofos e Astrônomos Antigos Famosos



Tales

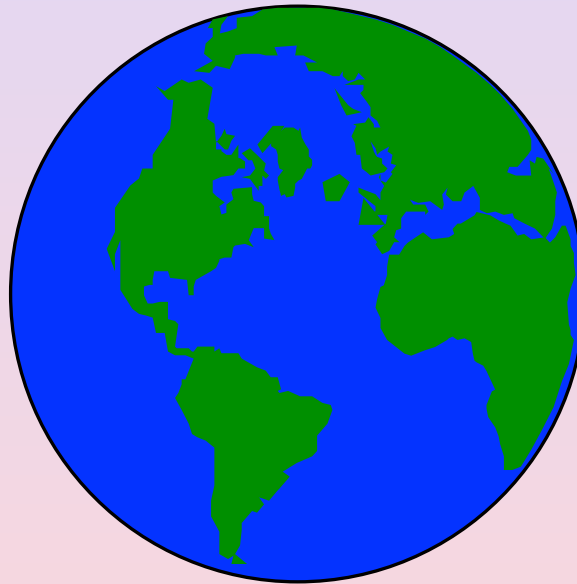
(Grego, séc. VI a.C.)



A Terra é um disco chato num
Universo infinito de água

Pitágoras

(Grego, séc. VI a.C.)

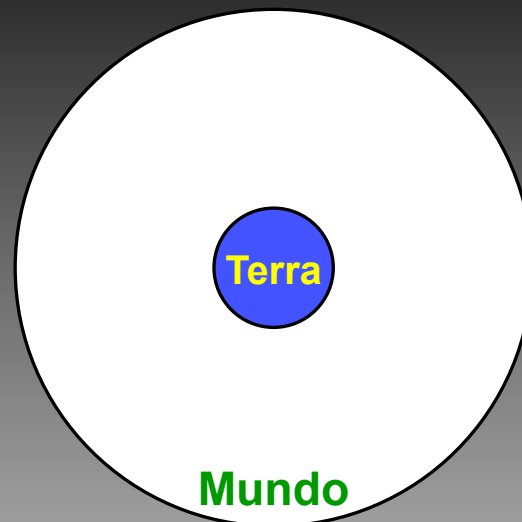


Propôs de que a Terra fosse esférica

Aristóteles

(Grego, séc. IV a.C.)

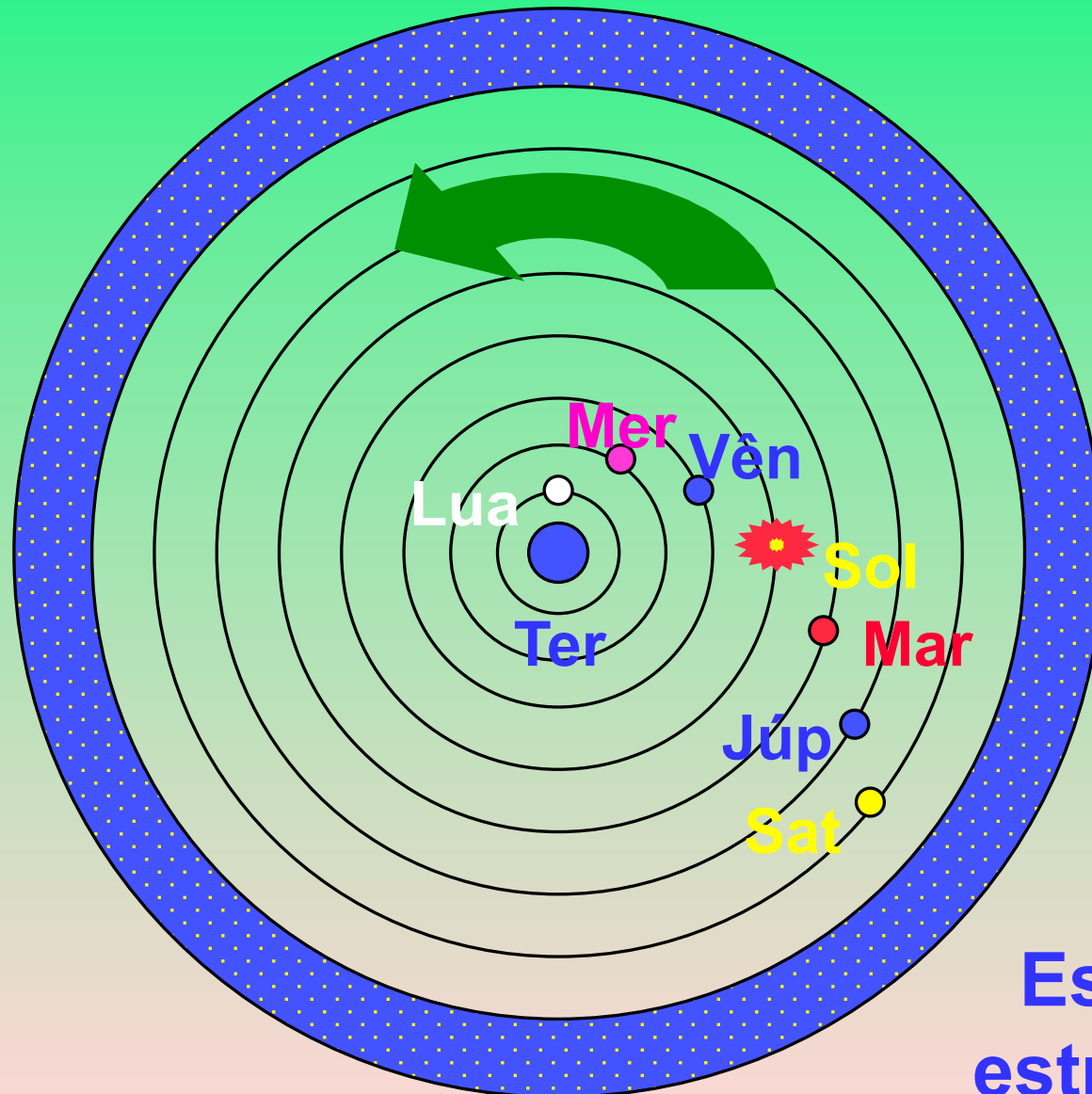
**Geocentrismo por
convicção filosófica!**



[illegible]

Sistema Geocêntrico

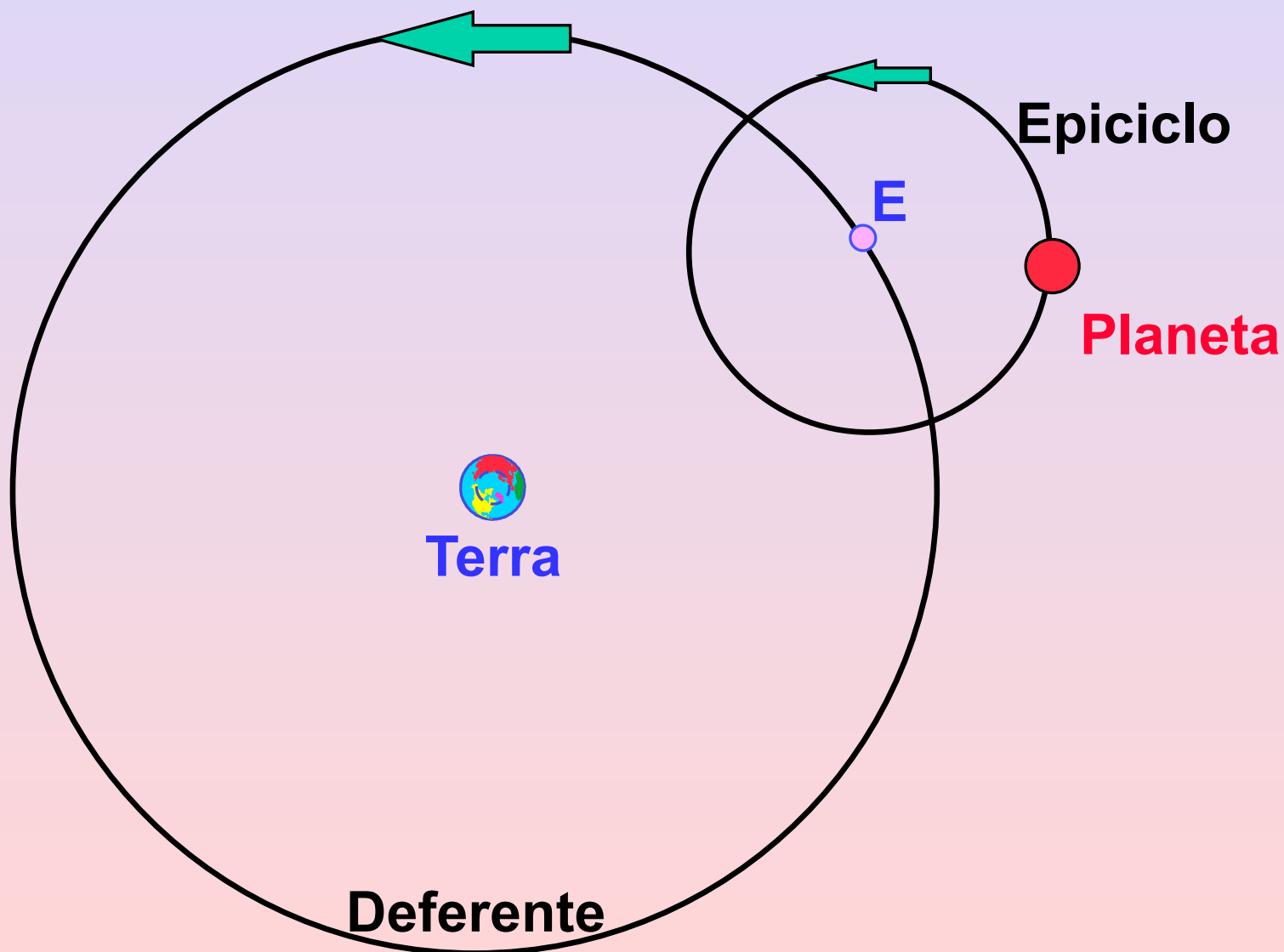
(Grego, Ptolomeu, séc. II)



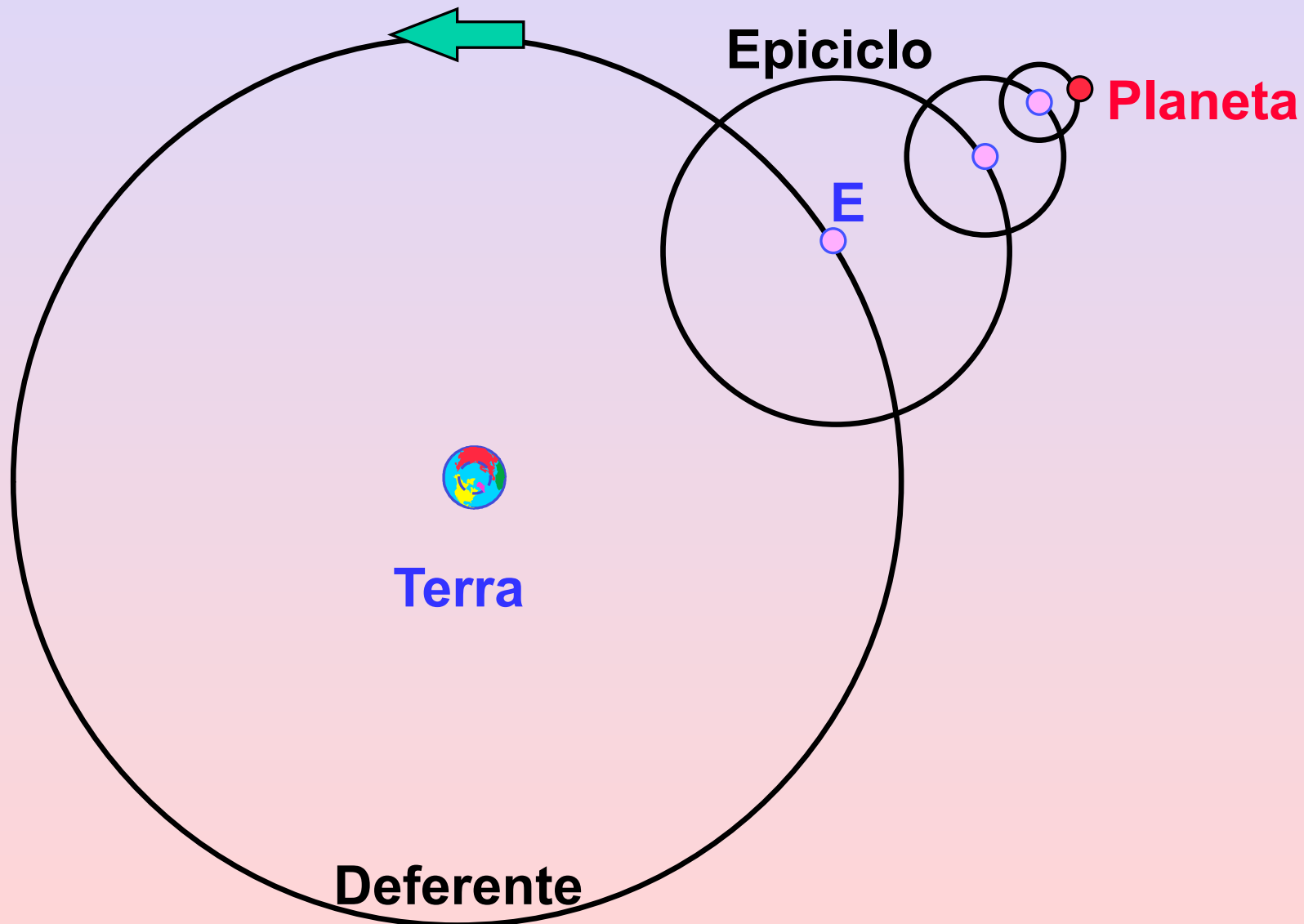
Esfera das
estrelas fixas

Sistema de Epiciclos

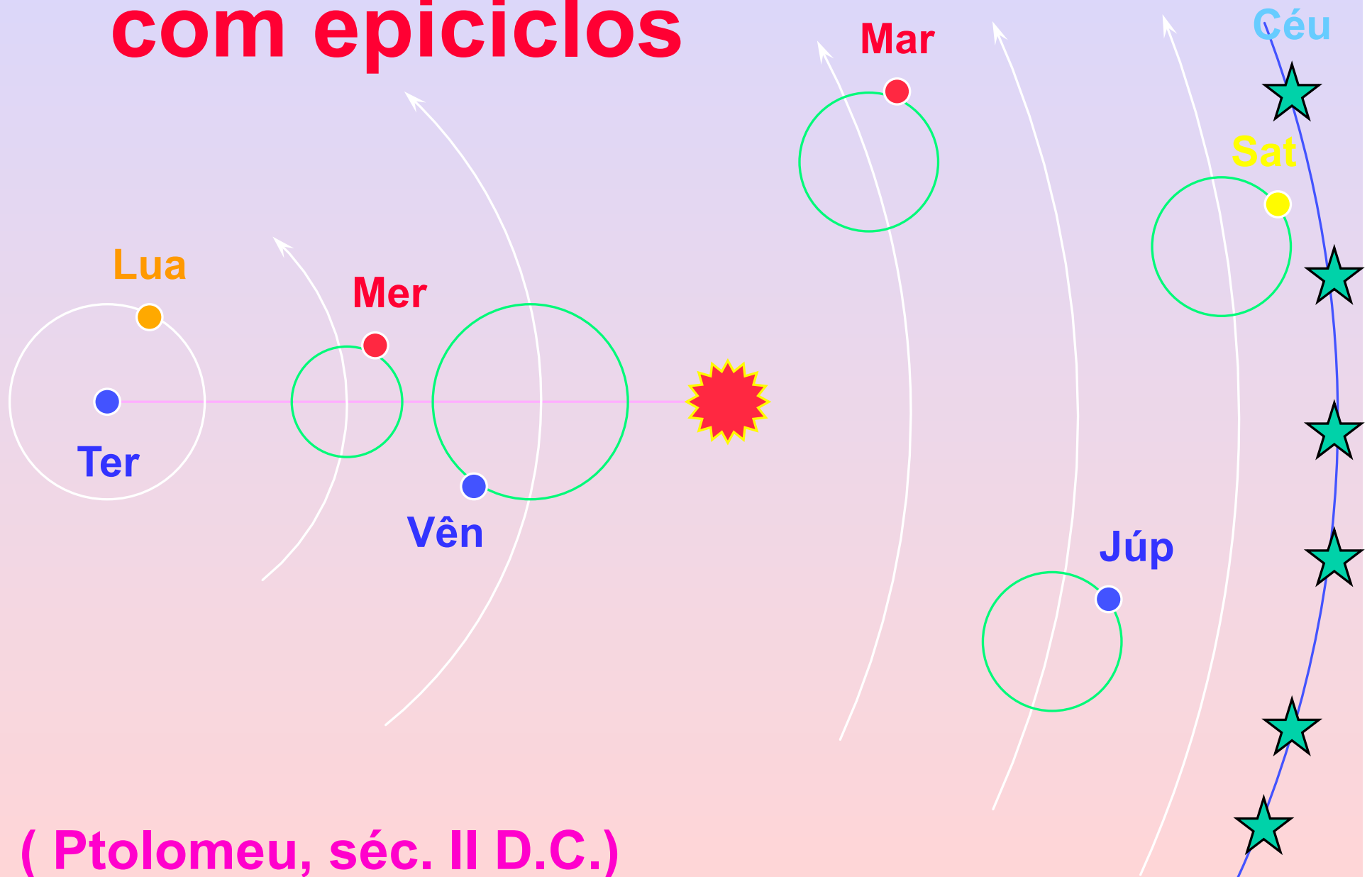
(Apolônio de Perga, 261 a.C. – 190 a.C.)



Sistema Complexo de Epiciclos



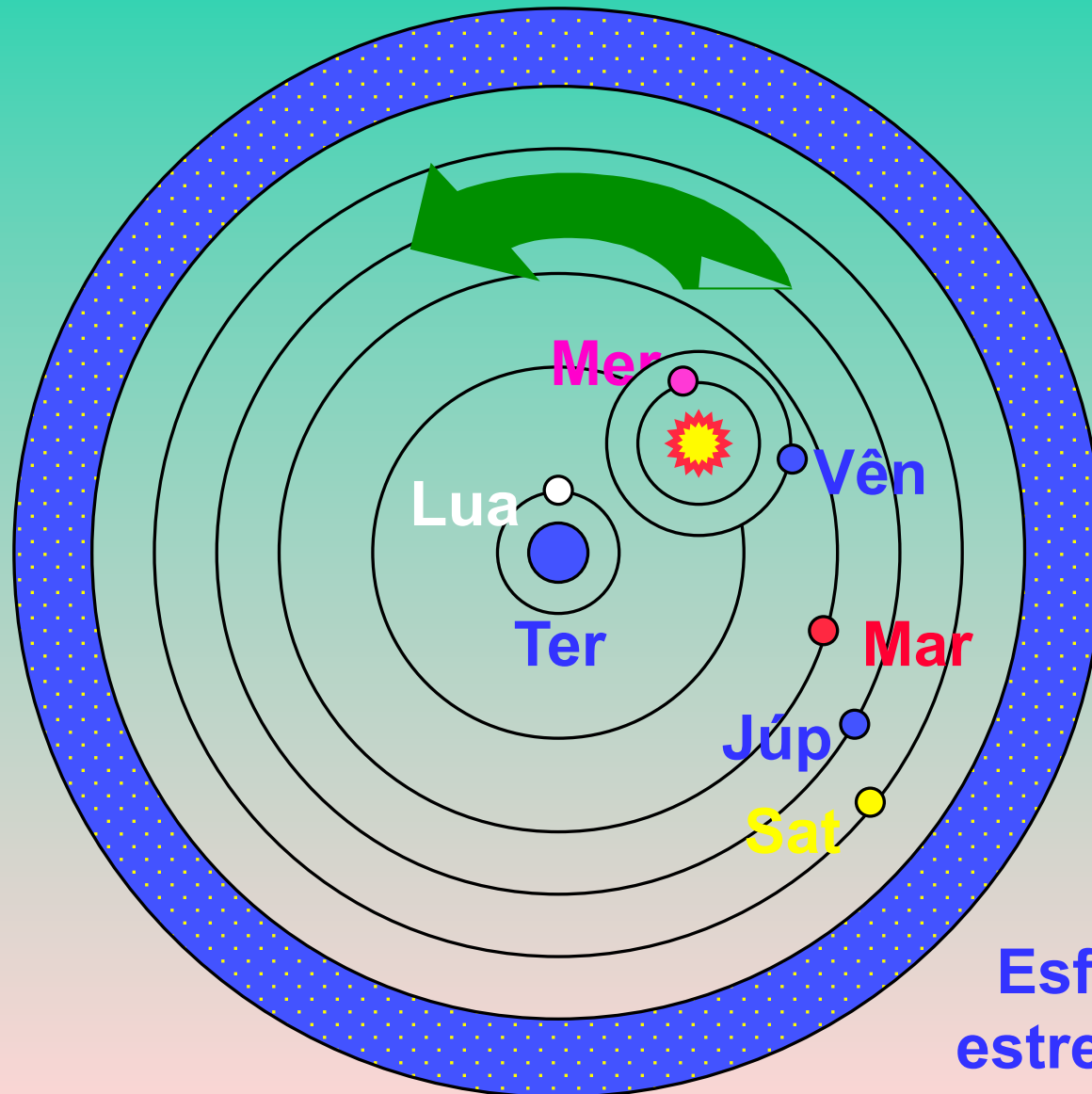
Geocentrismo com epiciclos



(Ptolomeu, séc. II D.C.)

Sistema Híbrido

(Heráclides, séc. IV a .C.)



Esfera das
estrelas fixas

Instrumentos Astronômicos Antigos

Sol



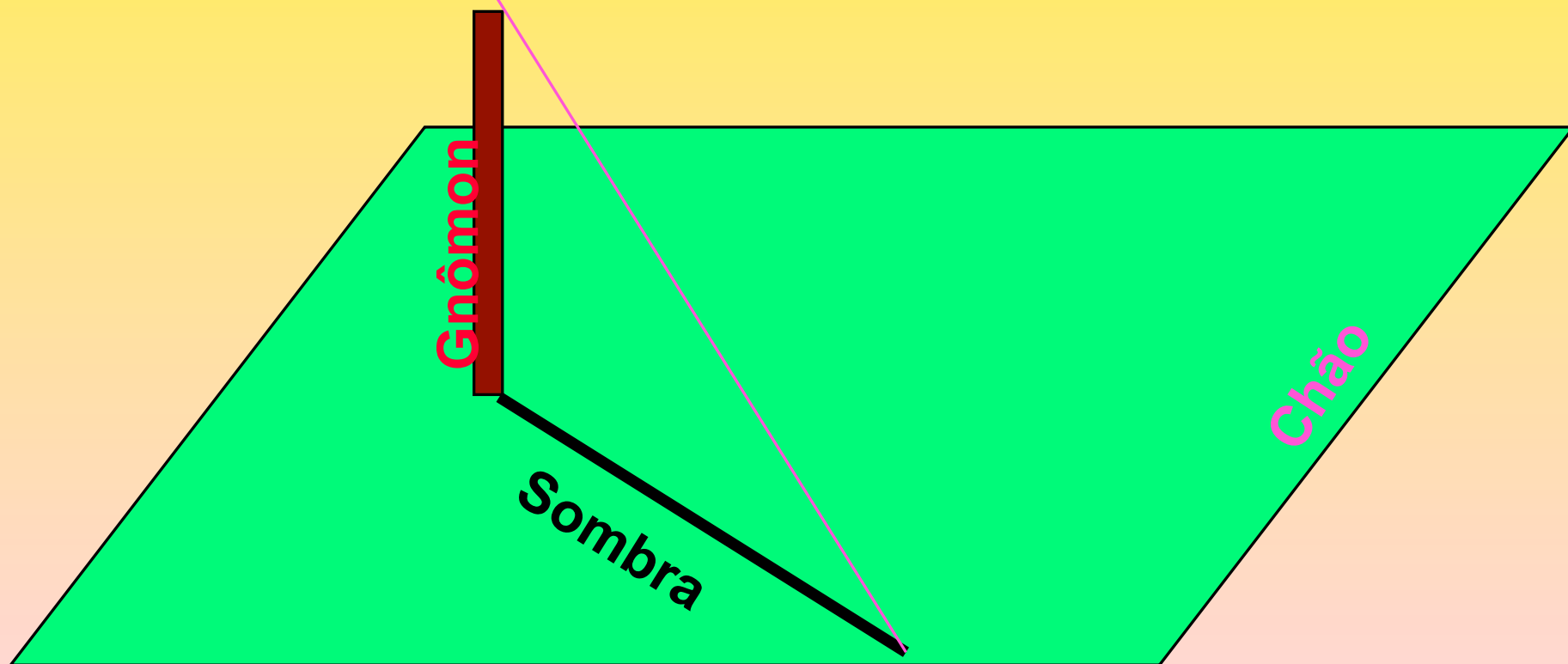
Gnômon

(Relógio de Sol)

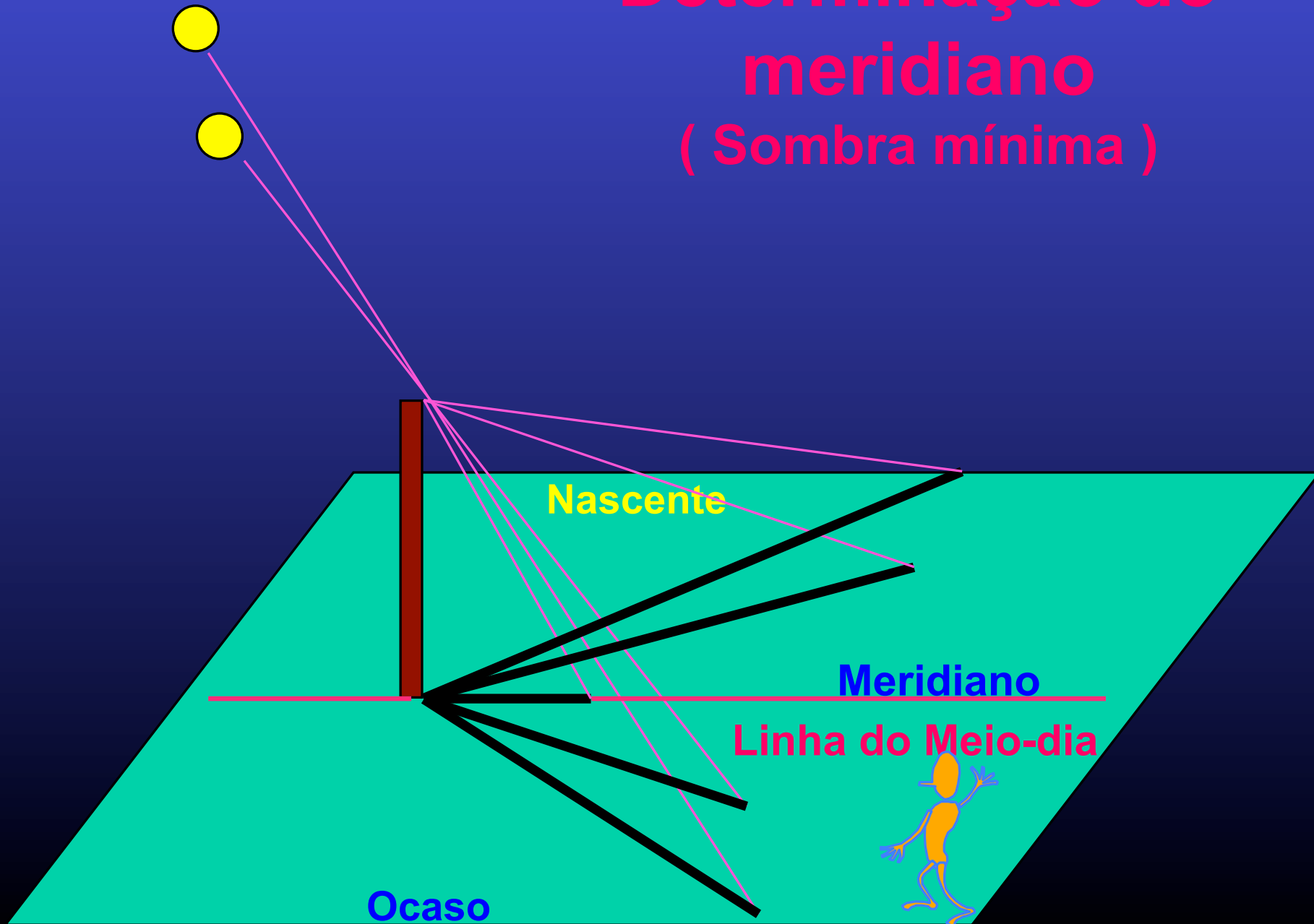
Gnômon

Chão

Sombra

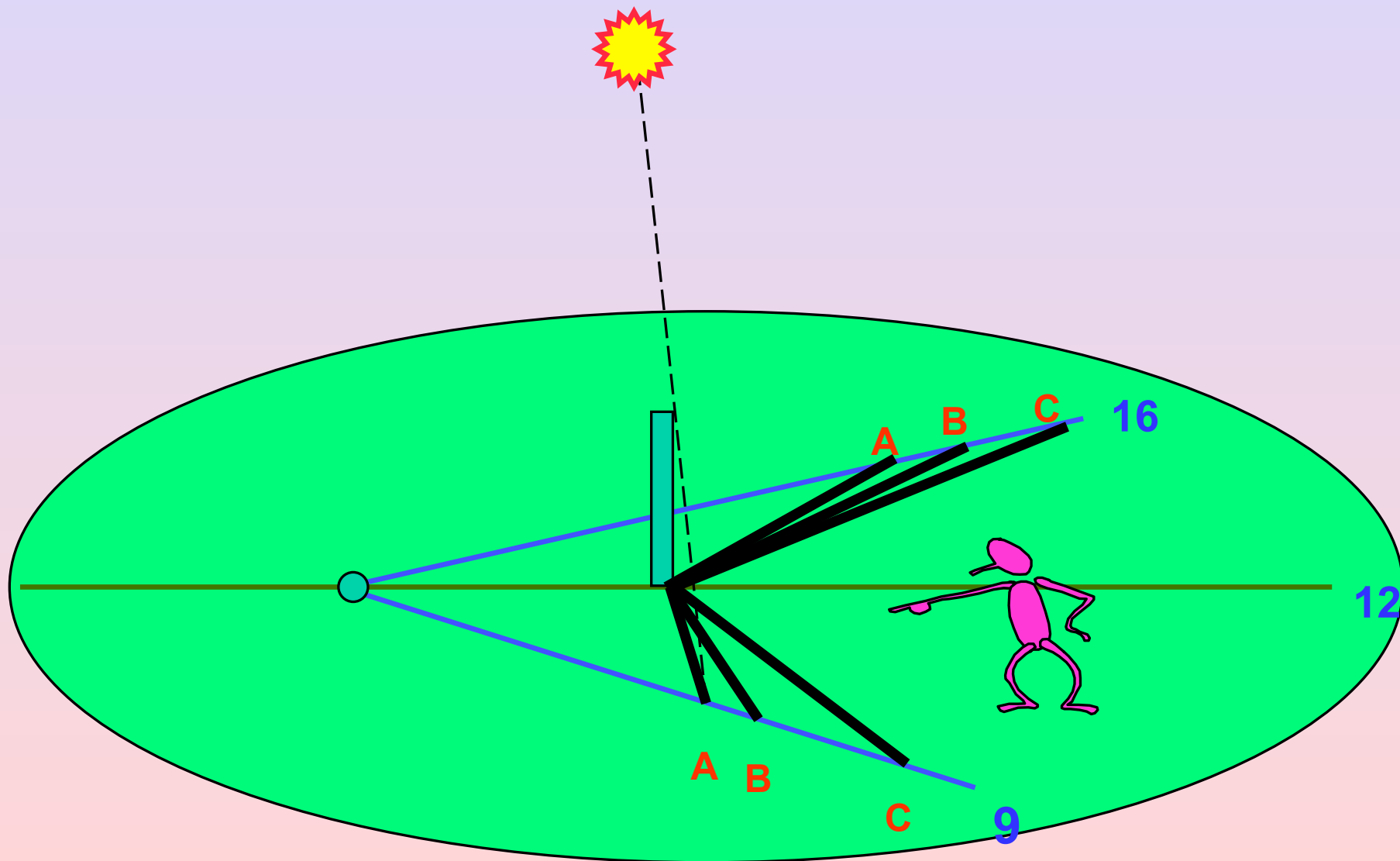


Determinação do meridiano (Sombra mínima)

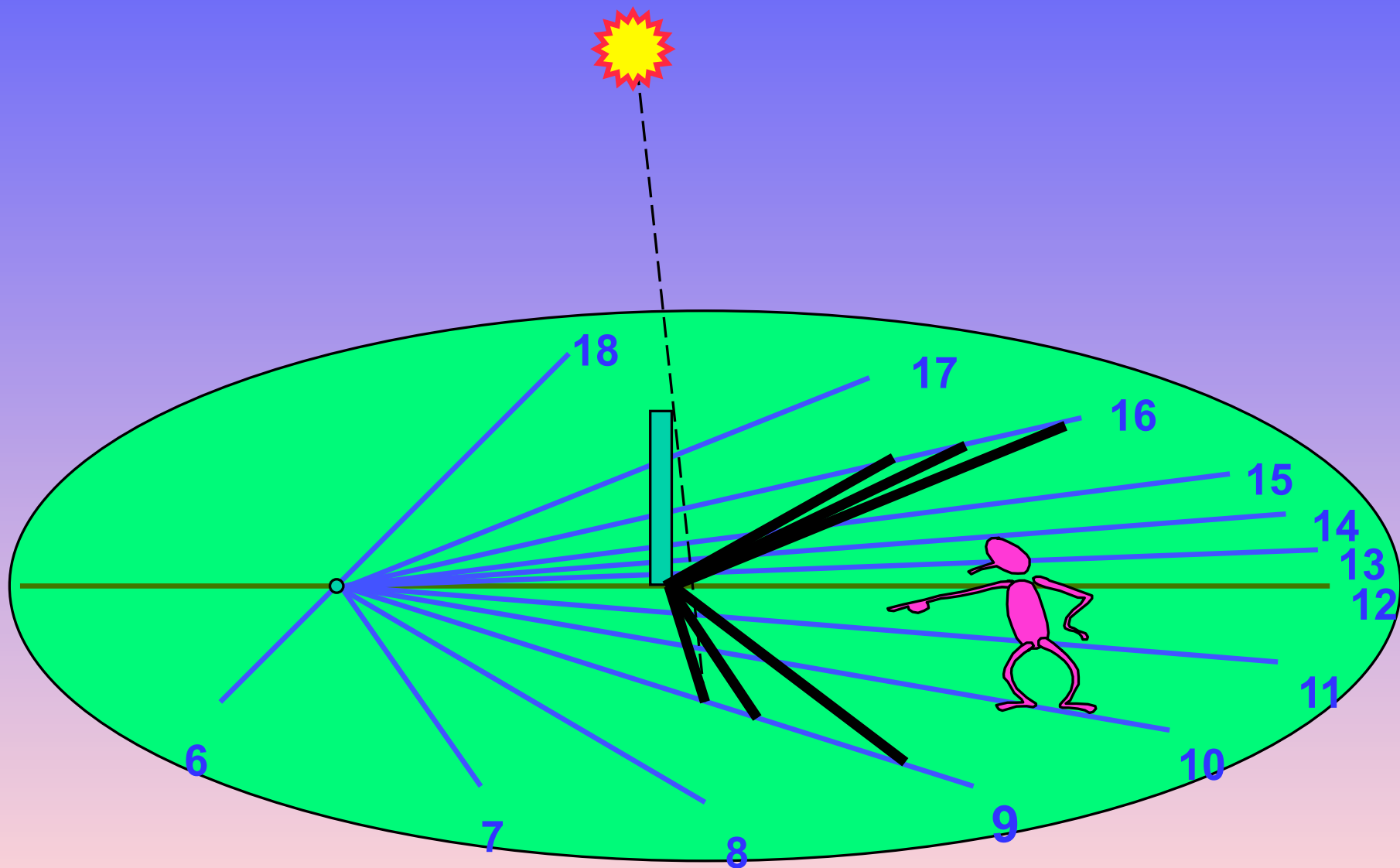


Relógios de Sol

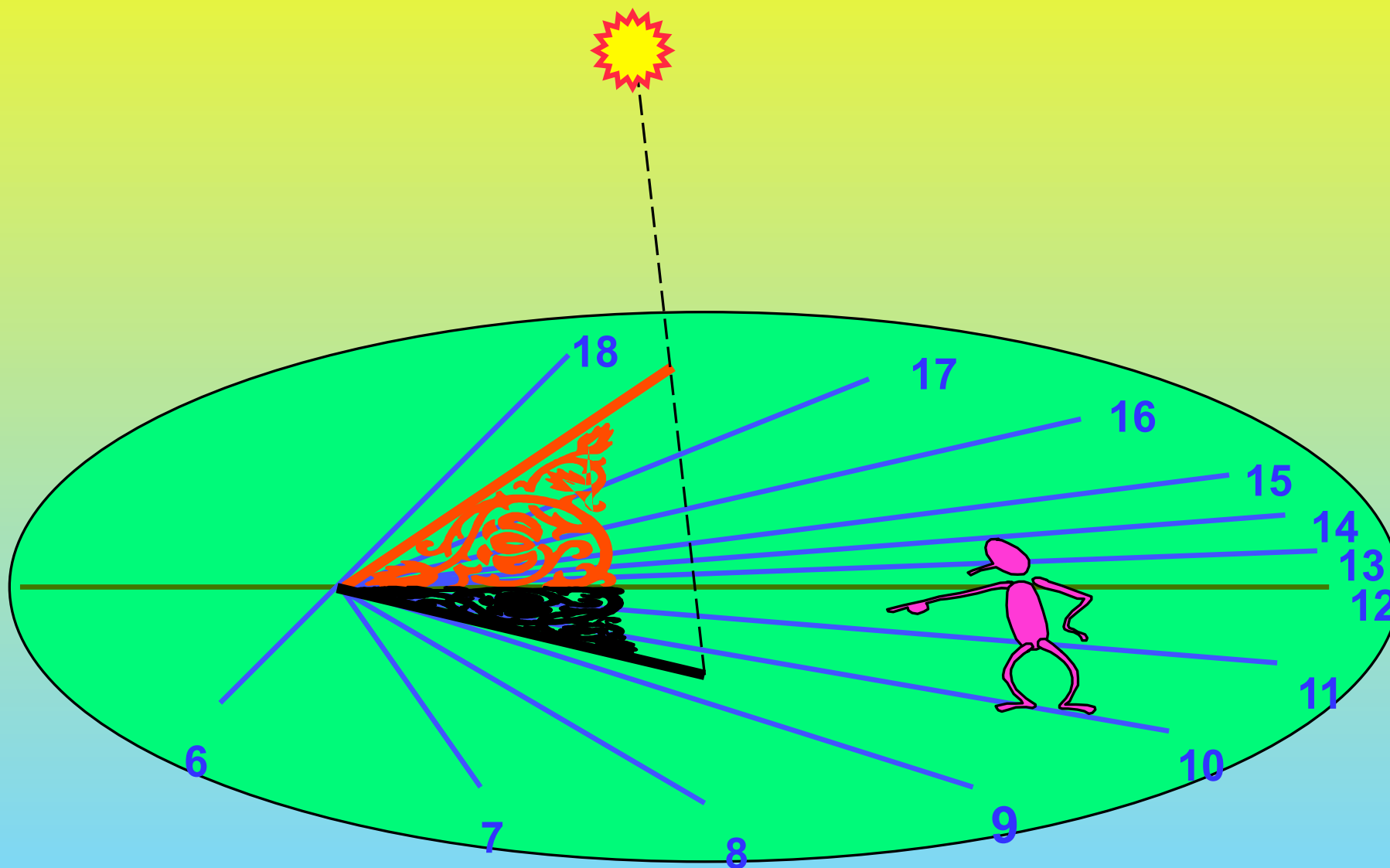
Fundamentos do Gnômon com mostrador horizontal



Gnômon com mostrador horizontal

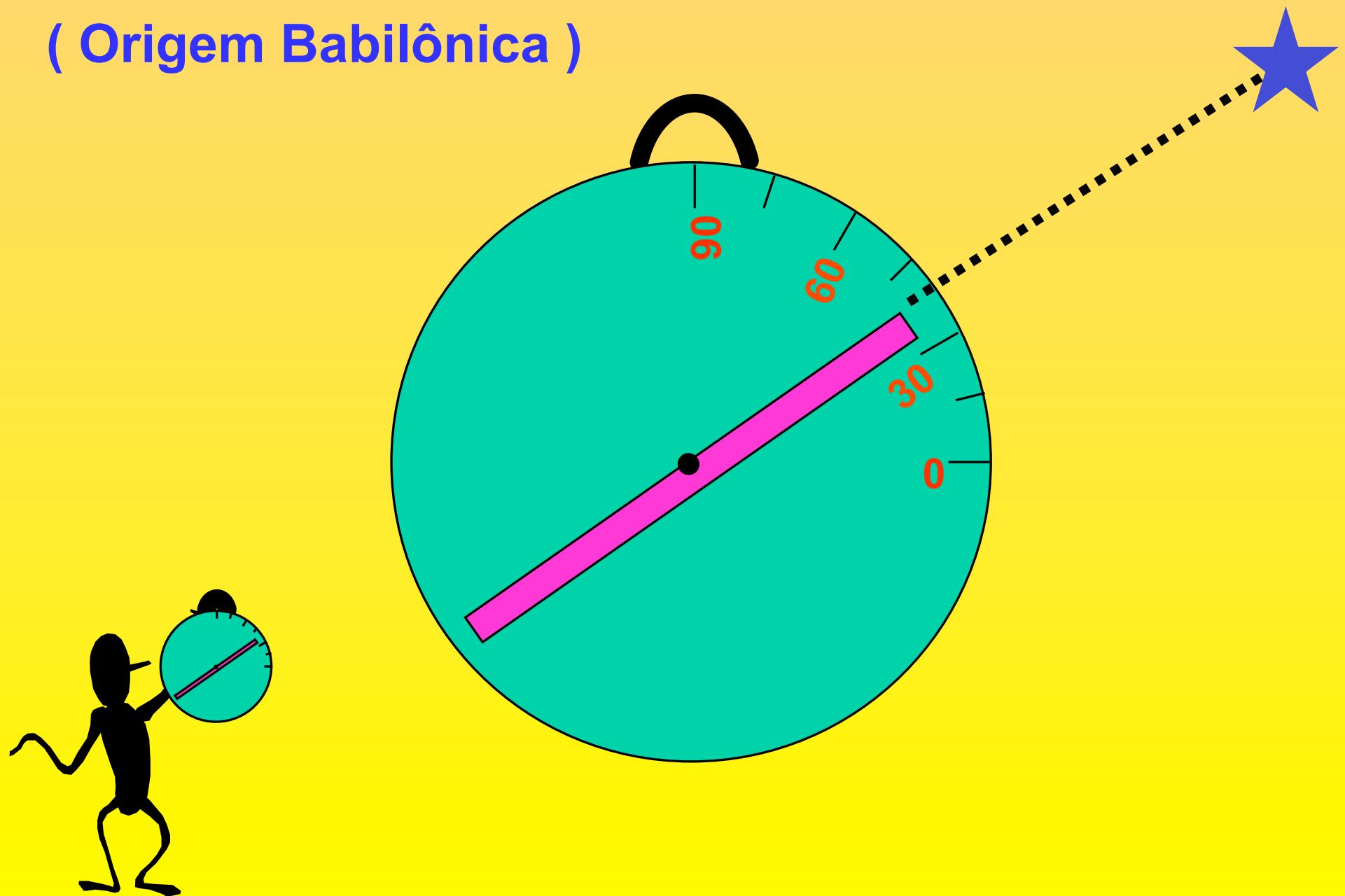


Gnômon com mostrador horizontal e haste artística



Astrolábio

(Origem Babilônica)





Astrolábio astronômico

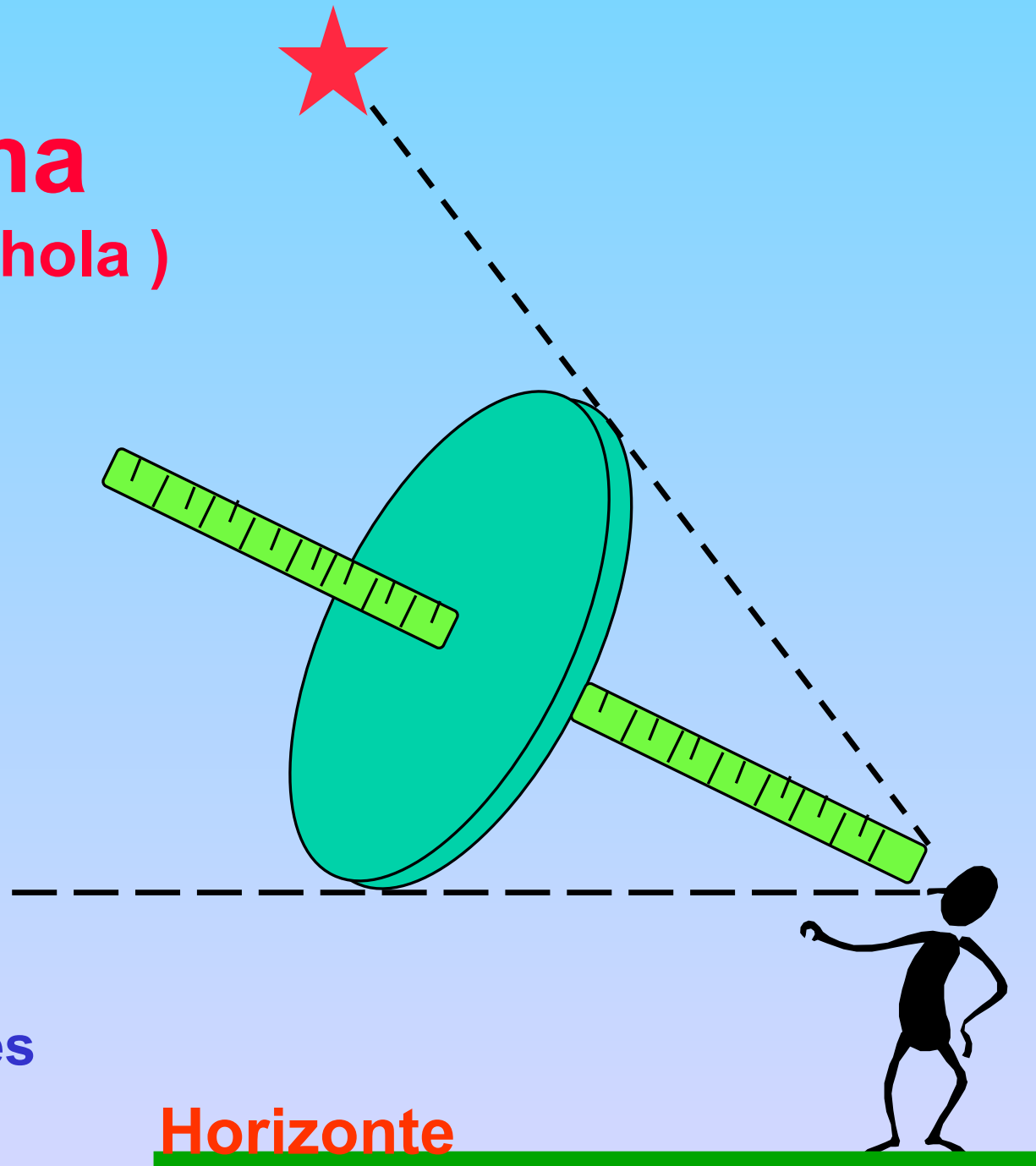


Astrolábio de marinheiro



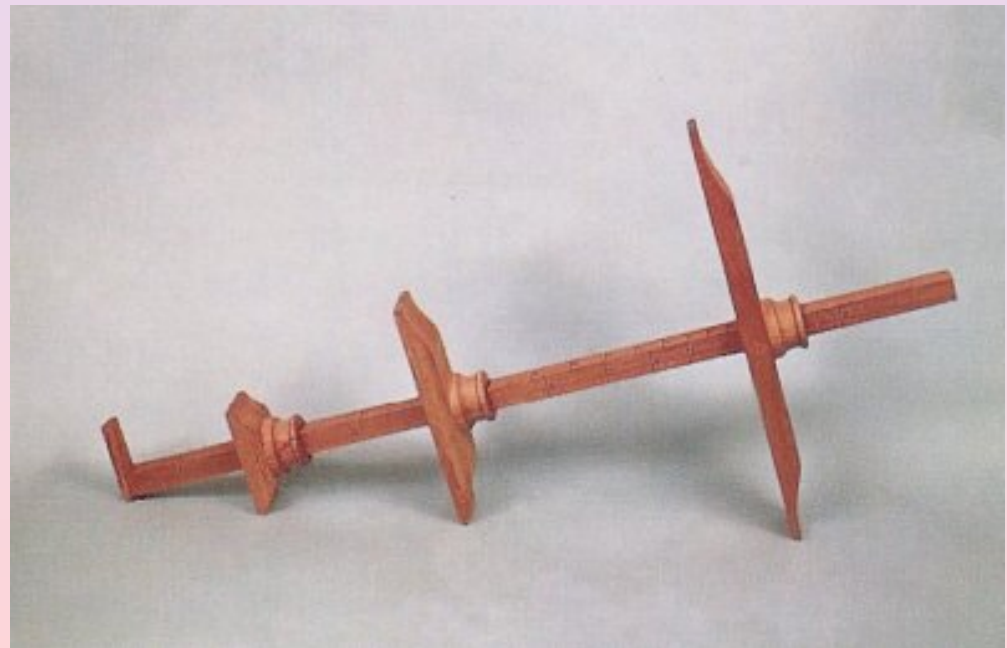
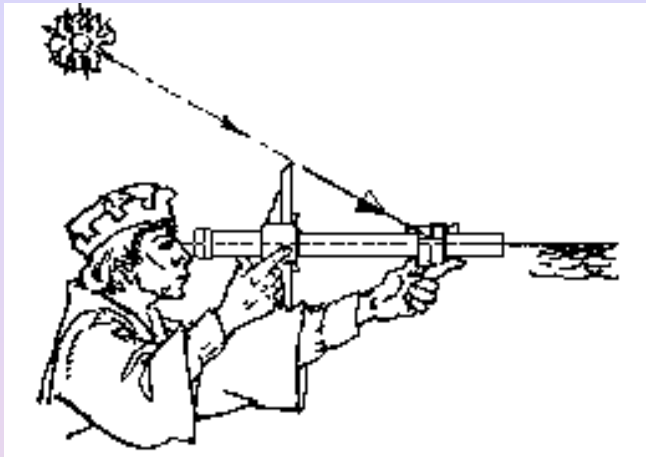
Balestilha

(Origem espanhola)

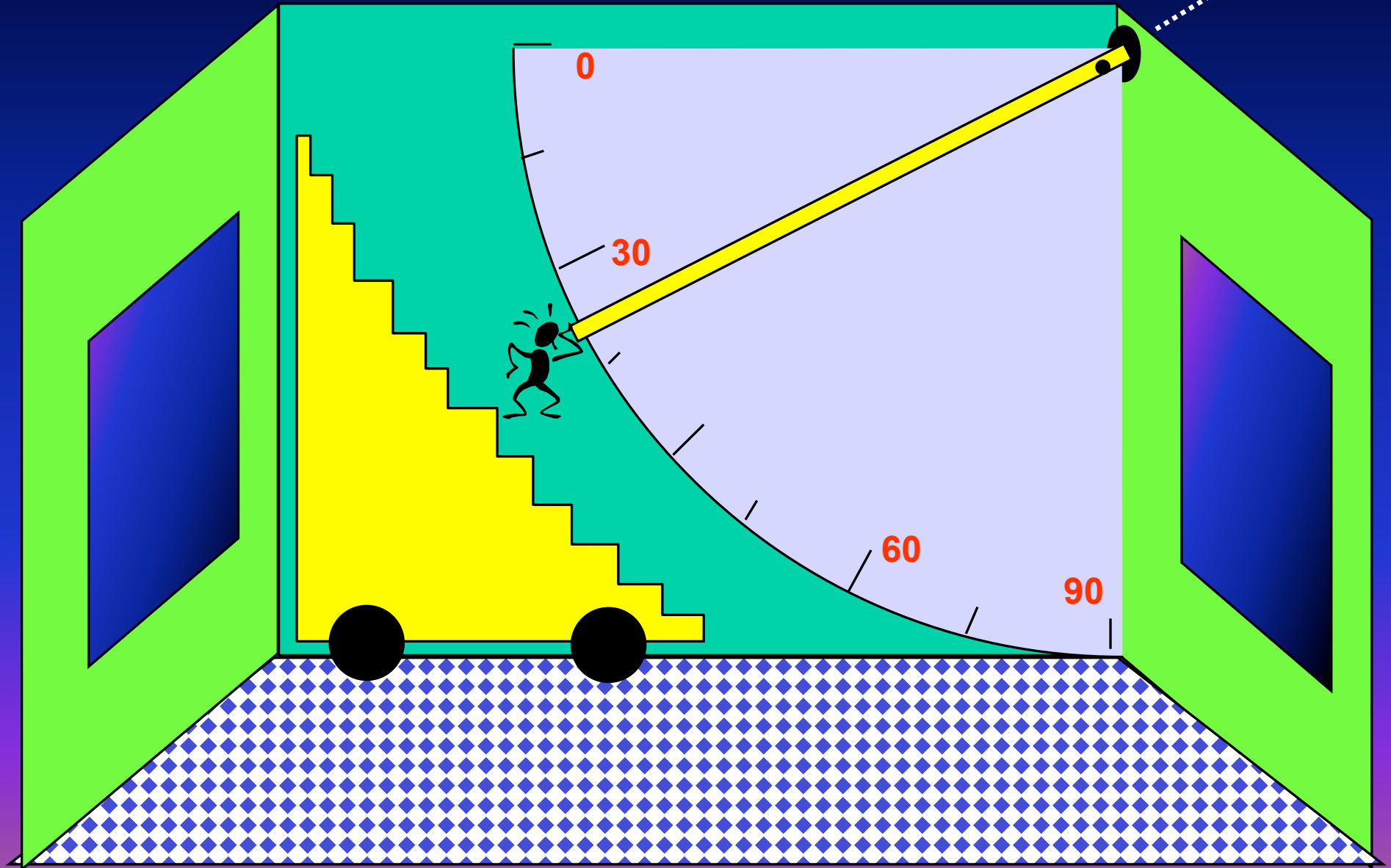


Usado pelo
Fernão de Magalhães

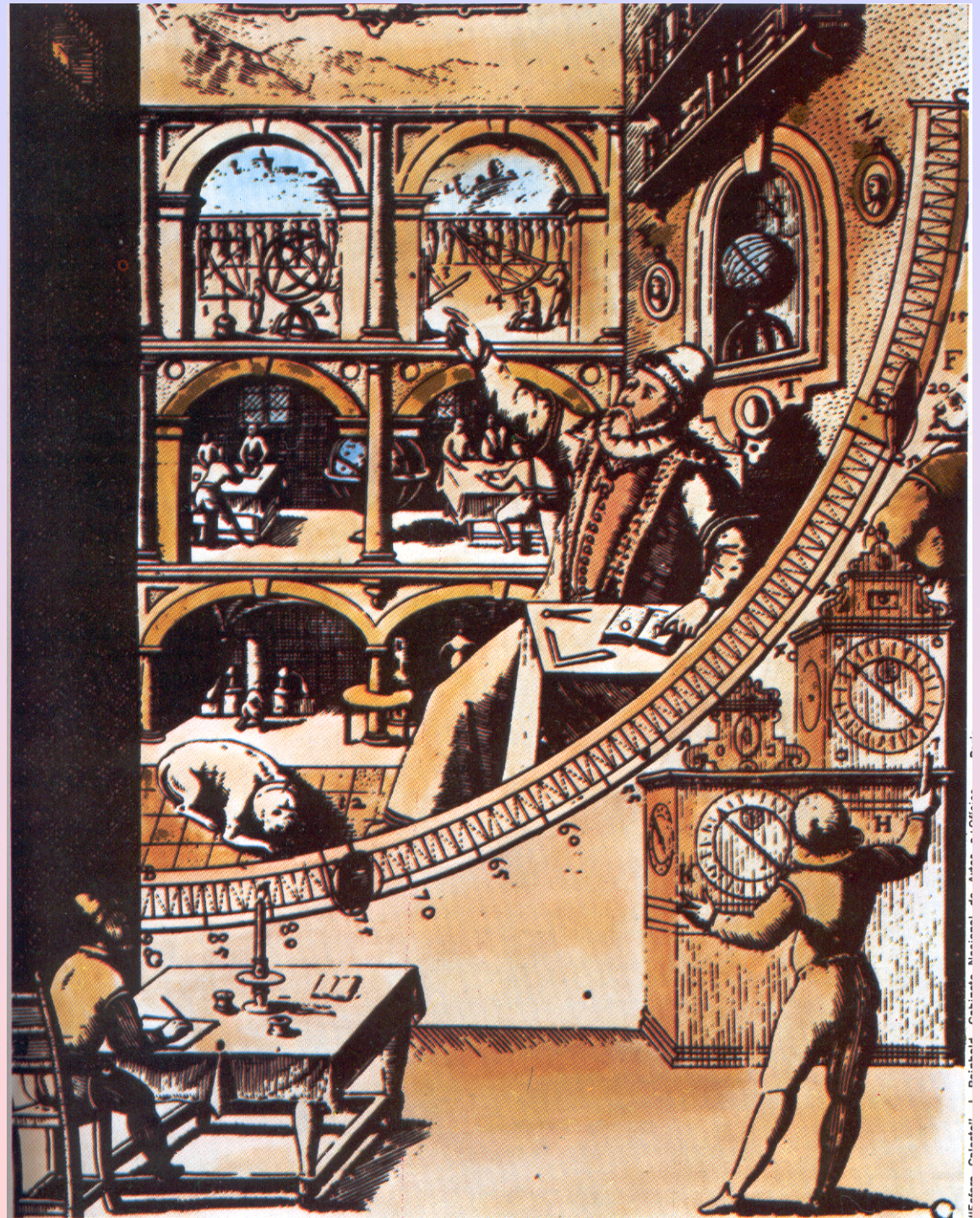
Horizonte



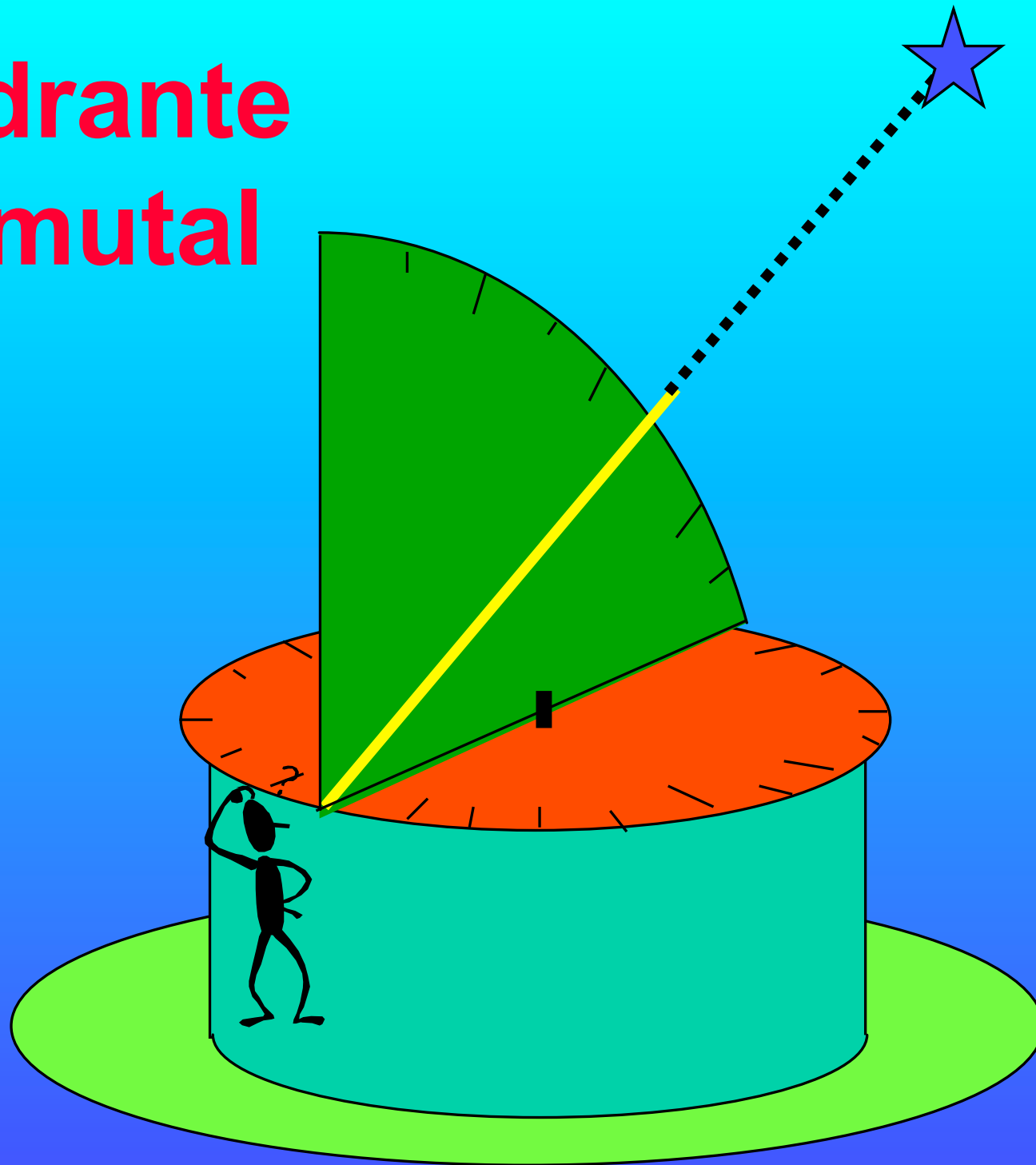
Quadrante Mural



Quadrante
mural do
Observatório
de
Tycho Brahe
da
Ilha de Ven
(Dinamarca)

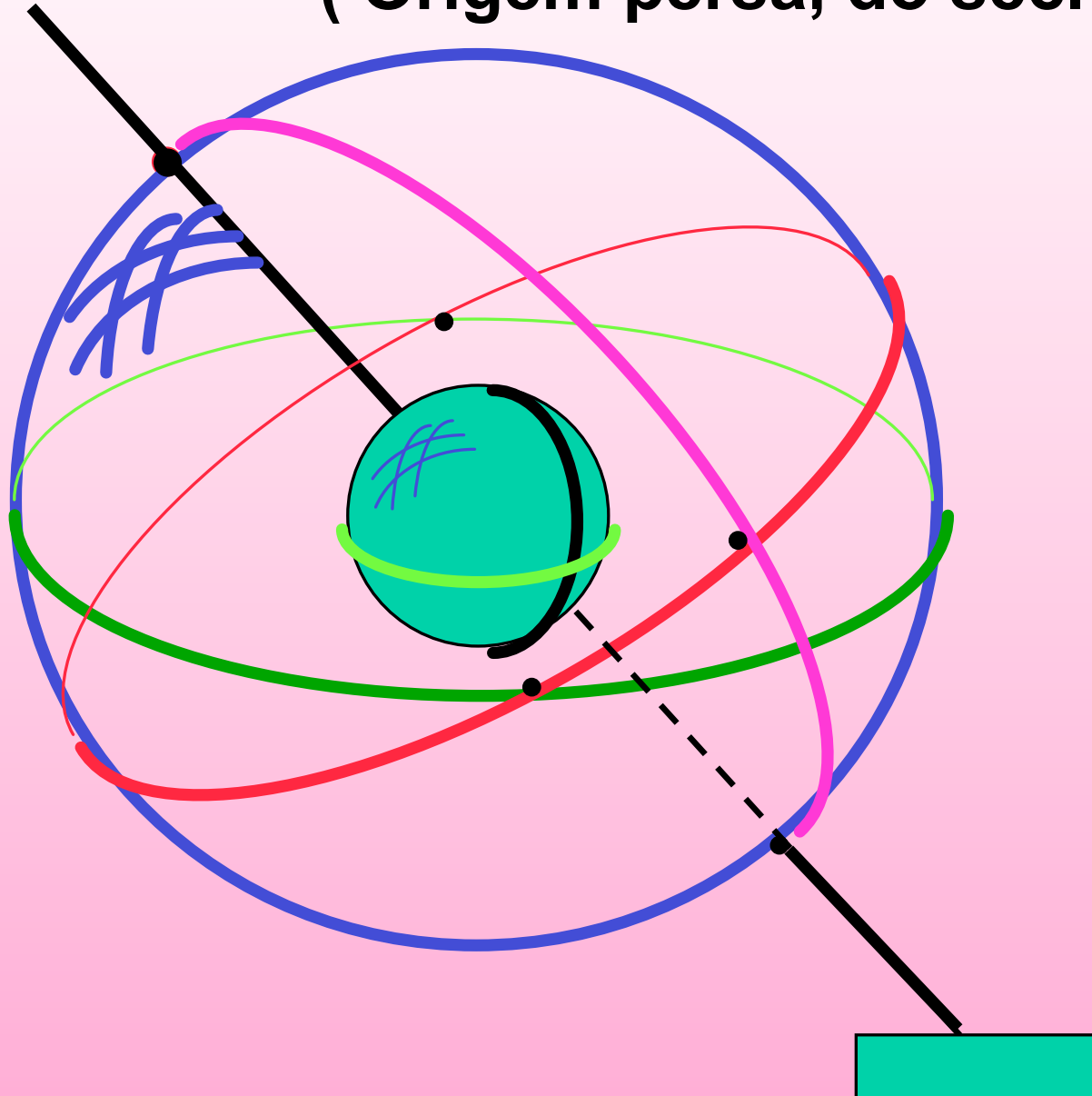


Quadrante Azimutal

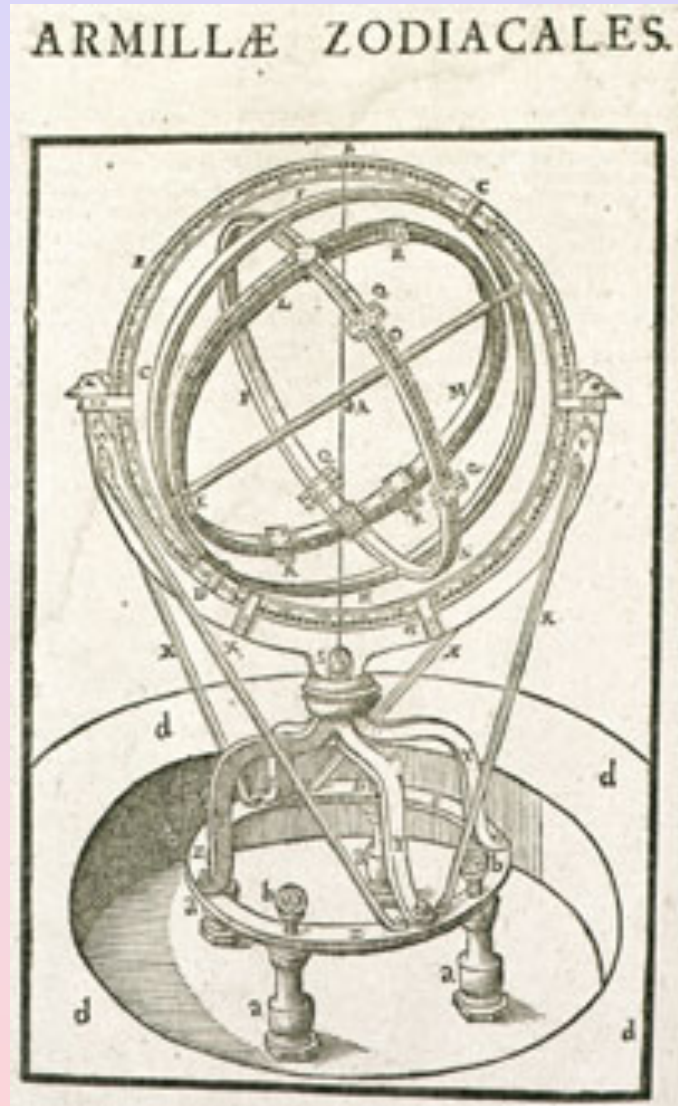


Esfera Armilar

(Origem persa, do séc. XIII)



Extraído de uma obra de Tycho Brahe



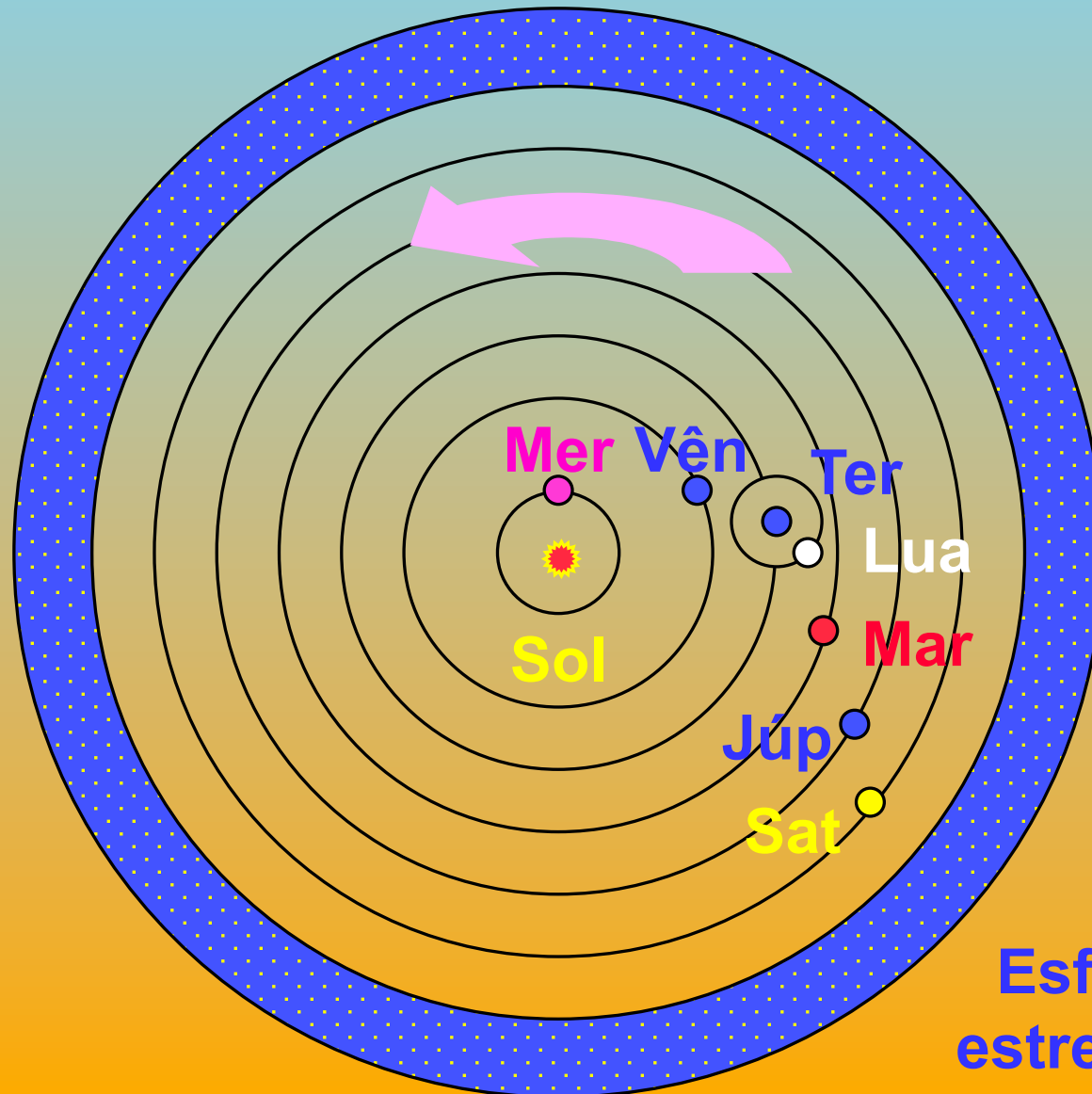
Esfera armilar moderna



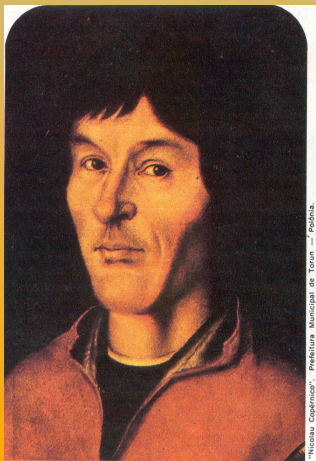
© Richard Pasell

Sistema Heliocêntrico

(Copérnico, séc. XVI)



Copérnico
(Polônia)
1473 - 1543

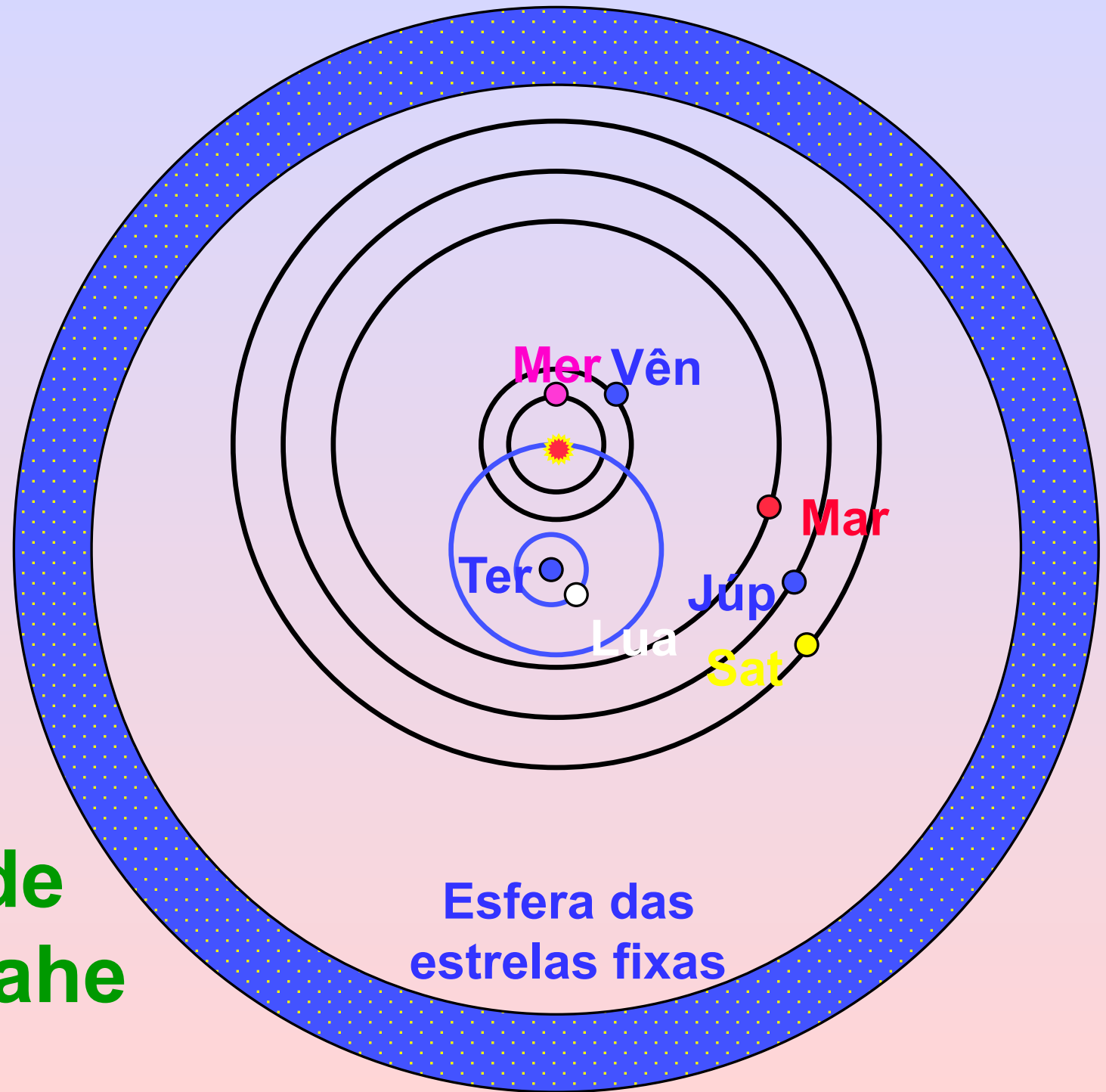


Sistema Heliocêntrico



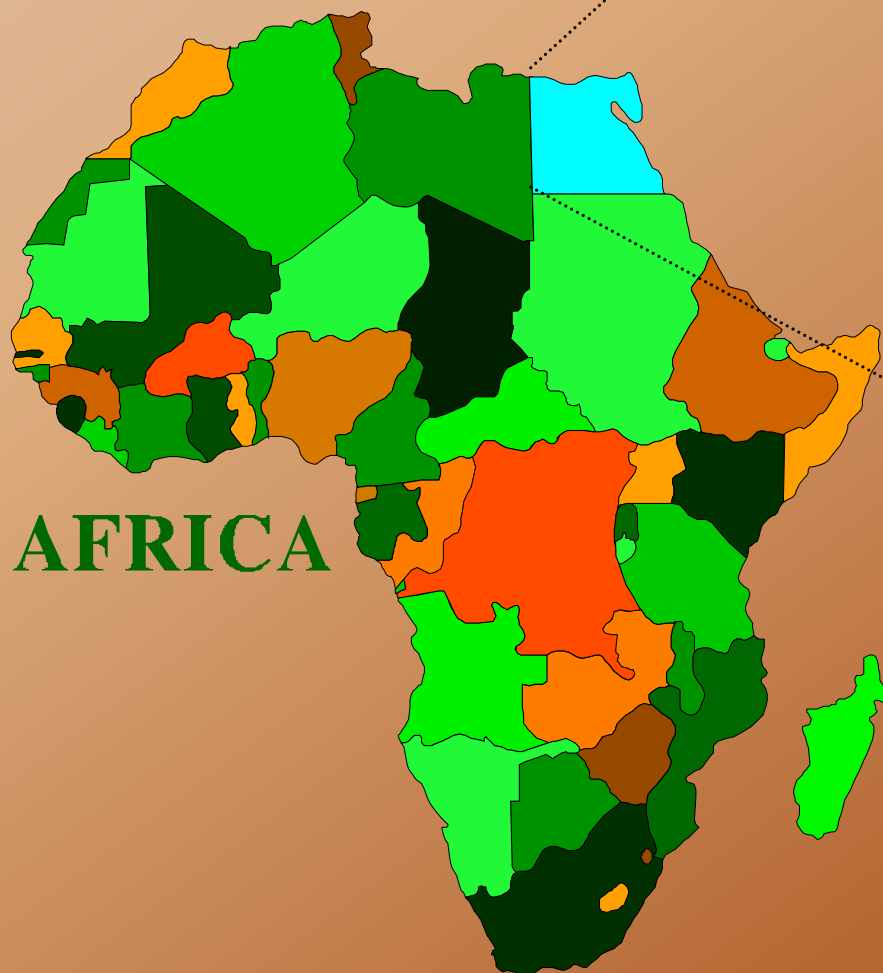
"O Universo Segundo Copérnico". In "Harmonia Macroscópica", Andreas Celarius.

Sistema de Tycho Brahe (séc. XVI)



Distâncias no Sistema solar

Egito



AFRICA

Alexandria

Cairo

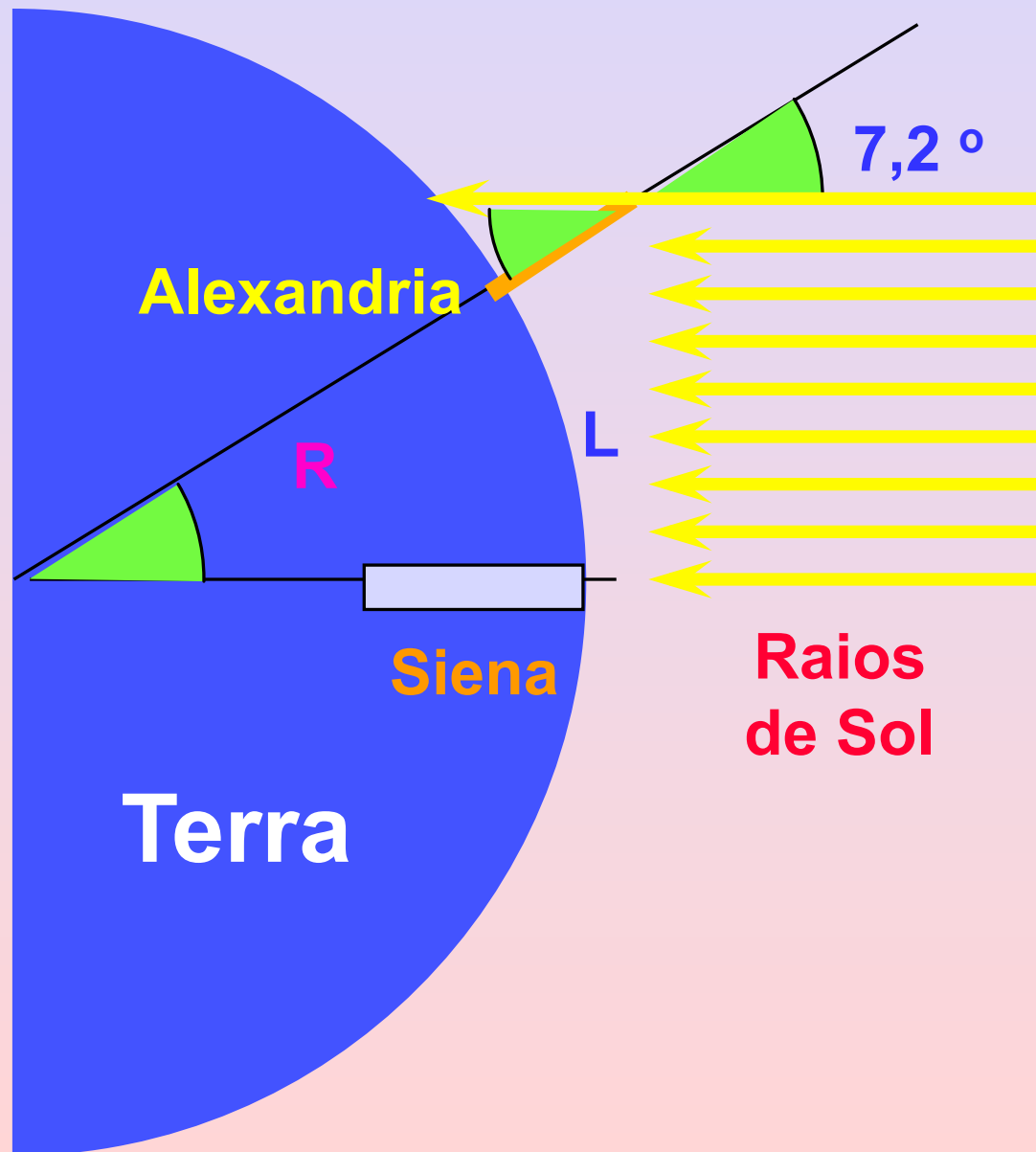
Egito

**Siena
(Assuan)**

Raio da Terra

Eratóstenes

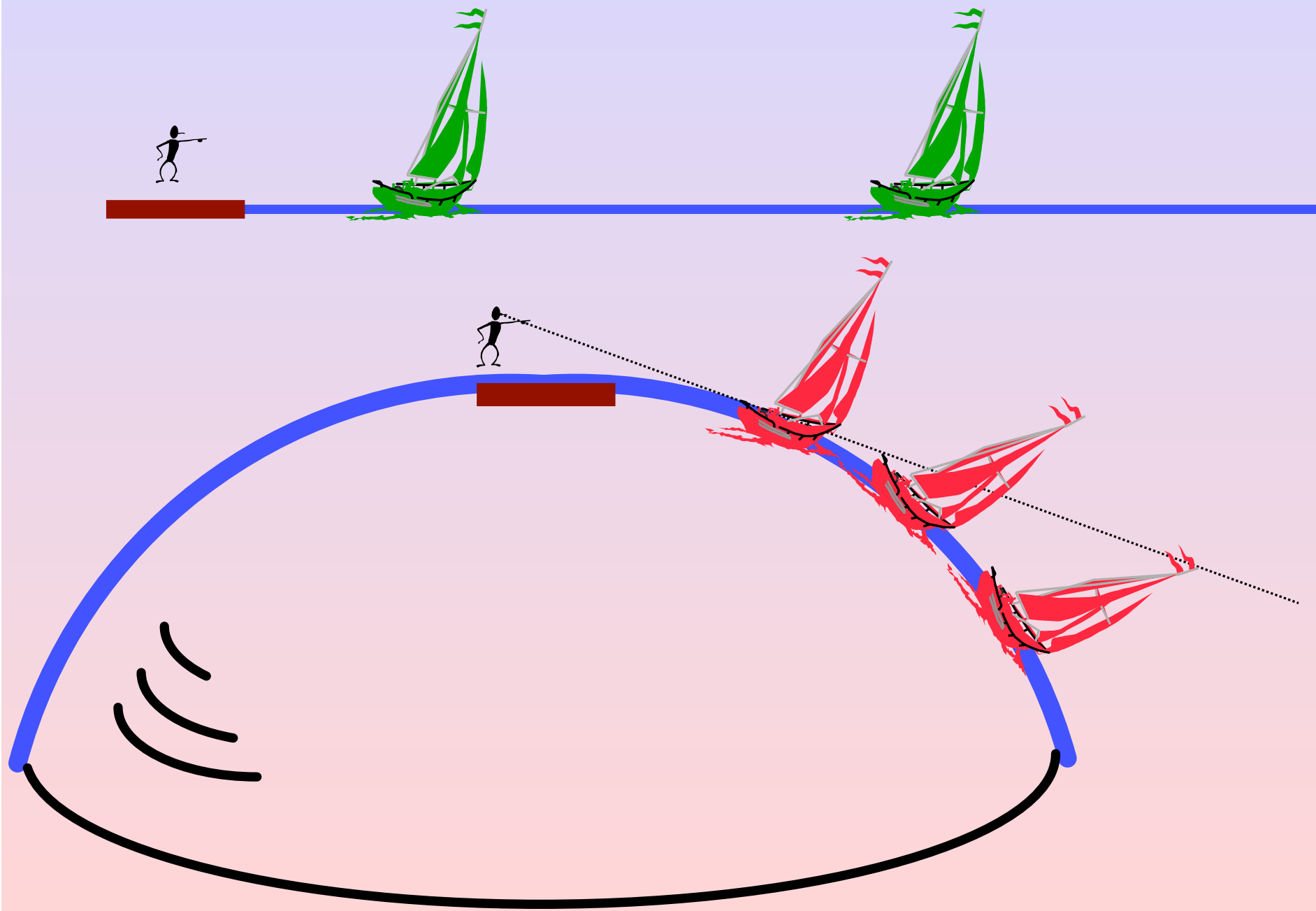
276 a.C. – 196 a.C.



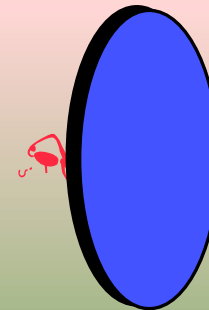
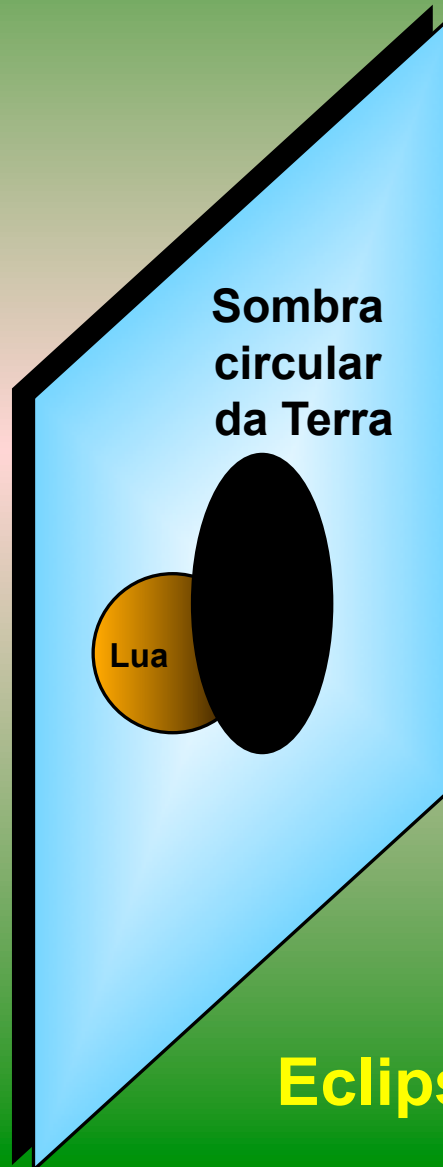
$$\frac{360^\circ}{7,2^\circ} = \frac{2\pi R}{L}$$

**Mas... já se sabia que a
Terra era esférica naquela
época?**

Esfericidade da Terra



Terra plana?



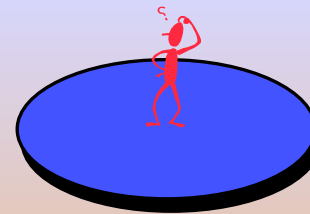
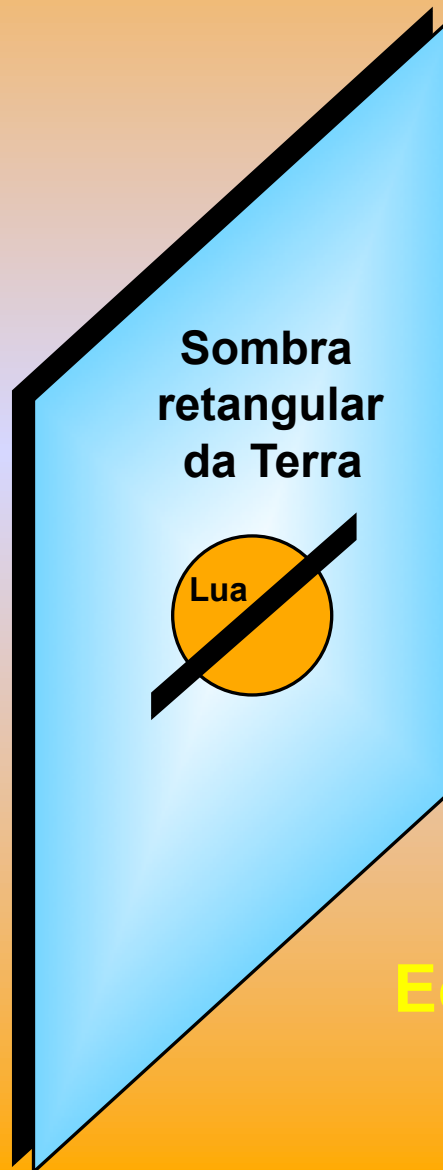
Terra plana



Eclipse lunar à meia-noite

Funciona!

Terra não é plana!



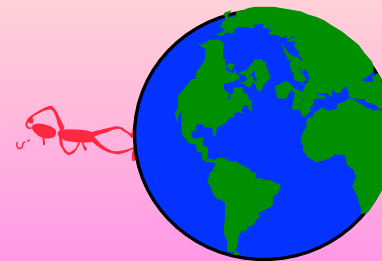
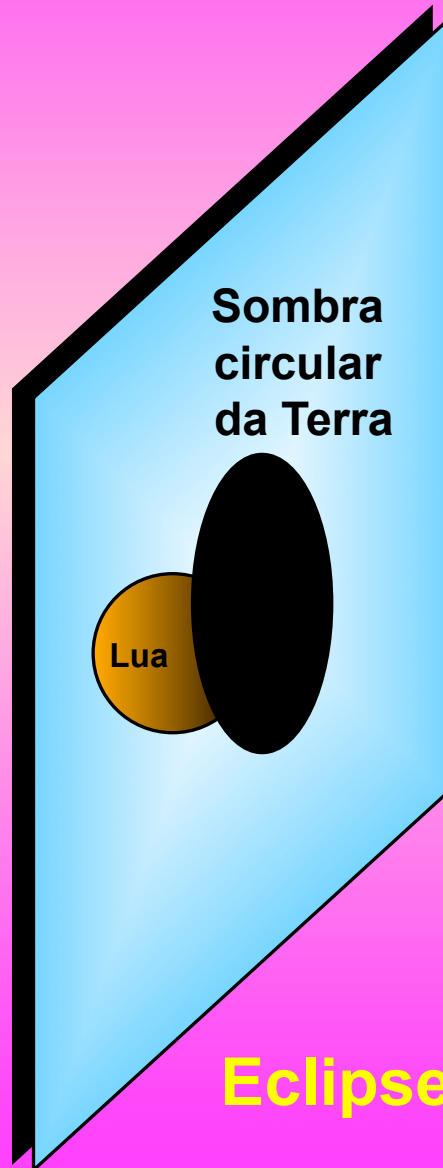
Terra plana



Eclipse lunar ao nascer ou ao ocaso do Sol

Não funciona!

Terra tem que ser esférica!



Terra esférica

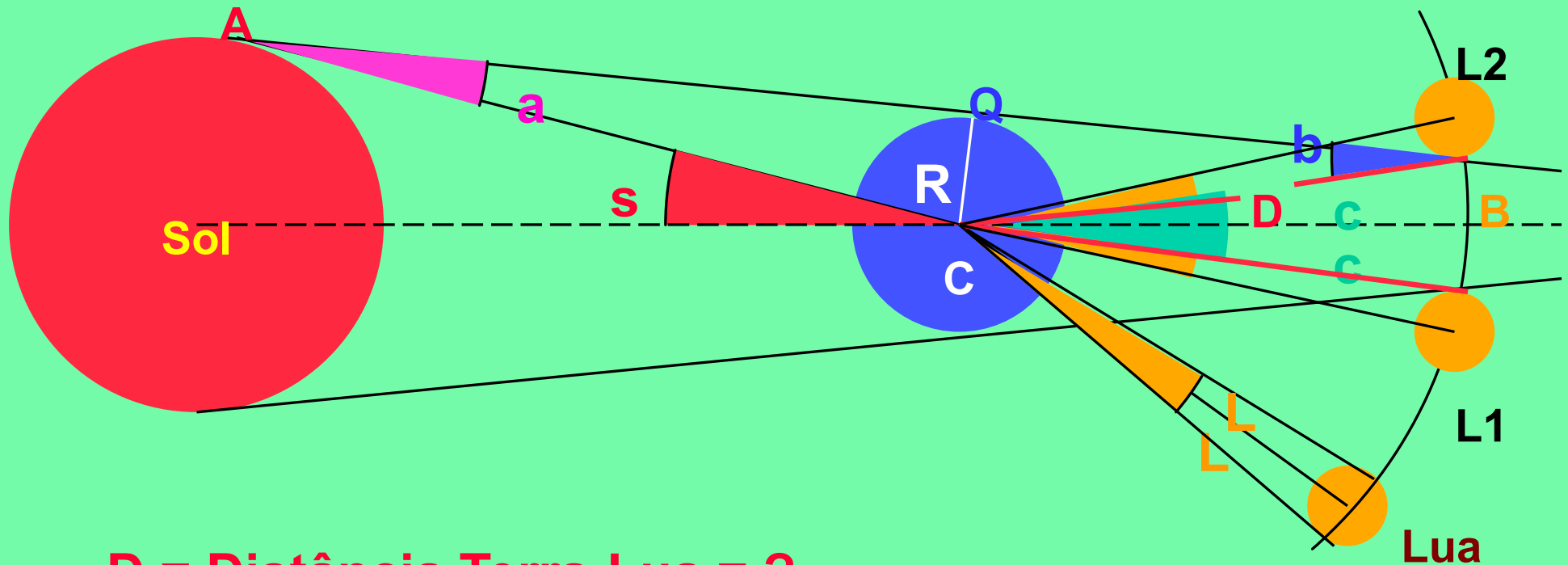


Eclipse lunar a qualquer hora

Funciona!

Distância da Terra à Lua

(Hiparcos, séc. II a .C.)



D = Distância Terra-Lua = ?

R = raio da Terra

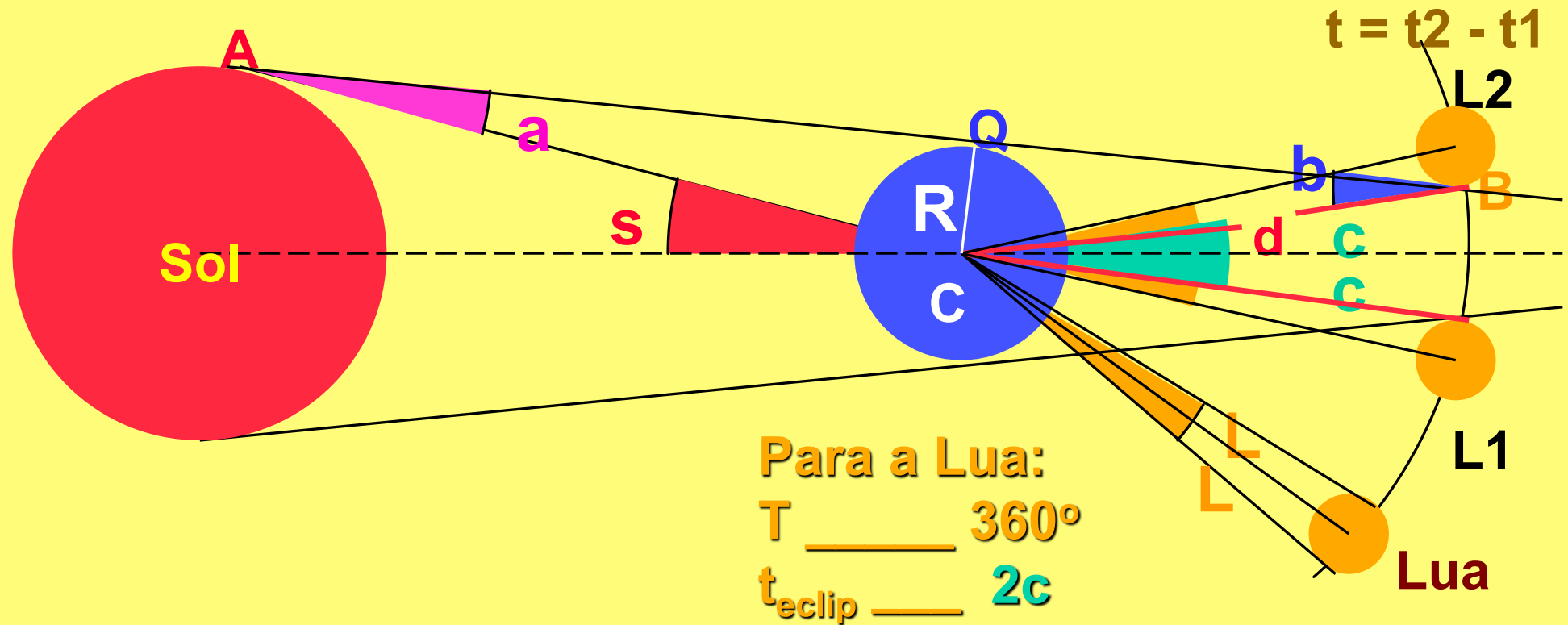
L = semi-diâmetro angular da Lua ~16' (medido)

s = semi-diâmetro angular do Sol ~ 16' (medido)

a = semi-diâmetro angular da Terra vista do Sol ~ 8,794"

T = período orbital da Lua ~ 27,3 dias

Distância da Terra à Lua



No triângulo ABC: $a + b + x = 180^\circ$
 Ângulo raso em C: $s + x + c = 180^\circ$

$$a + b + x = s + x + c$$

$$a + b = s + c$$

$$a \sim 0$$

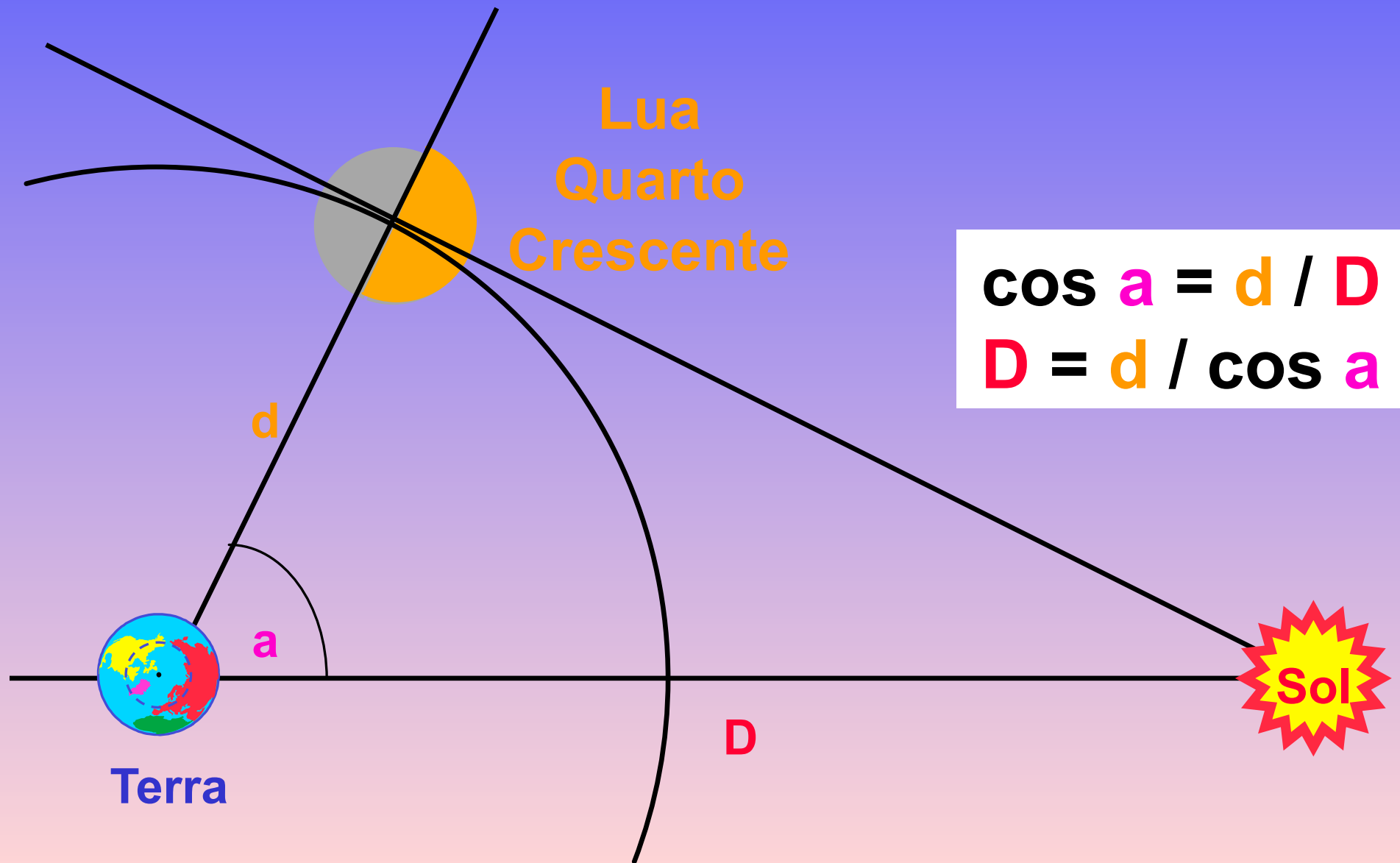
$$b = s + c$$

No triângulo BCQ: $\sin b = R / d$

Logo: $d = R / \sin b$

Distância da Terra ao Sol

(Aristarco, grego, 320 a.C. – 250 a.C.)

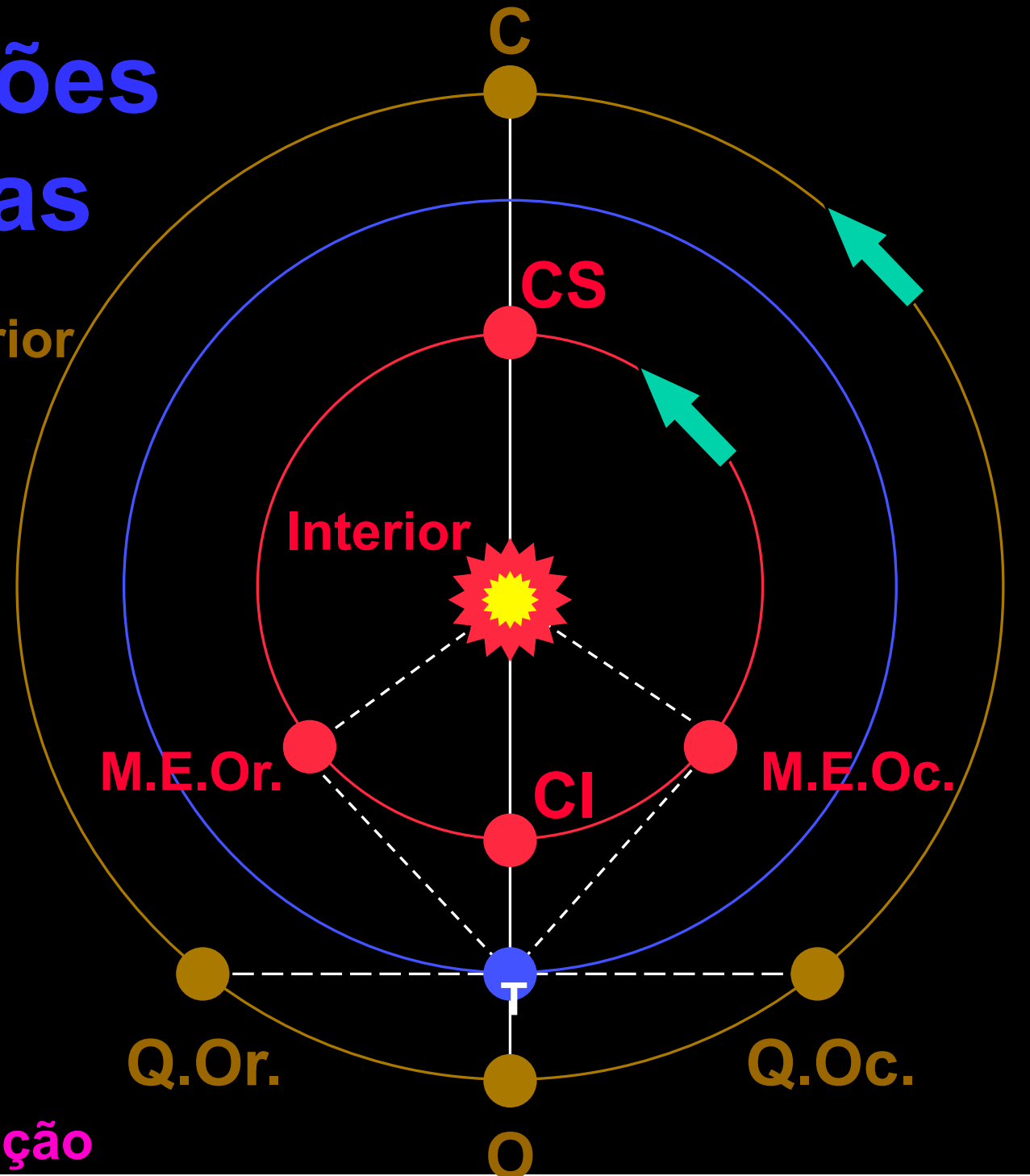


Configurações Planetárias

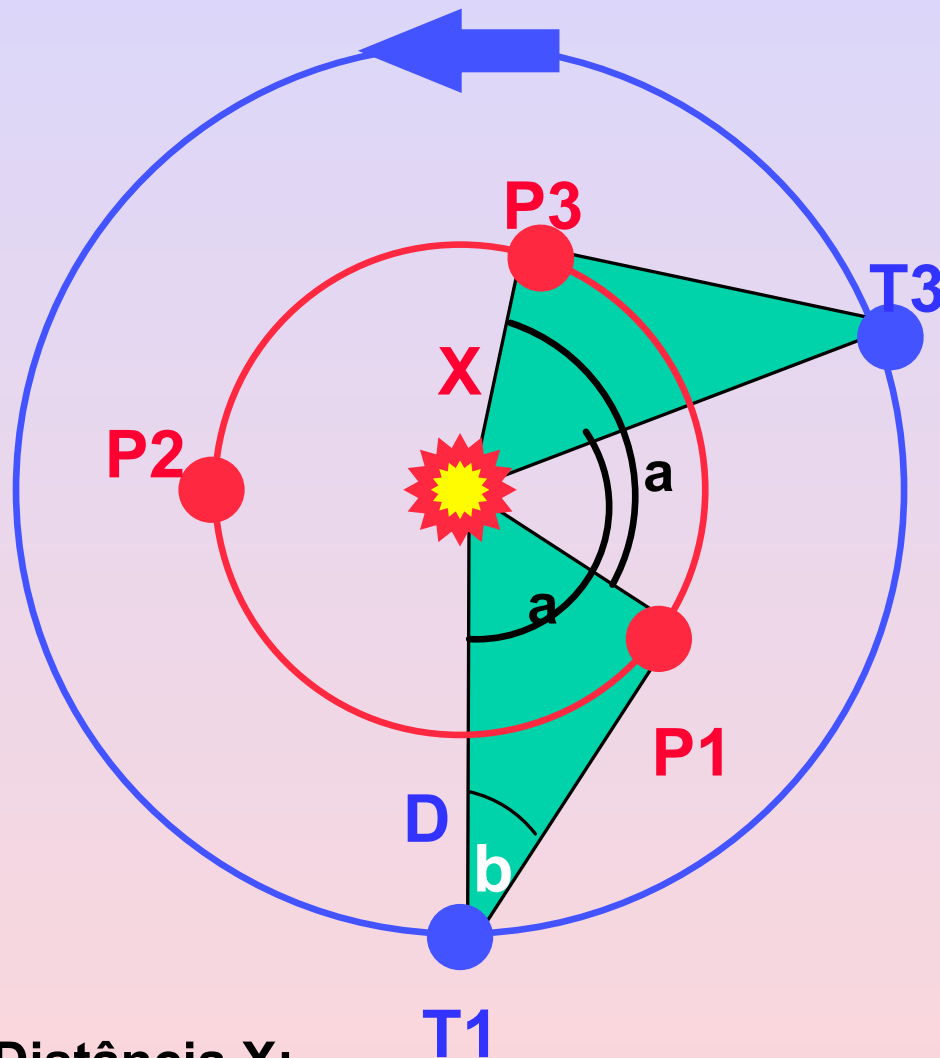
C = Conjuncão
O = Oposição
Q = Quadratura
Oc. = Ocidental (W)
Or. = Oriental (E)
S = Superior
I = Inferior
ME = Máxima Elongação

Exterior

Interior



Método de Copérnico para calcular raios orbitais e períodos dos Planetas Interiores



Distância X:
Na máxima elongação
 $\text{sen } b = X / D$
 $X = D \cdot \text{sen } b$

Períodos: em dois períodos sinódicos sucessivos

$$S = t_3 - t_1 = \text{Per. Sinódico}$$

$$T = ? = \text{Per. Orbital}$$

$$A = 365,25 \text{ (Orb. da Terra)}$$

Terra

$$A \text{ } \underline{\hspace{1cm}} \text{ } 360^\circ$$

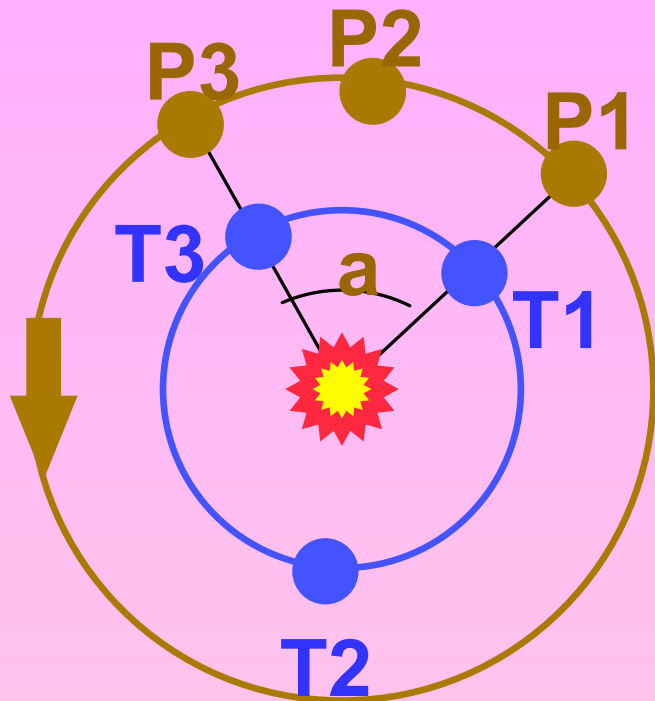
$$S \text{ } \underline{\hspace{1cm}} \text{ } a$$

Planeta

$$S \text{ } \underline{\hspace{1cm}} \text{ } 360 + a$$

$$T \text{ } \underline{\hspace{1cm}} \text{ } 360^\circ$$

$$1/T = 1/A + 1/S$$



Período: em duas oposições sucessivas

Terra

A ____ 360°

S ____ $360 + a$

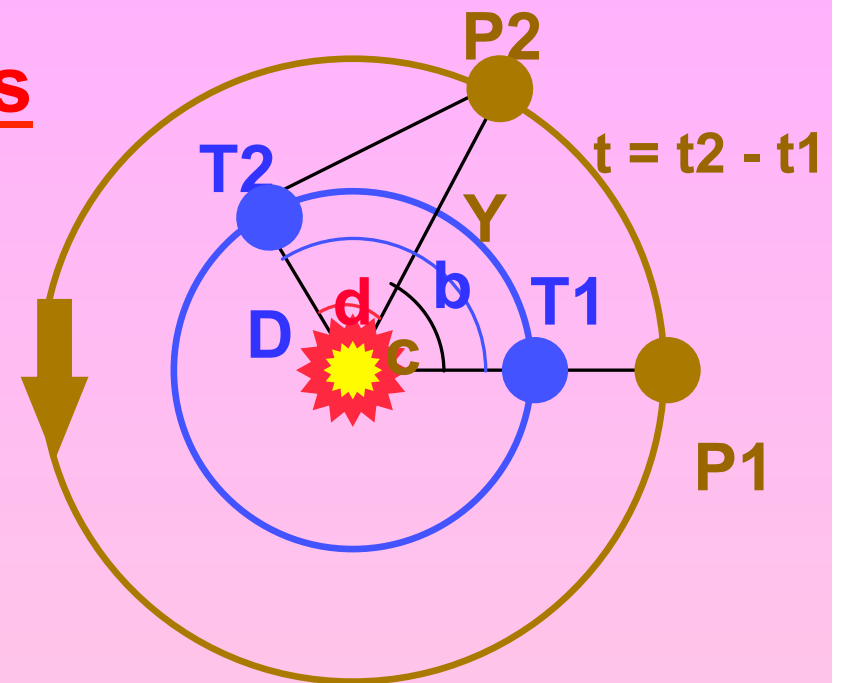
Planeta

S ____ a

T ____ 360°

$$1/T = 1/A - 1/S$$

Planetas Exteriores



Raio orbital: duma oposição à próxima quadratura

Terra

A ____ 360°

t ____ b

Planeta

T ____ 360°

t ____ c

$$d = b - c$$

$$\cos d = D / Y$$

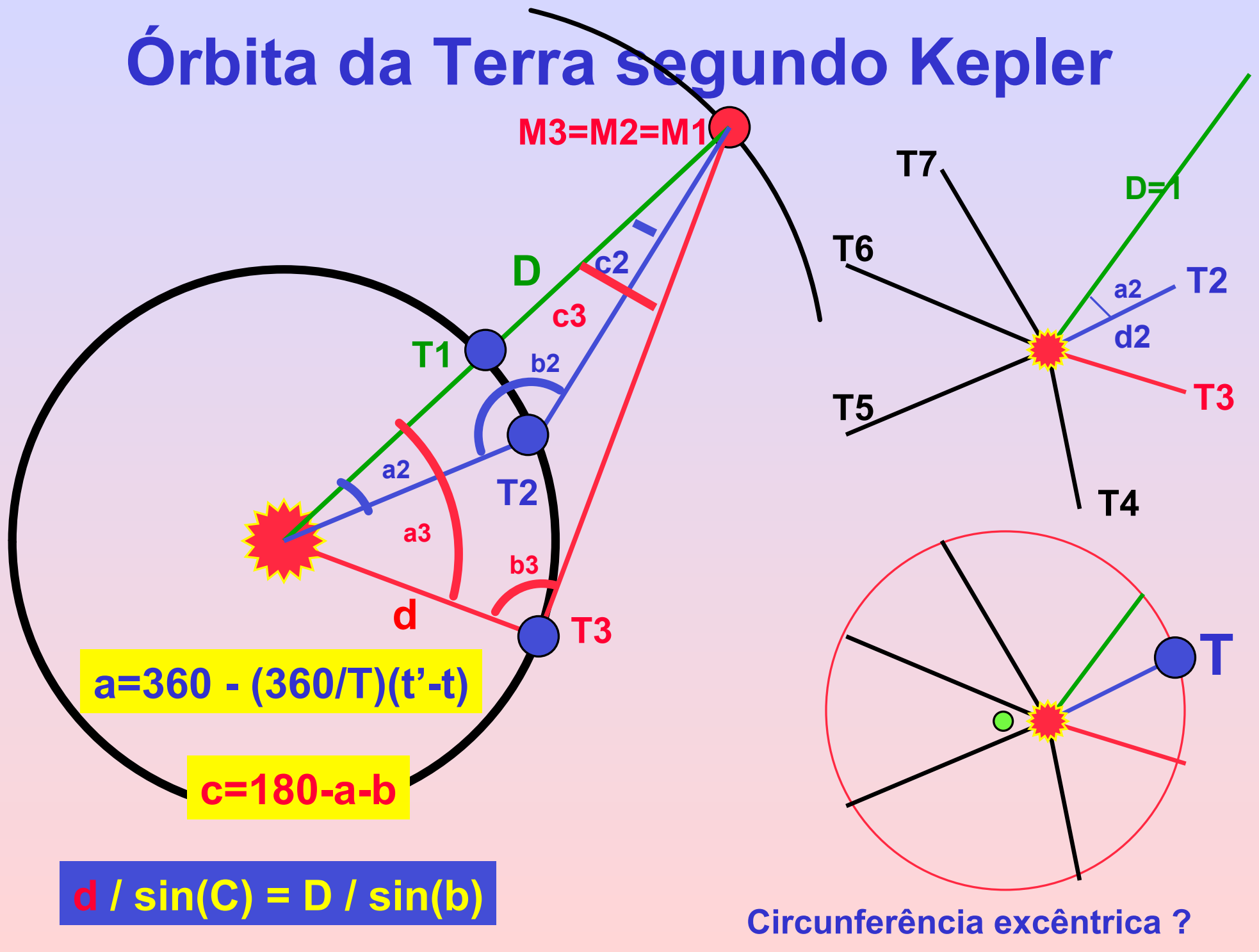
$$Y = D / \cos d$$

**Mas será que
as órbita
dos planetas
são
mesmo
circulares?**



Johann Kepler
1571 - 1630

Órbita da Terra segundo Kepler

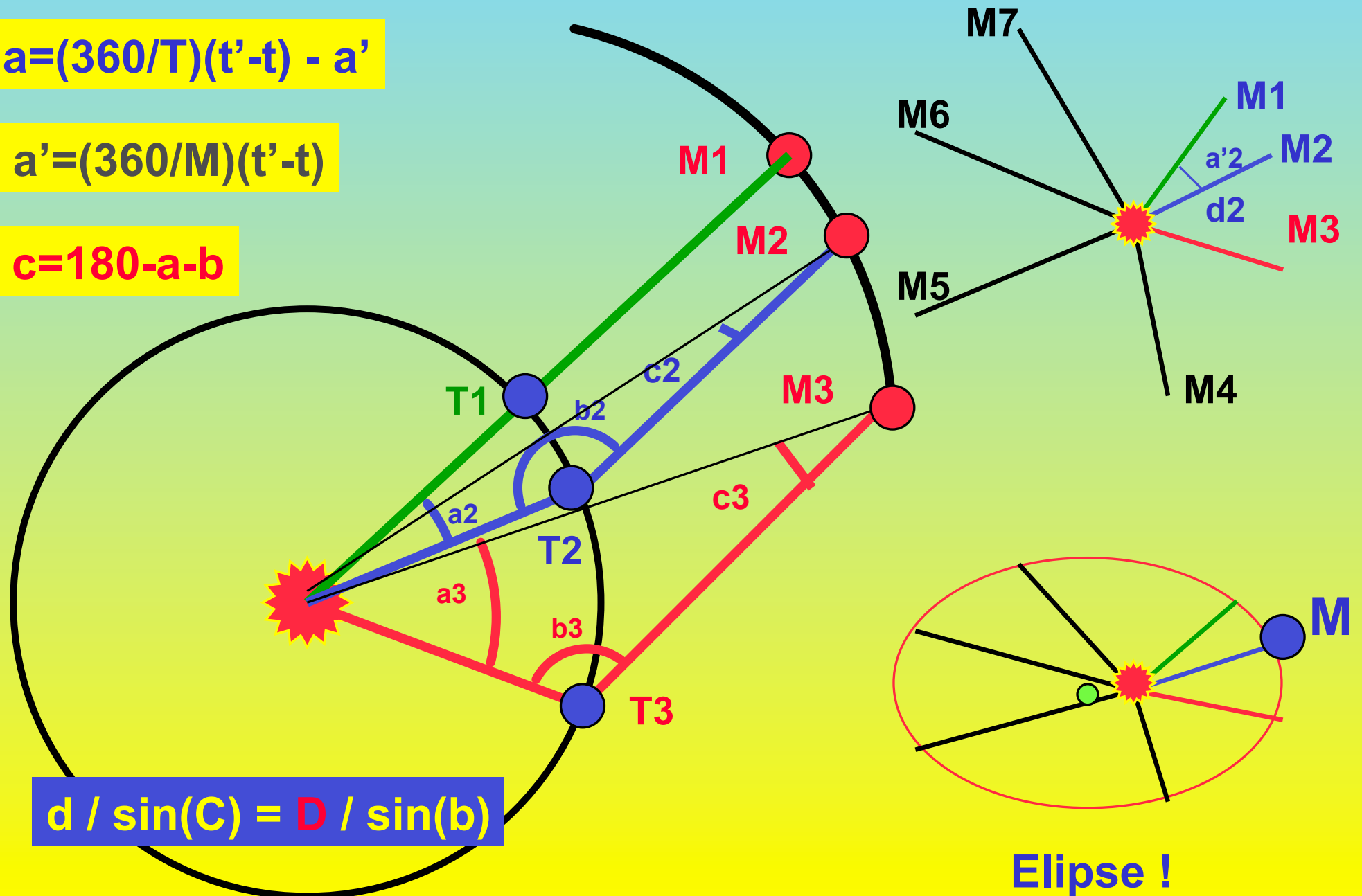


Órbita de Marte segundo Kepler

$$a = (360/T)(t' - t) - a'$$

$$a' = (360/M)(t' - t)$$

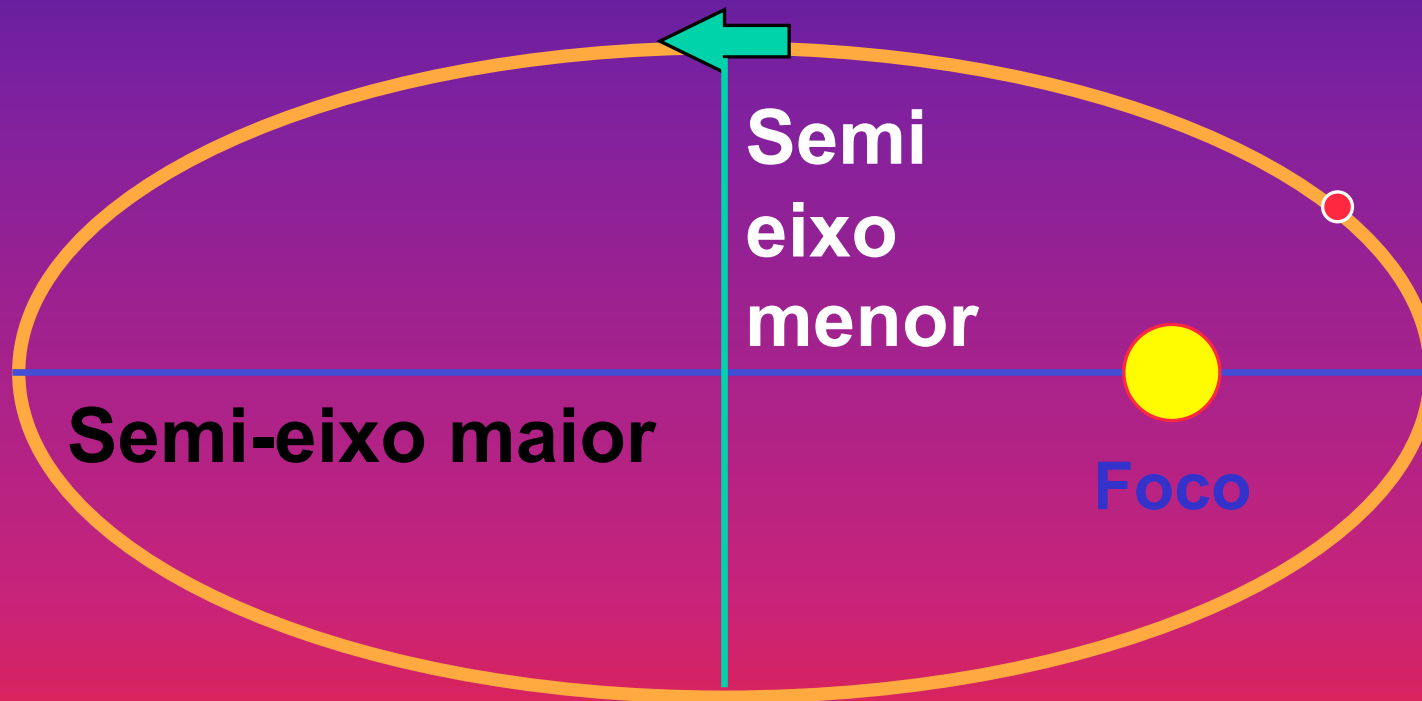
$$c = 180 - a - b$$



Leis de Kepler

Primeira Lei de Kepler

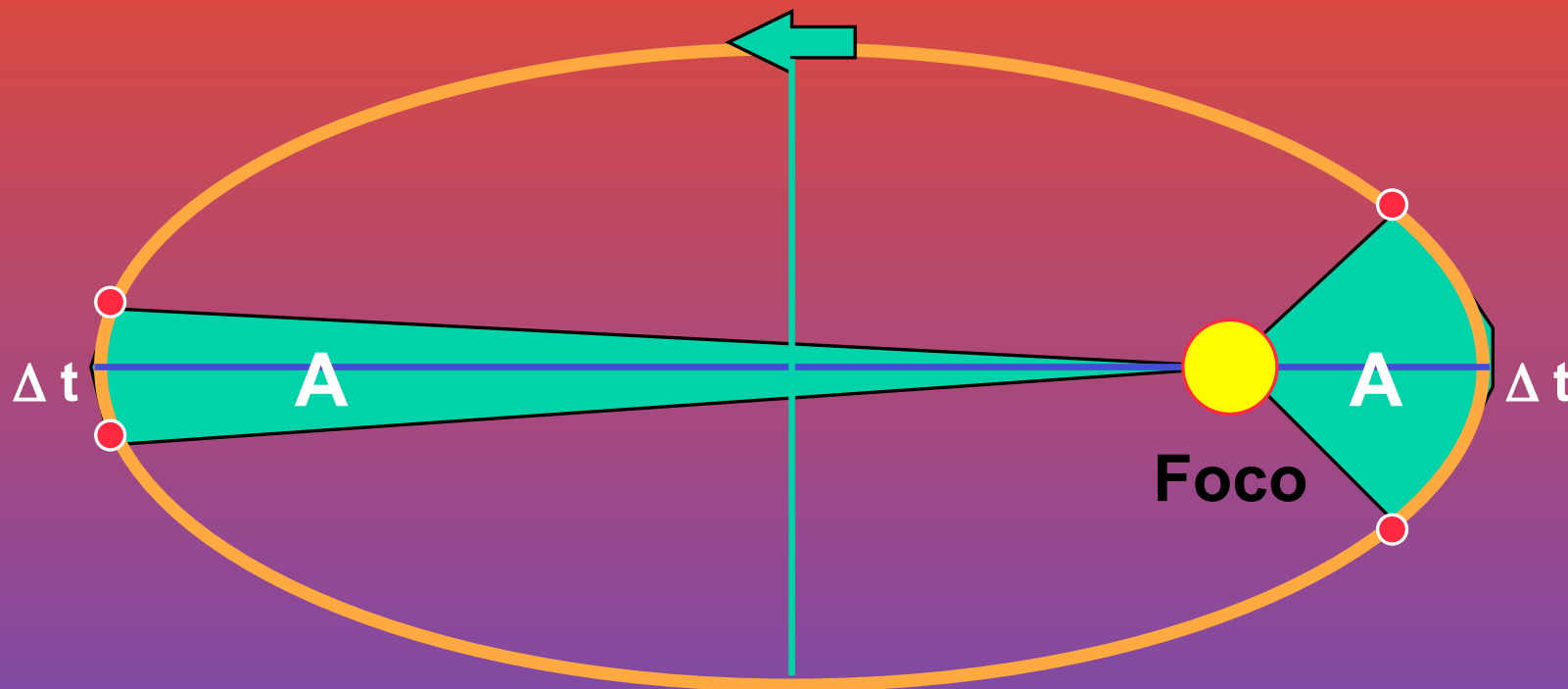
(1571 - 1630)



Um corpo ligado a outro gravitacionalmente
gira em torno dele numa órbita elíptica,
sendo que um deles ocupa o foco da elipse.

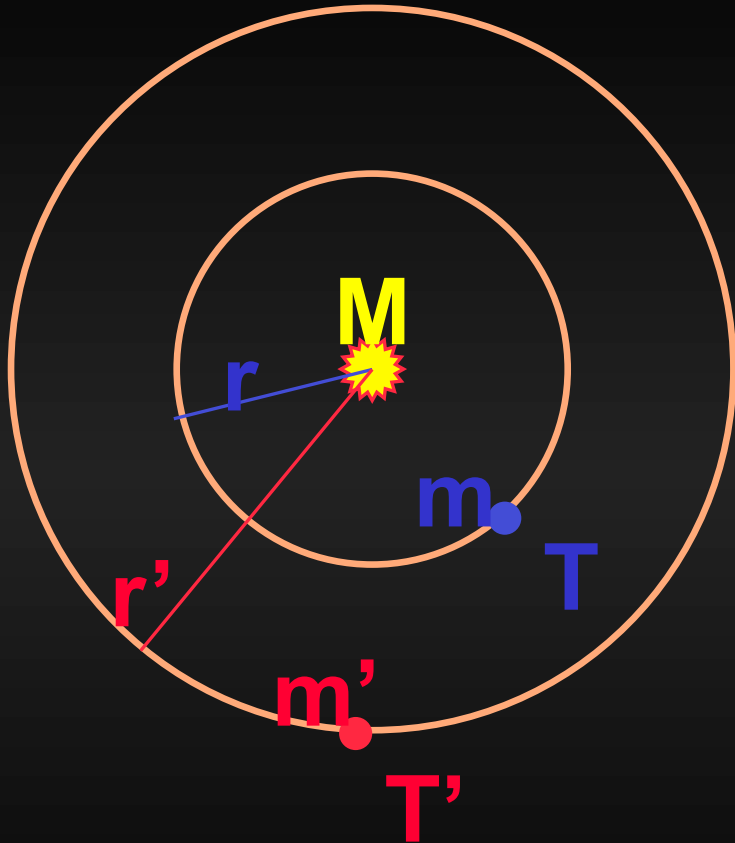
Segunda Lei de Kepler

(1571 - 1630)



Um corpo ligado a outro gravitacionalmente
gira em torno dele, com seu raio vetor
varrendo áreas iguais em tempos iguais.

Terceira Lei de Kepler



$$(r / r')^3 = (T / T')^2$$

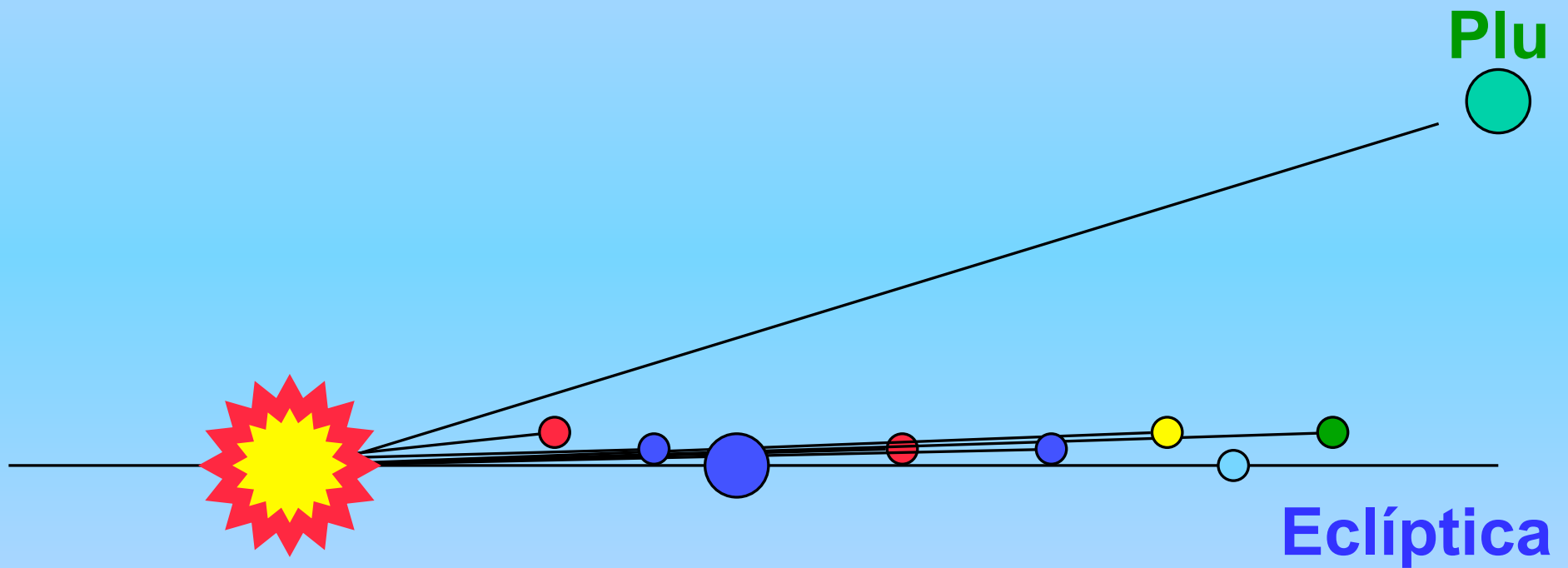
Expressão correta:

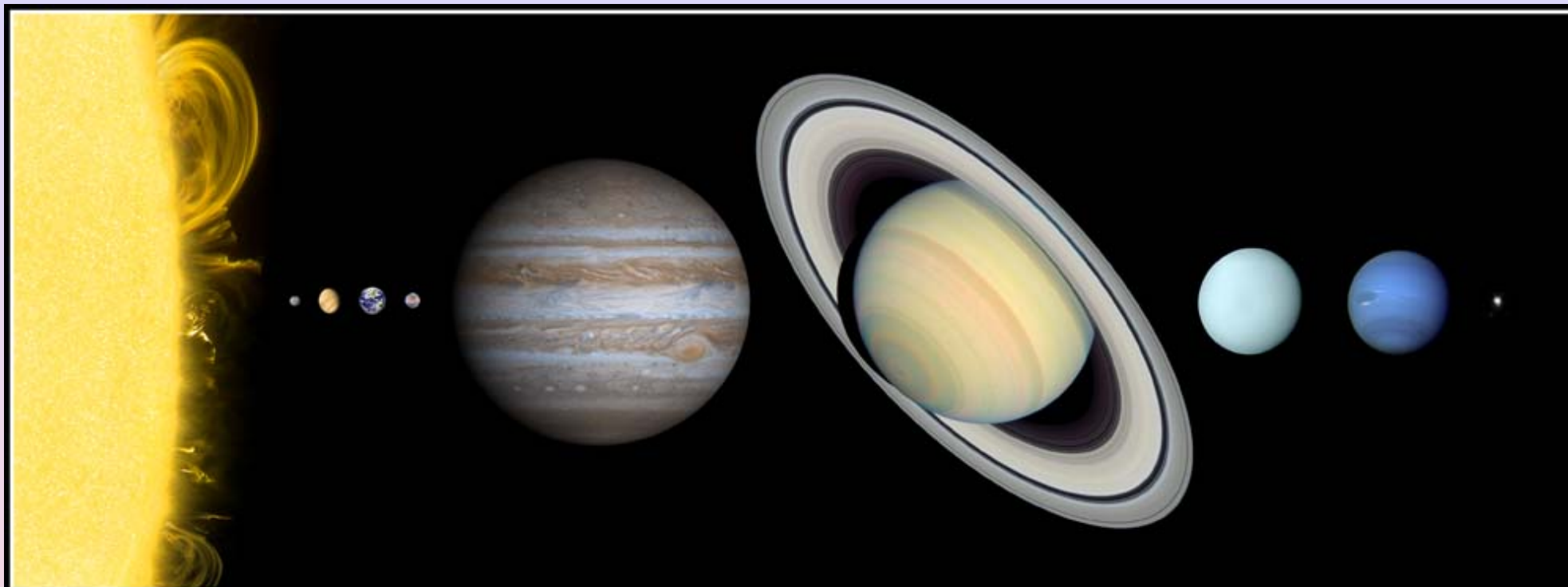
$$(r / r')^3 = ((M + m) / (M + m')) \times (T / T')^2$$

$$r^3 = G (M + m) T^2$$

Estrutura atualmente conhecida do Sistema Planetário

Órbitas não coplanares

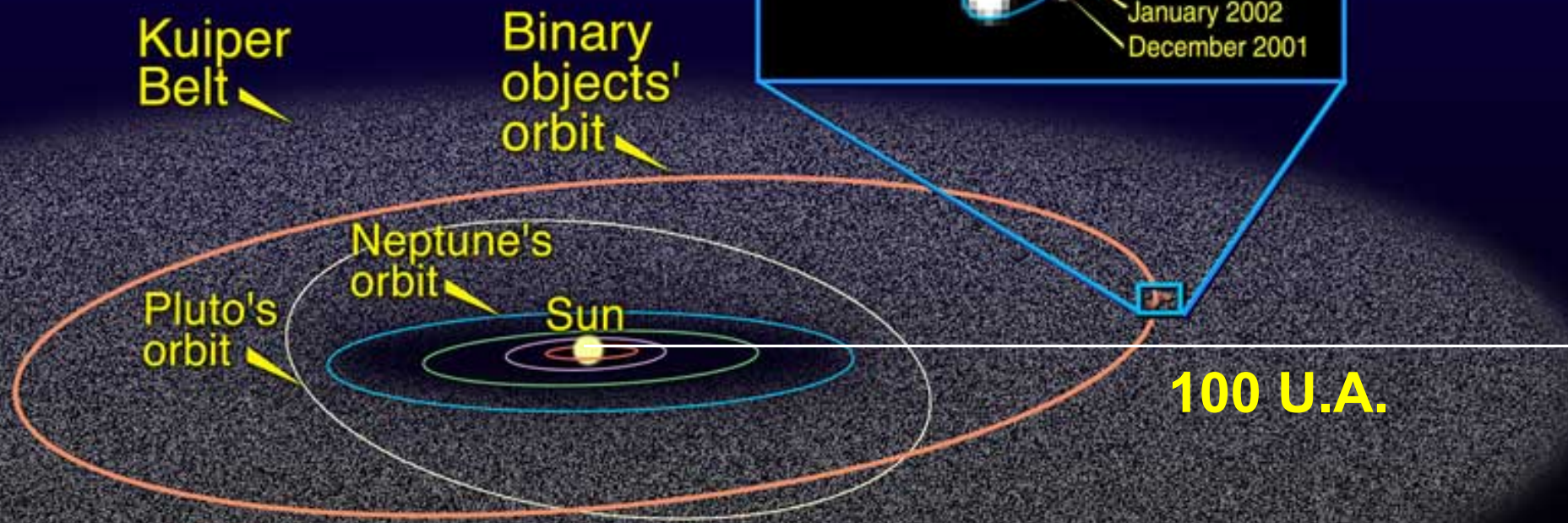




The Sun and Nine Planets

Copyright © Calvin J. Hamilton

Kuiper Belt Object 1998 WW31



Binary objects
orbit each other

July 2001

August 2001

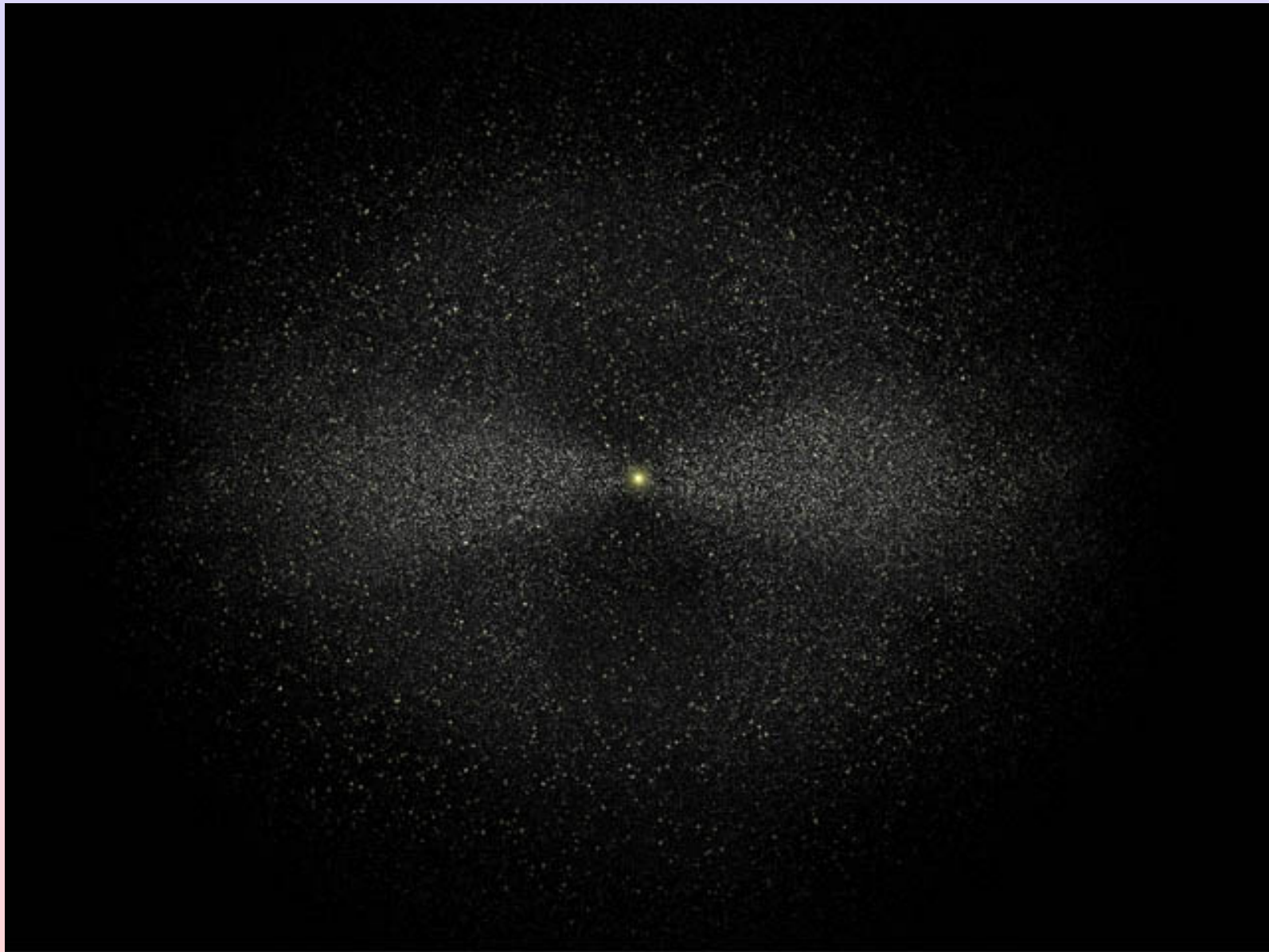
September 2001

February 2002

January 2002

December 2001

50.000 U.A.



The Oort Cloud

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