Início da Astronomia: História e Métodos

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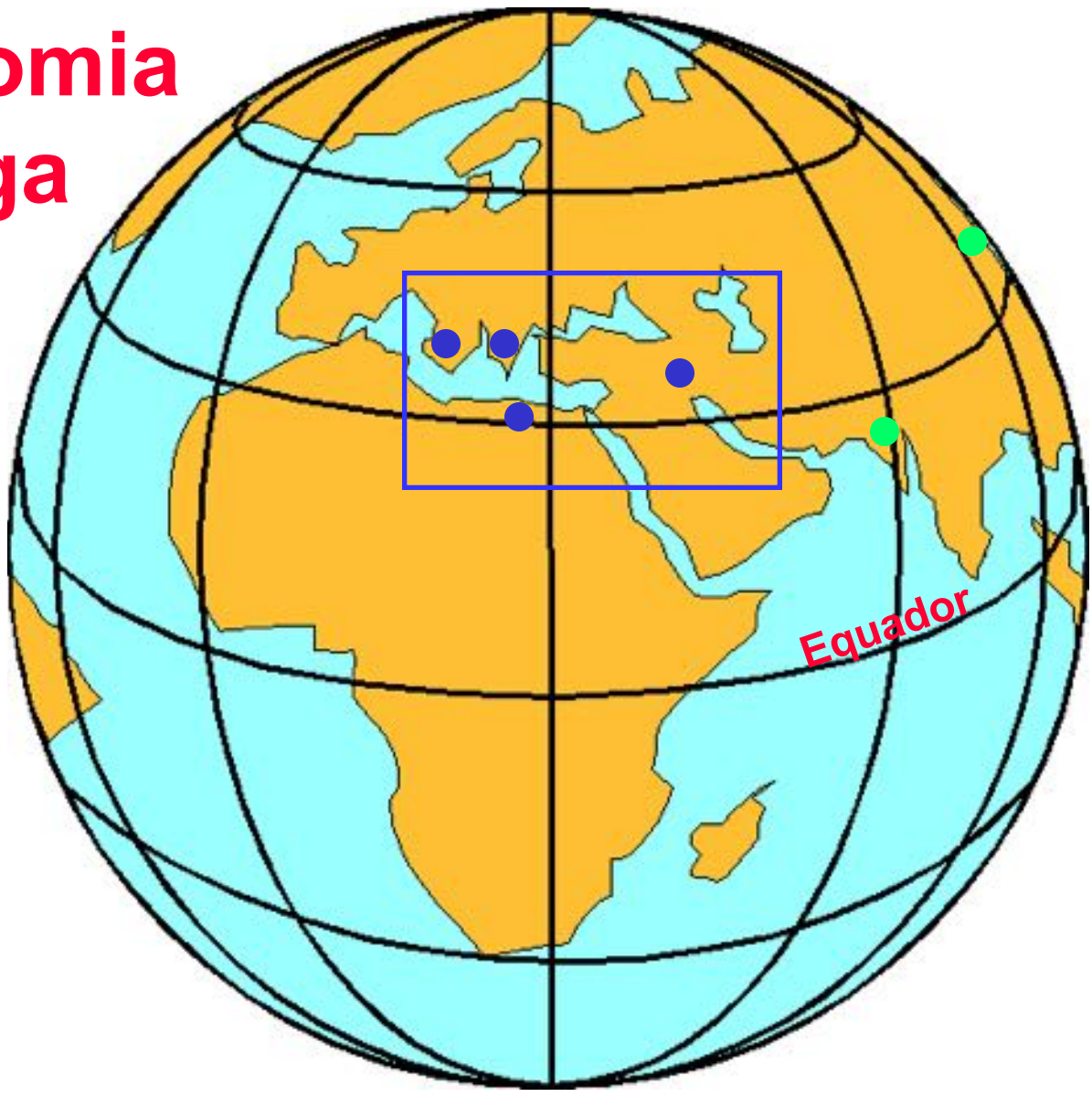
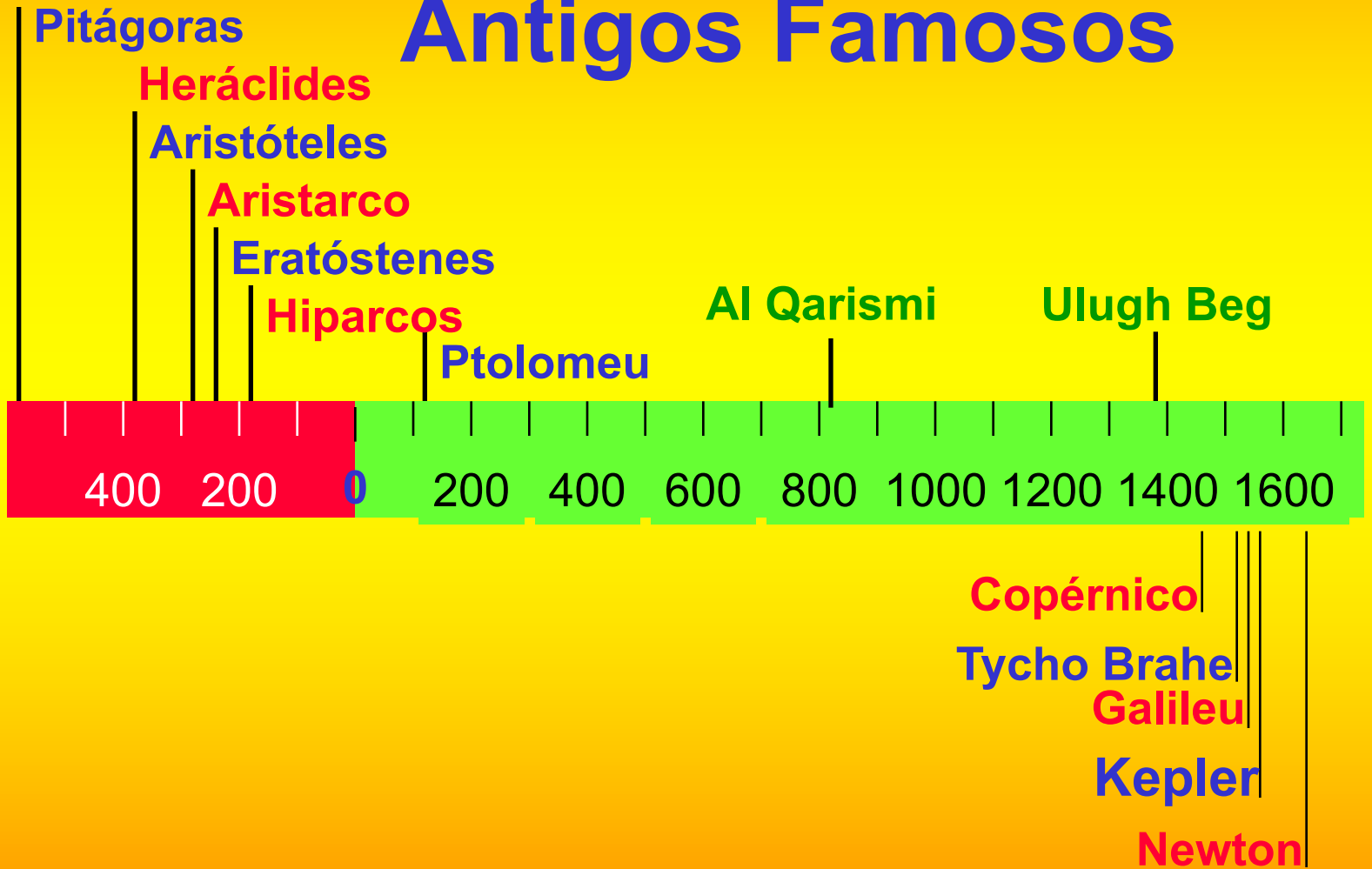
(mod. R. Costa)
IAG-USP

02
04
05

Astronomia Antiga

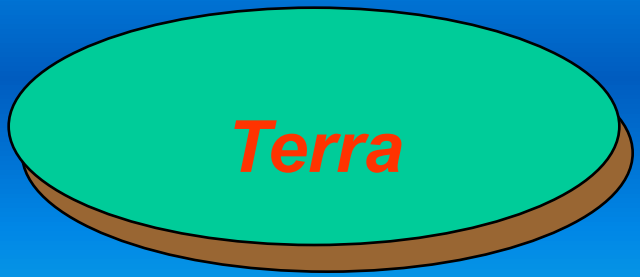


Filósofos e Astrônomos Antigos Famosos



Tales

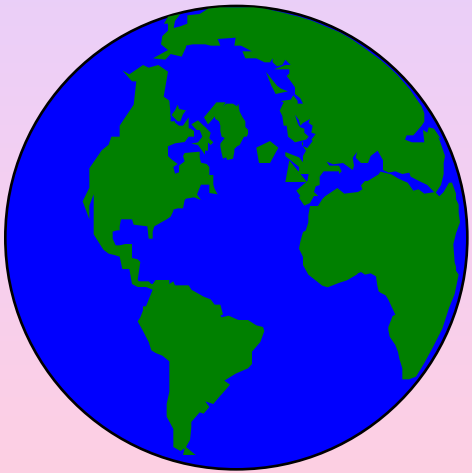
(Grego, séc. VI a.C.)



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

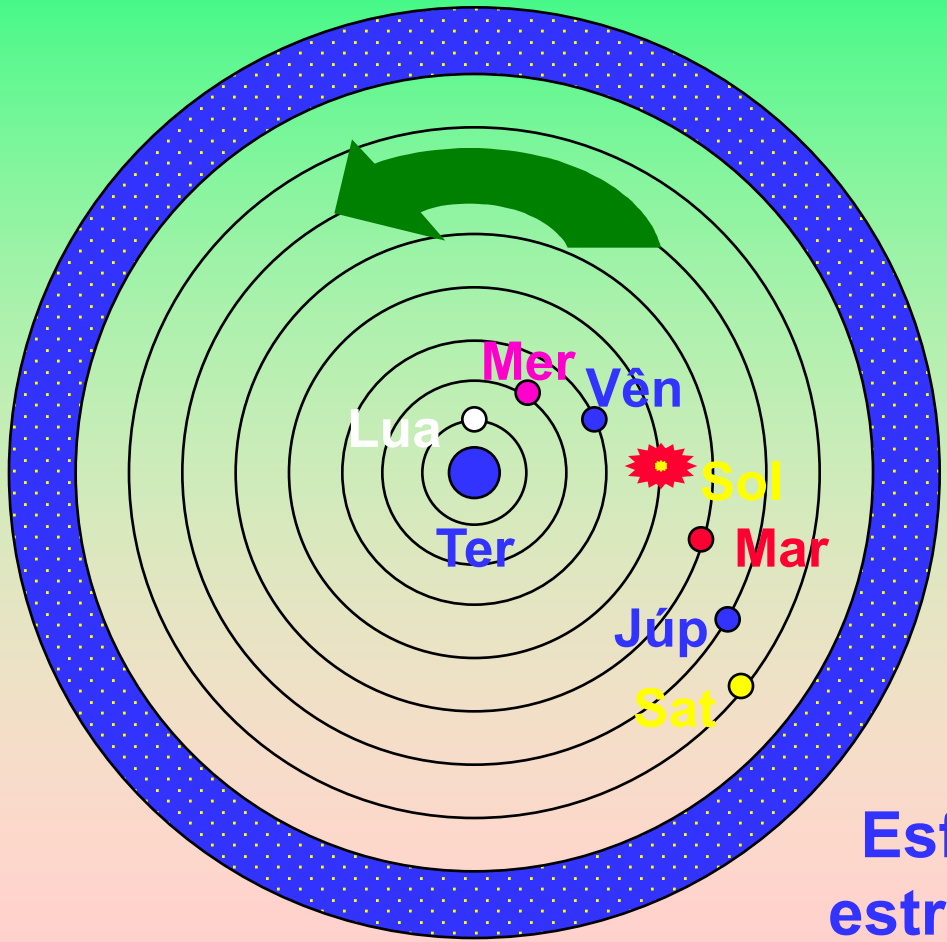
(Grego, séc. IV a.C.)

Geocentrismo por convicção filosófica!

Sistema Geocêntrico

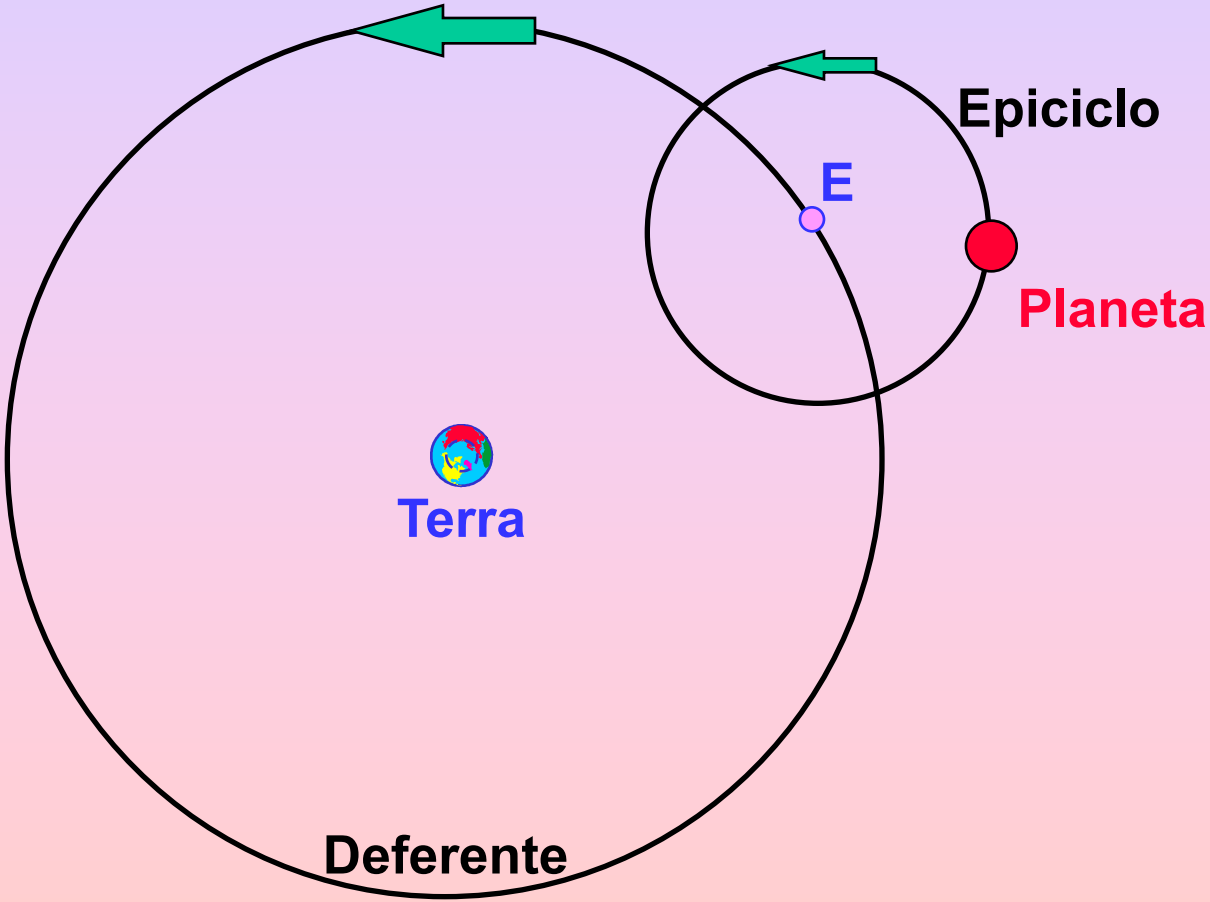
Sistema Geocêntrico

(Grego, Ptolomeu, séc. II)

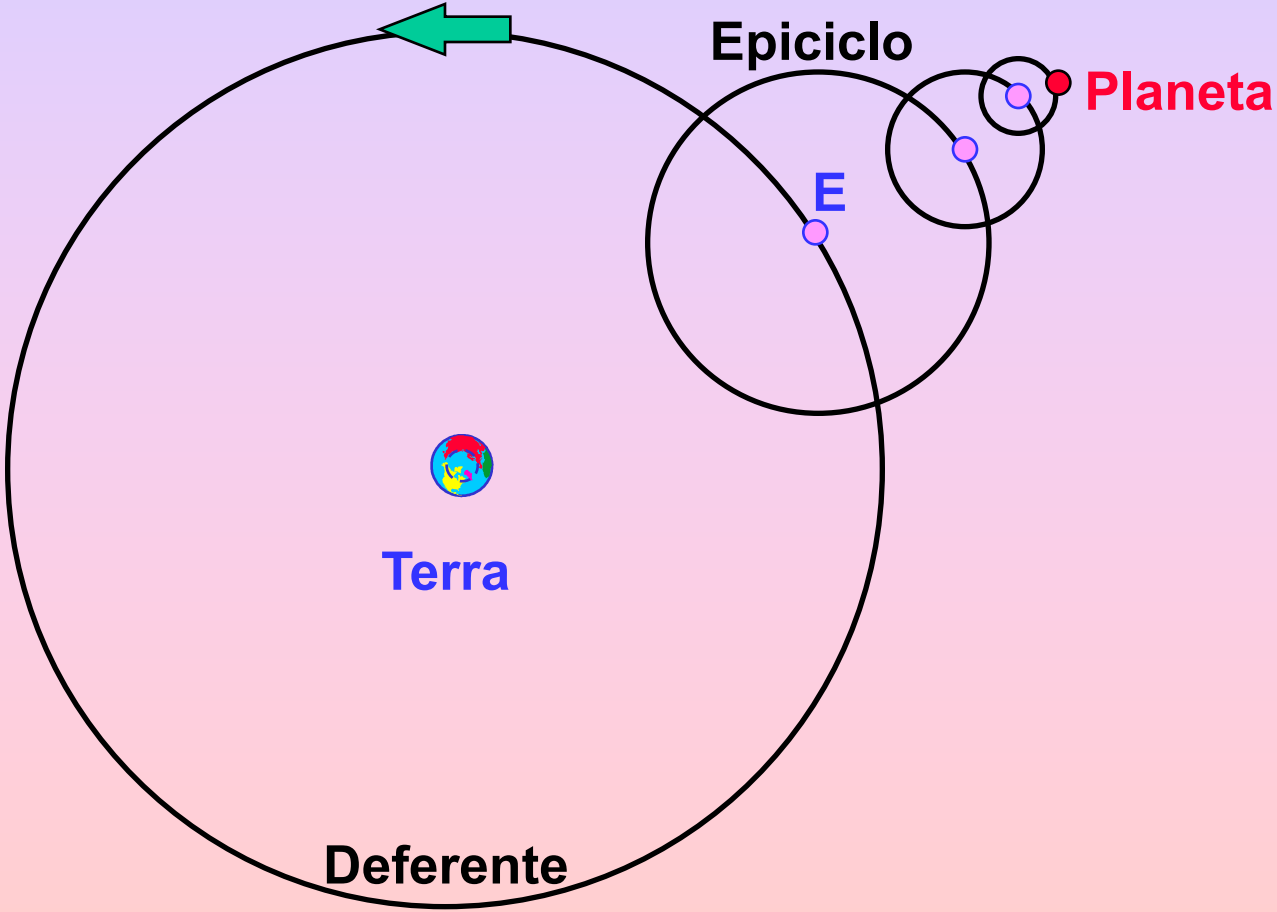


Sistema de Epiciclos

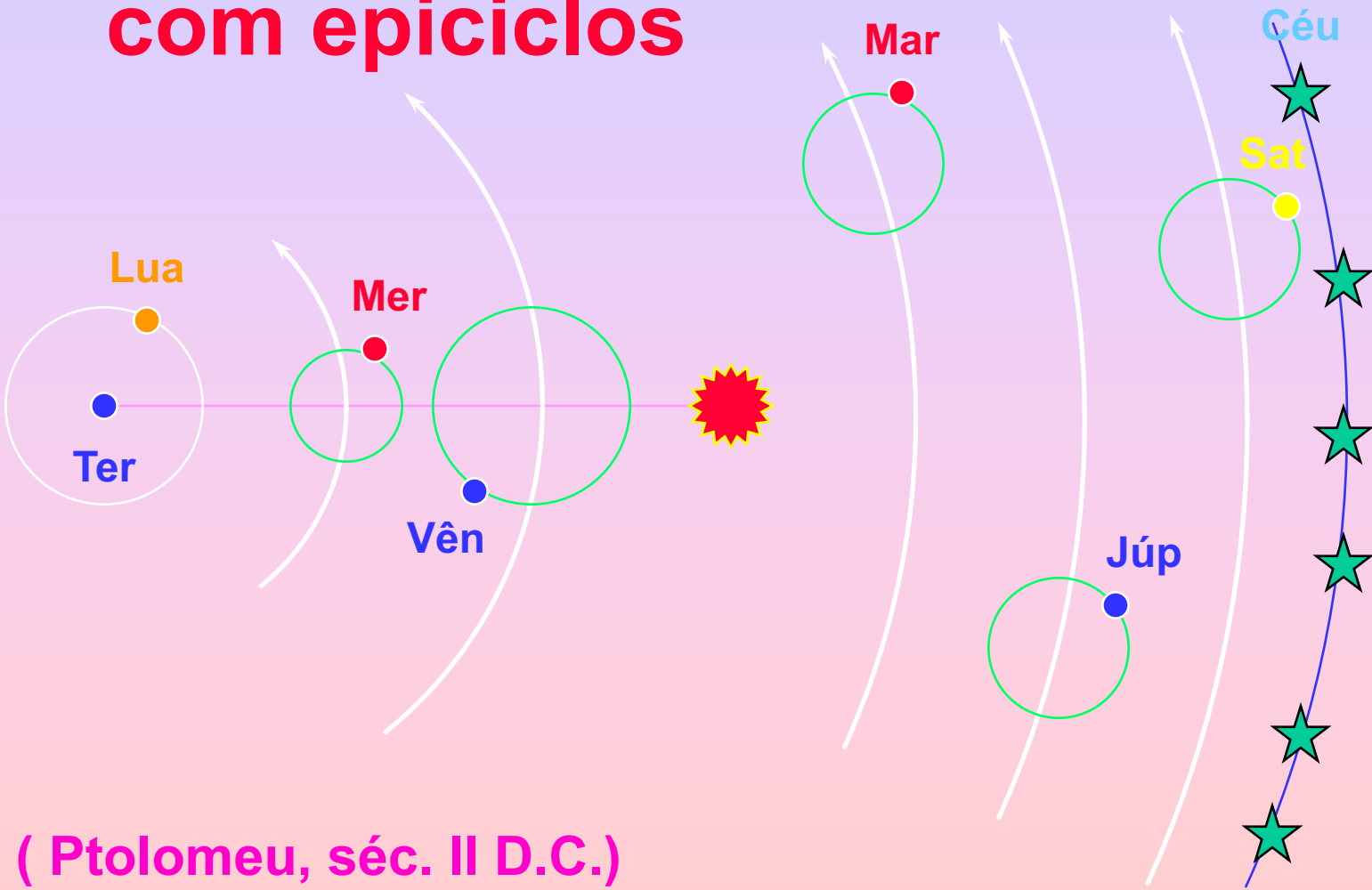
(Apolônio de Perga, 261 a.C. – 190 a.C.)



Sistema Complexo de Epiciclos



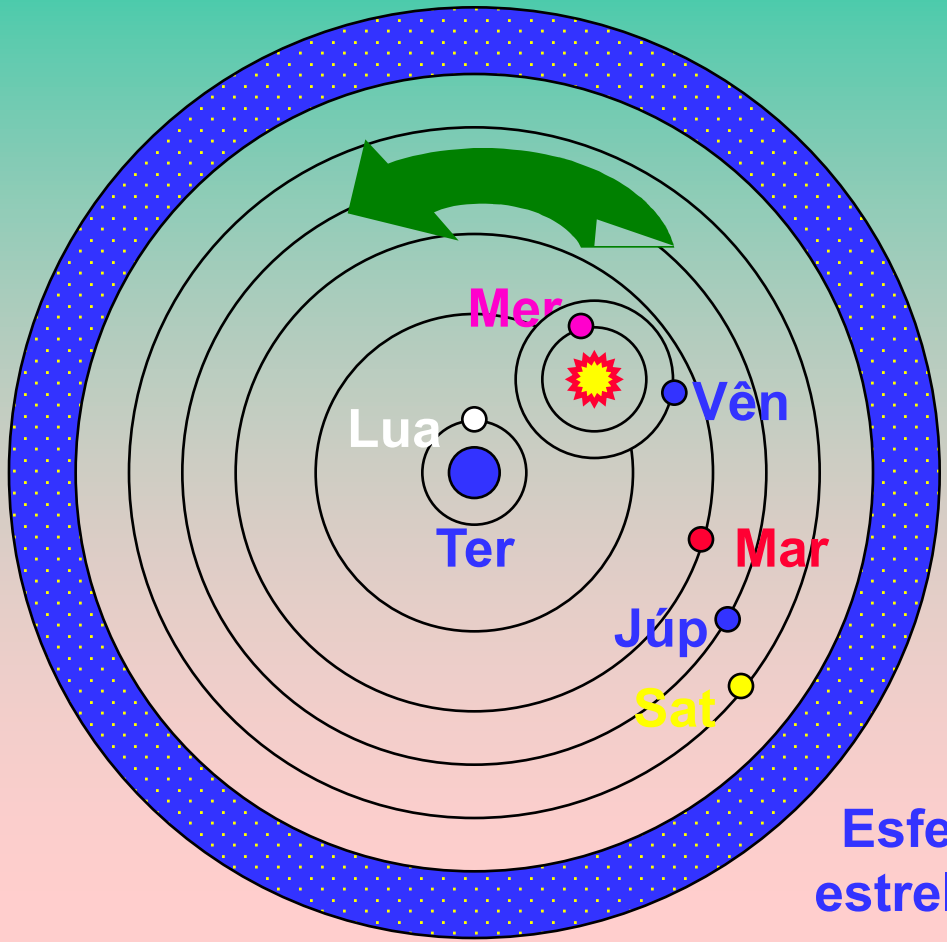
Geocentrismo com epiciclos



(Ptolomeu, séc. II D.C.)

Sistema Híbrido

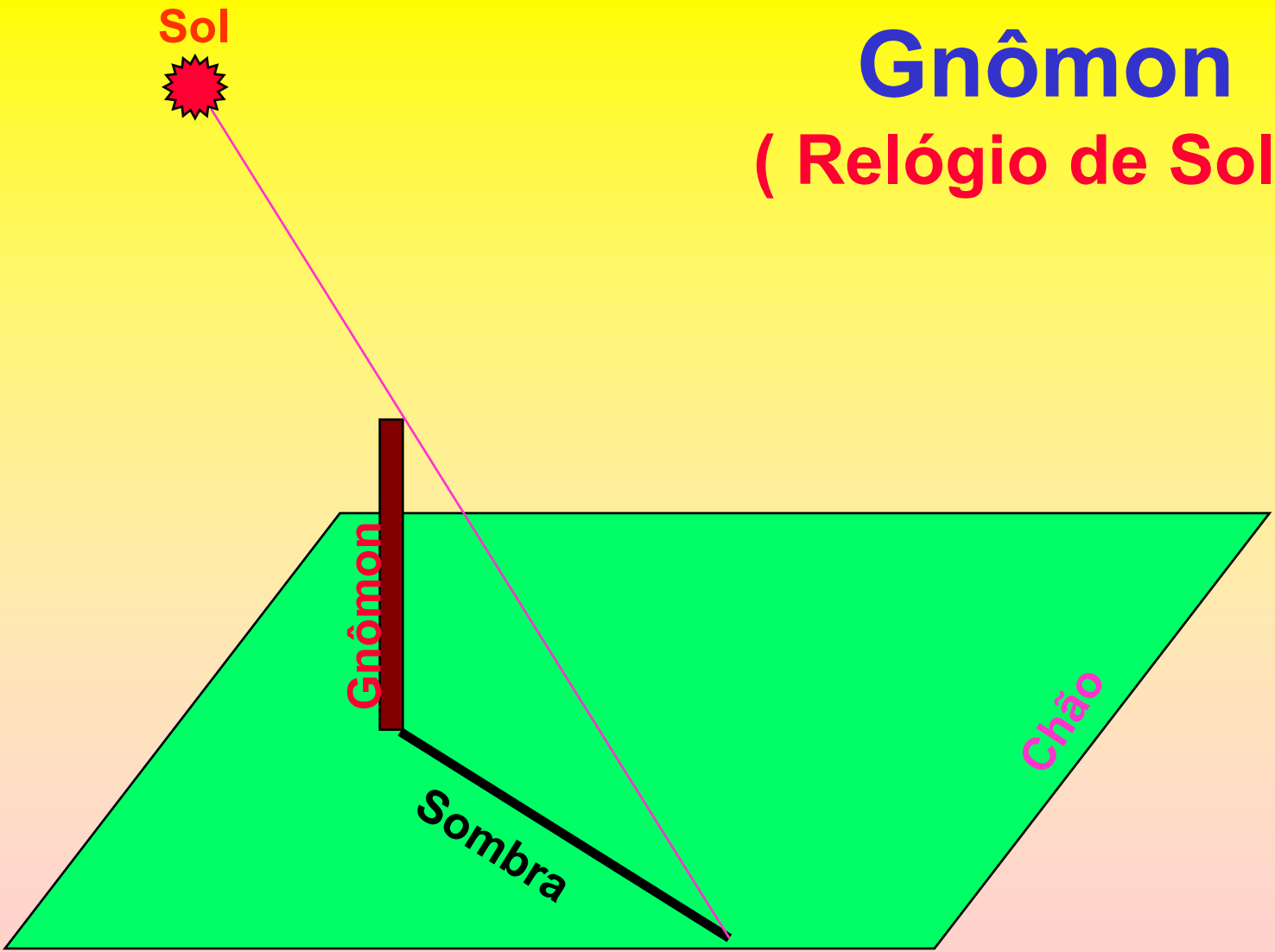
(Heráclides, séc. IV a .C.)



Instrumentos Astronômicos Antigos

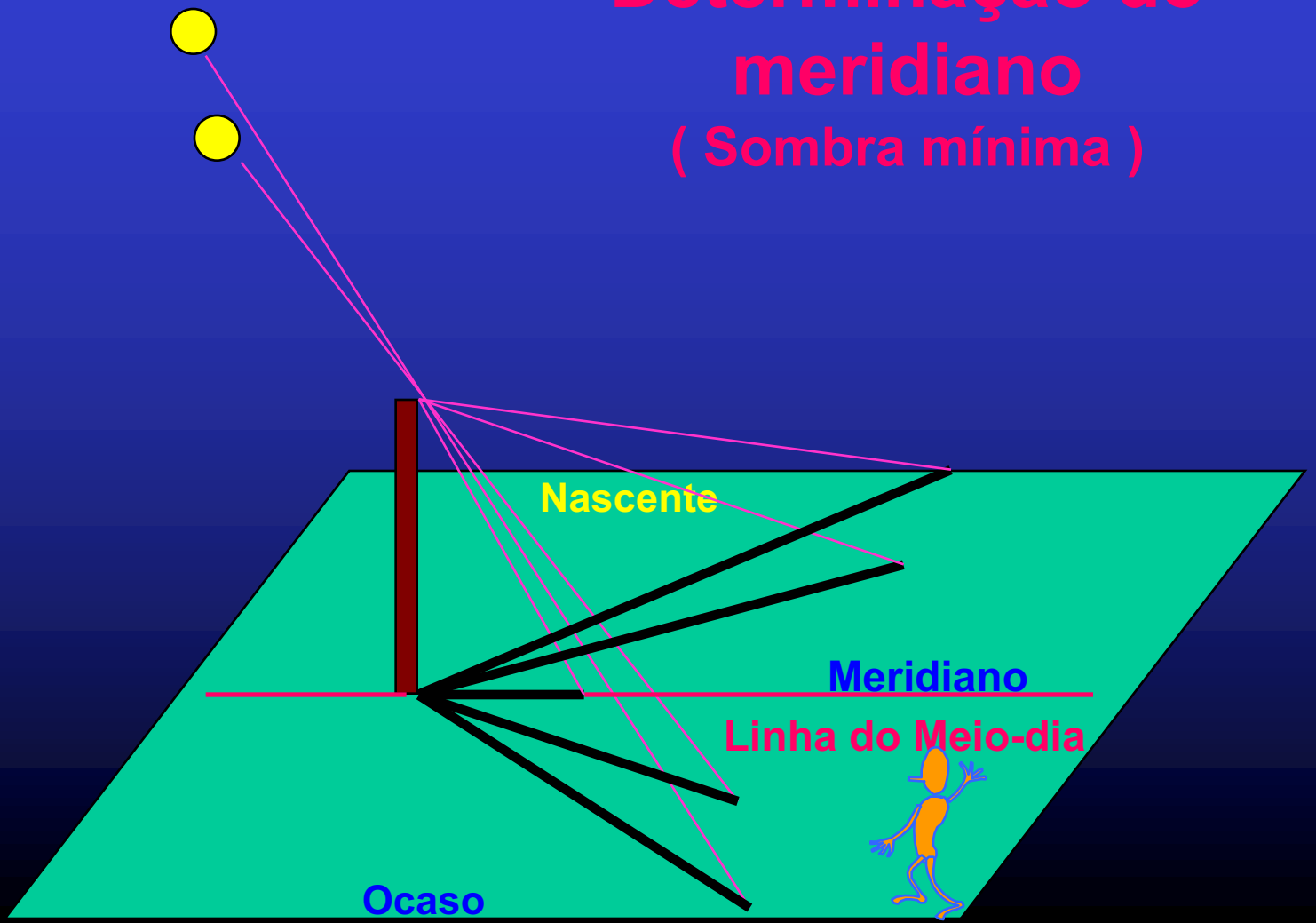
Gnômon

(Relógio de Sol)



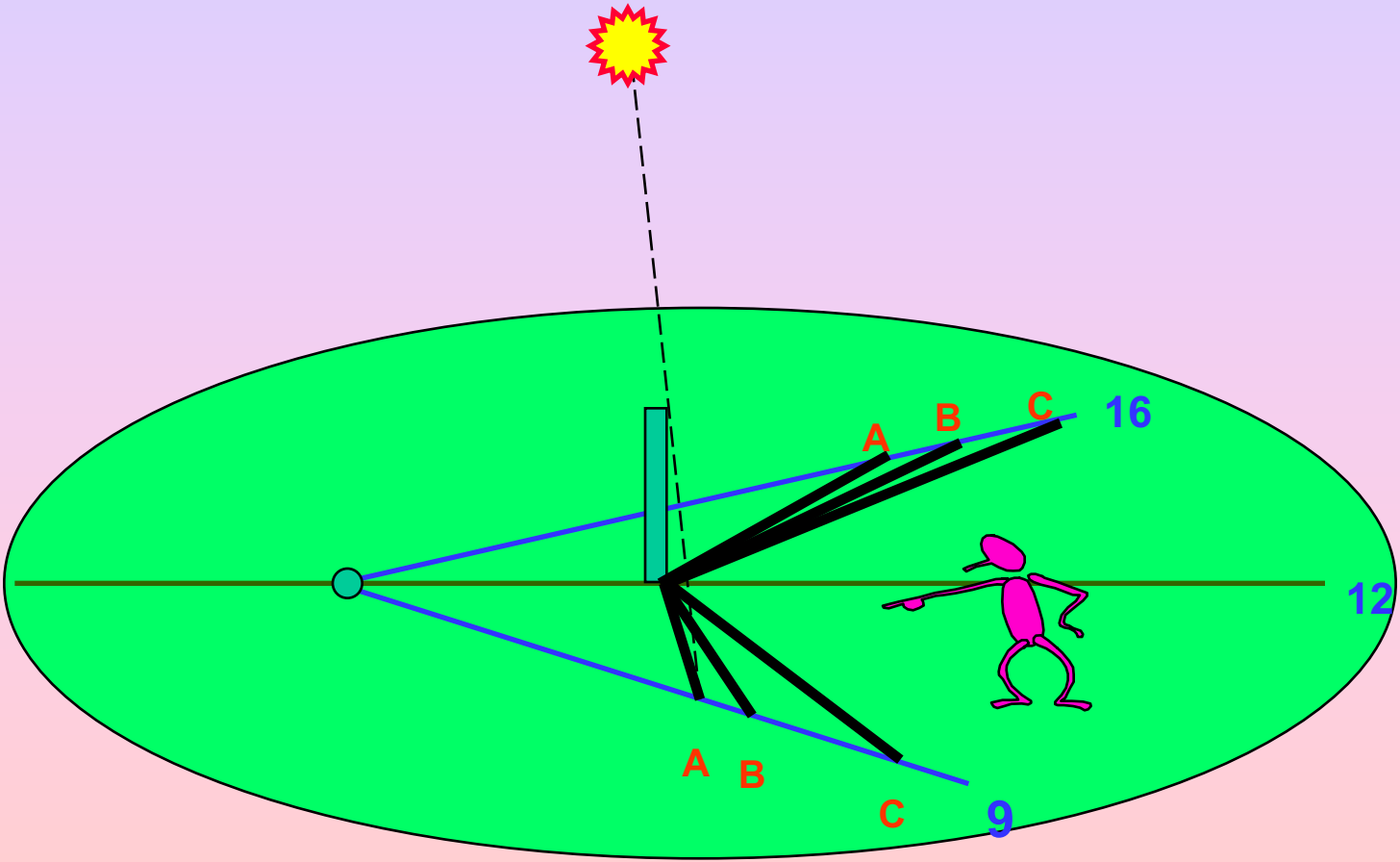
Determinação do meridiano

(Sombra mínima)

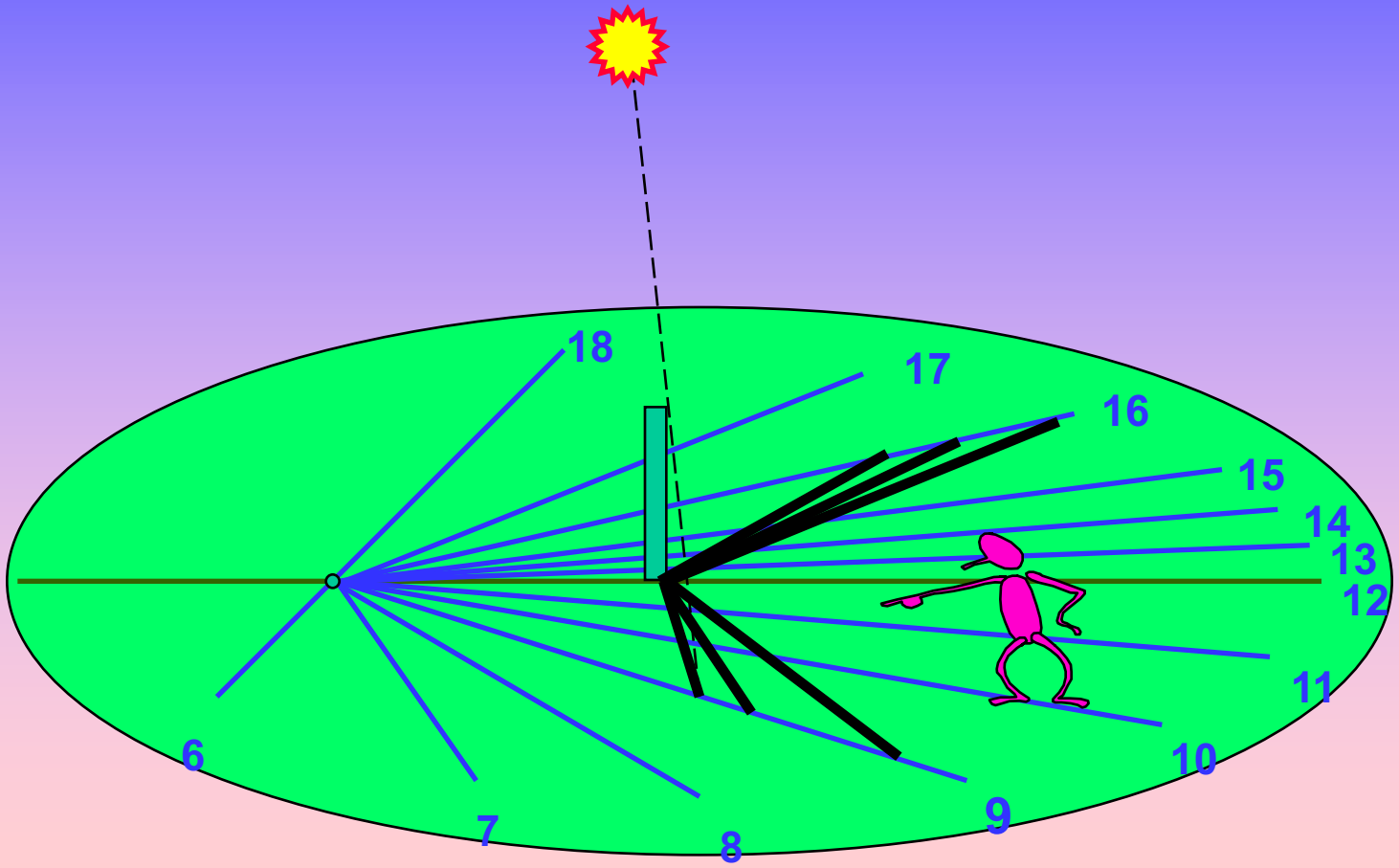


Relógios de Sol

Fundamentos do Gnômon com mostrador horizontal

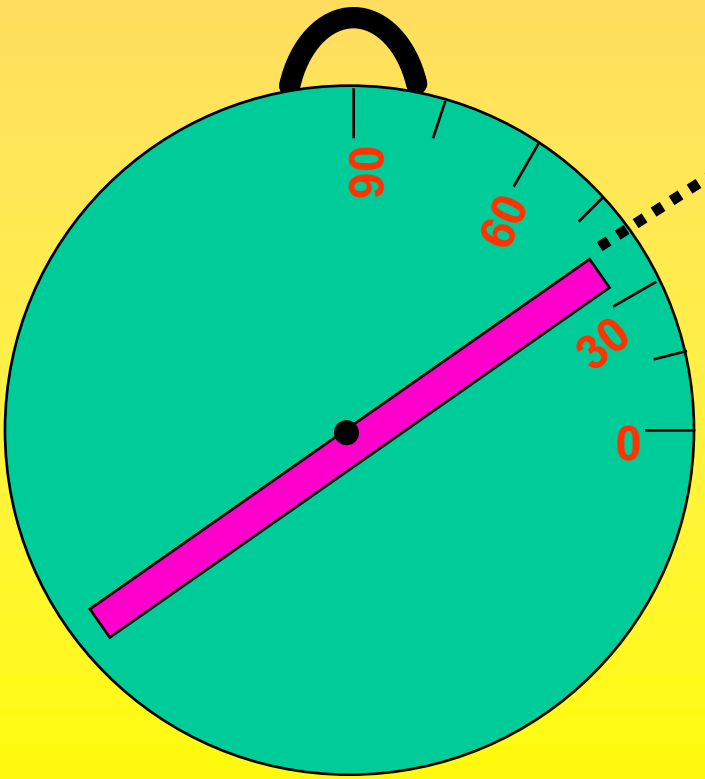


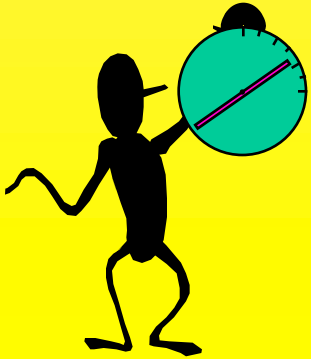
Gnômon com mostrador horizontal

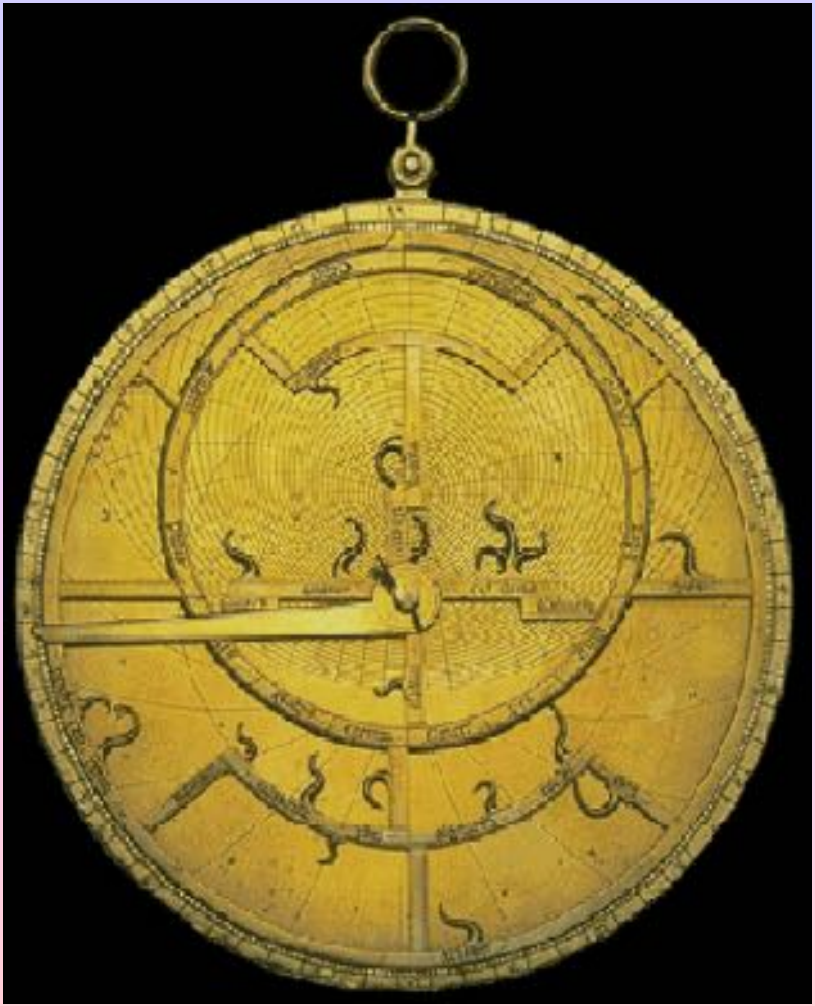


Astrolábio

(Origem Babilônica)





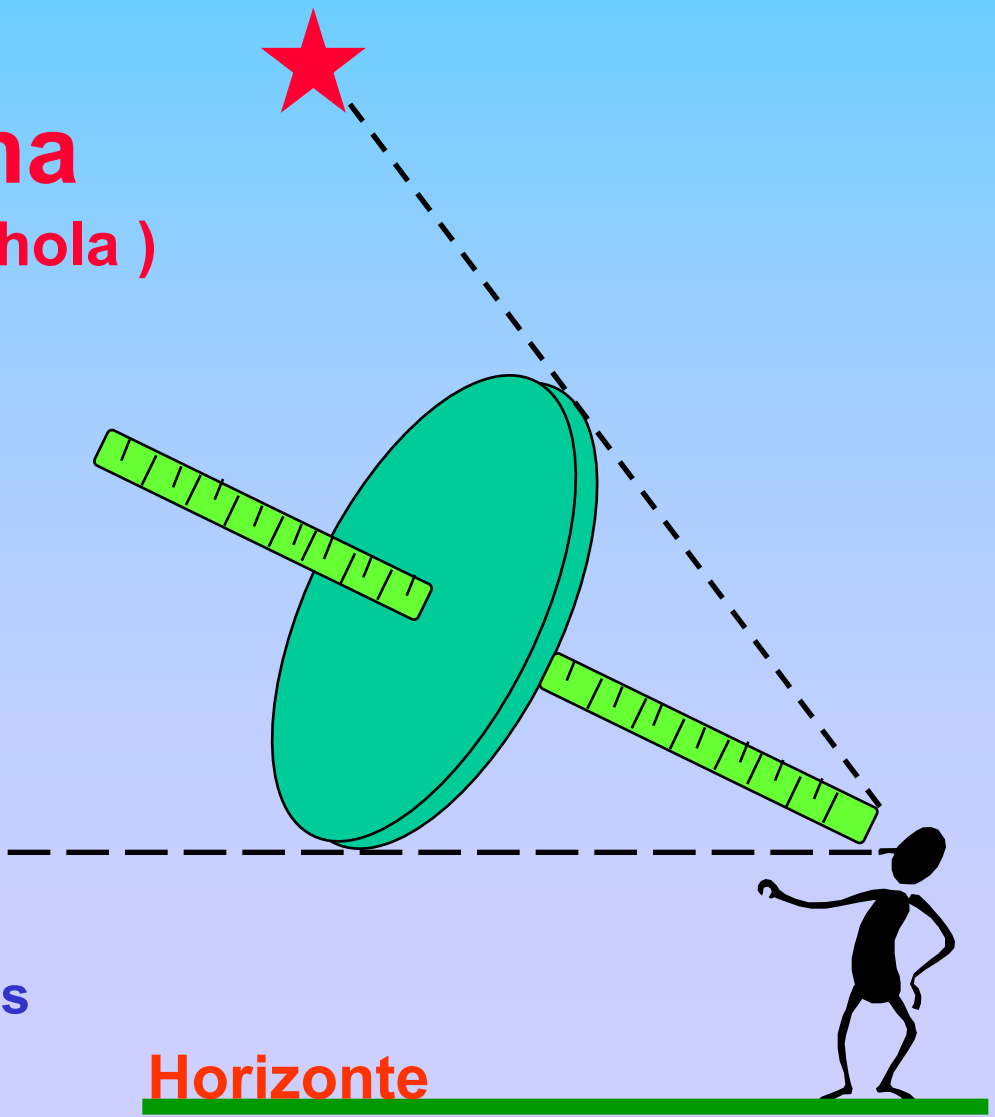


Astrolábio astronômico

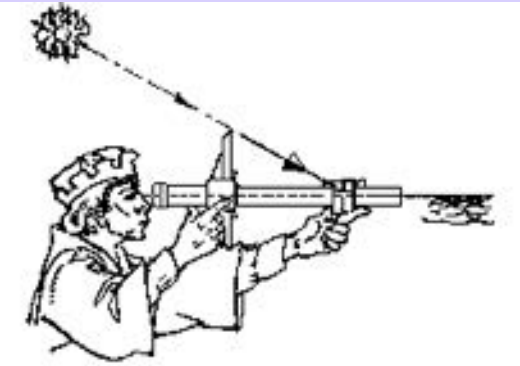
Astrolábio de marinheiro

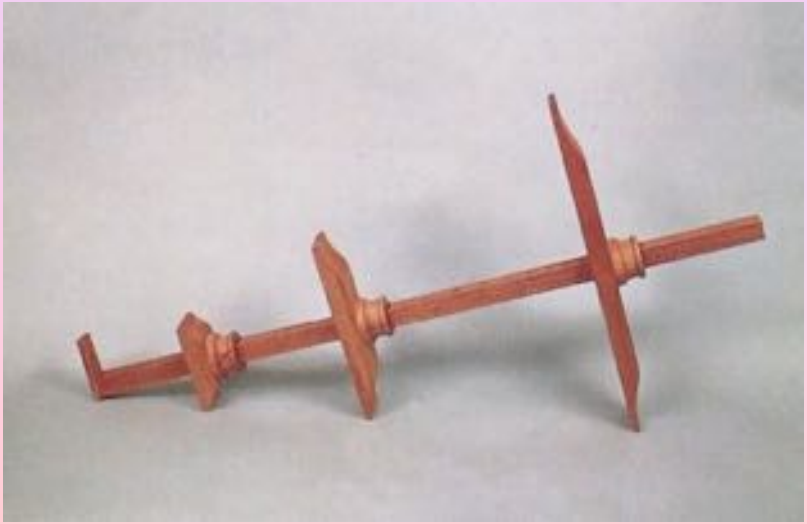
Balestilha

(Origem espanhola)

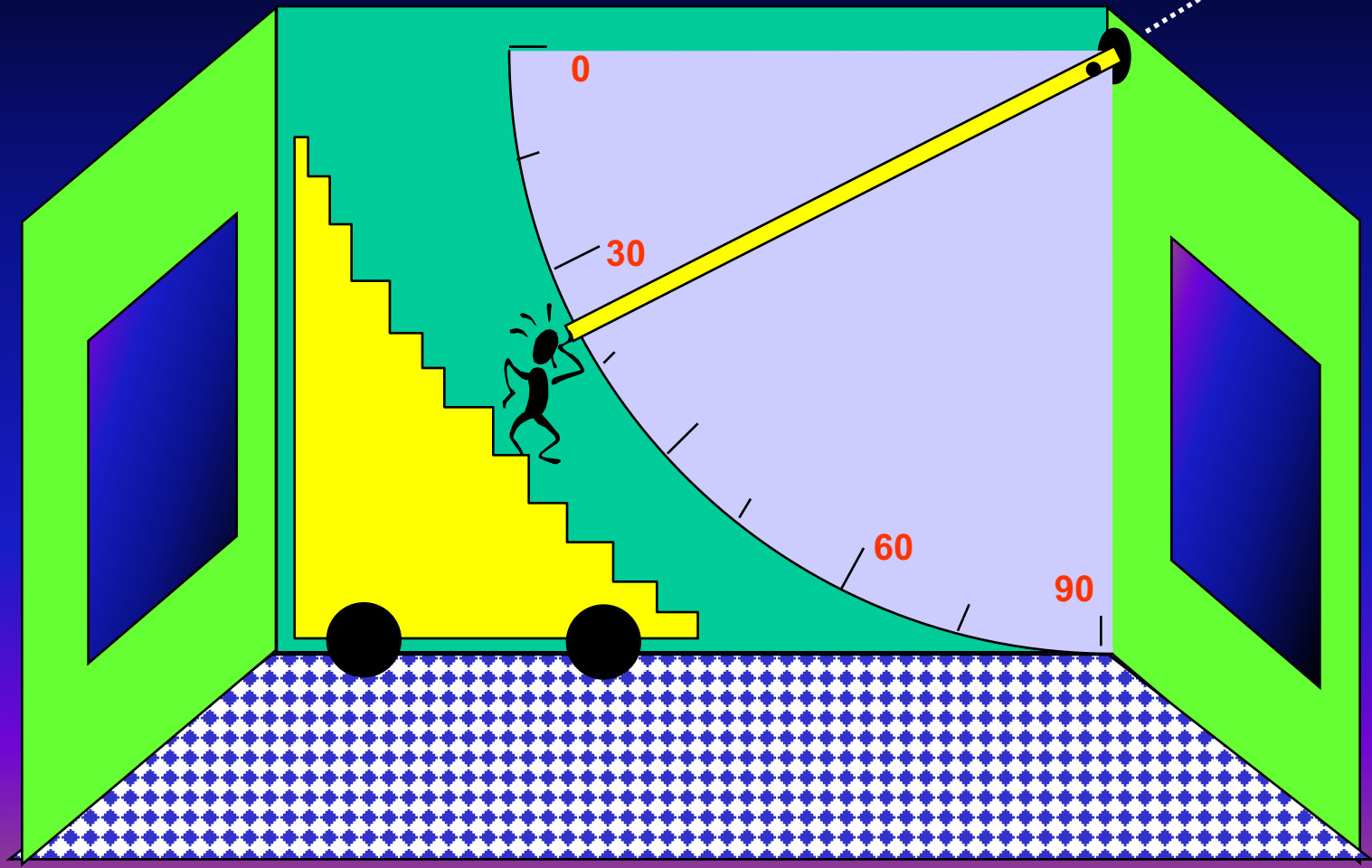


Usado pelo
Fernão de Magalhães



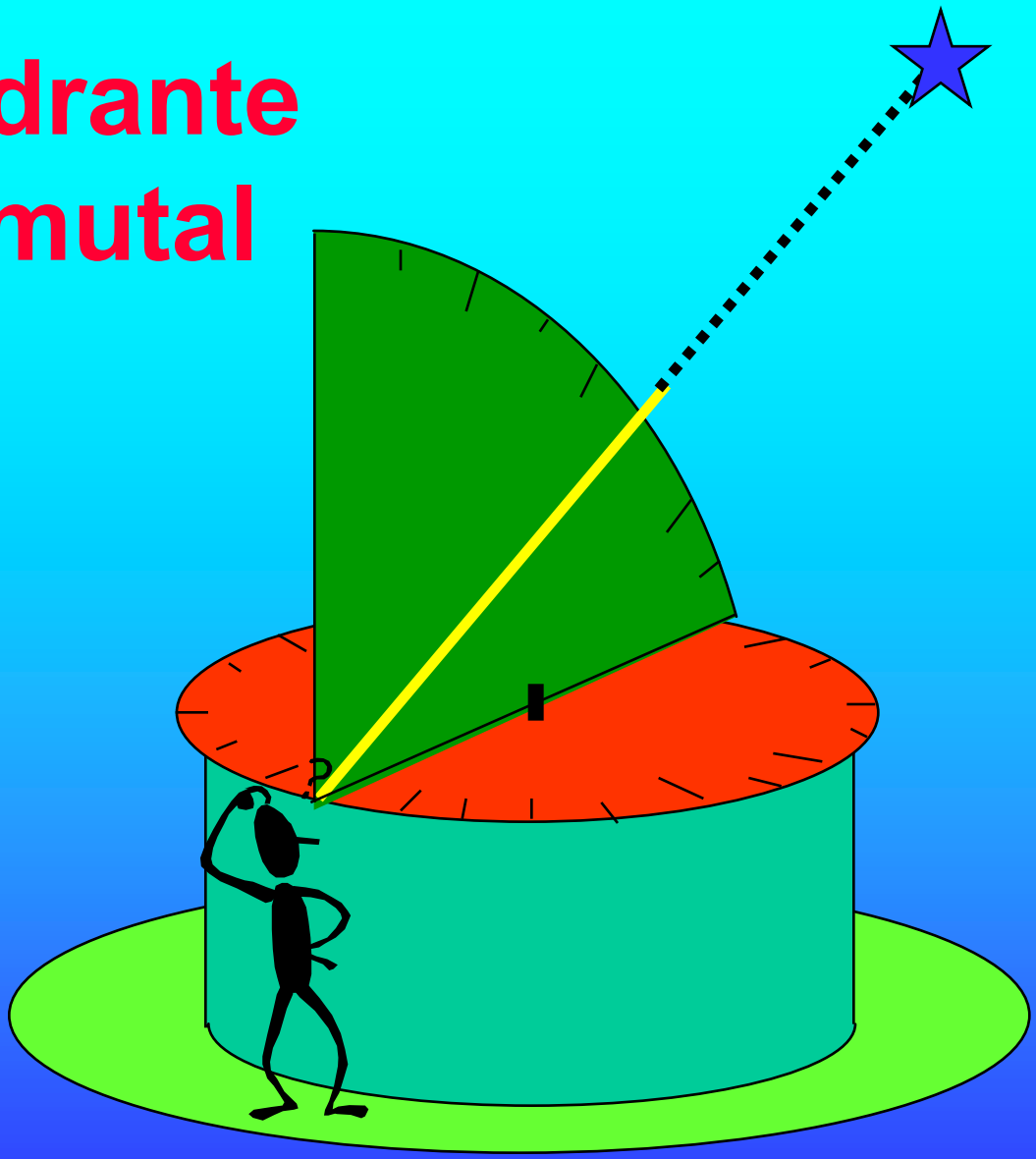


Quadrante Mural

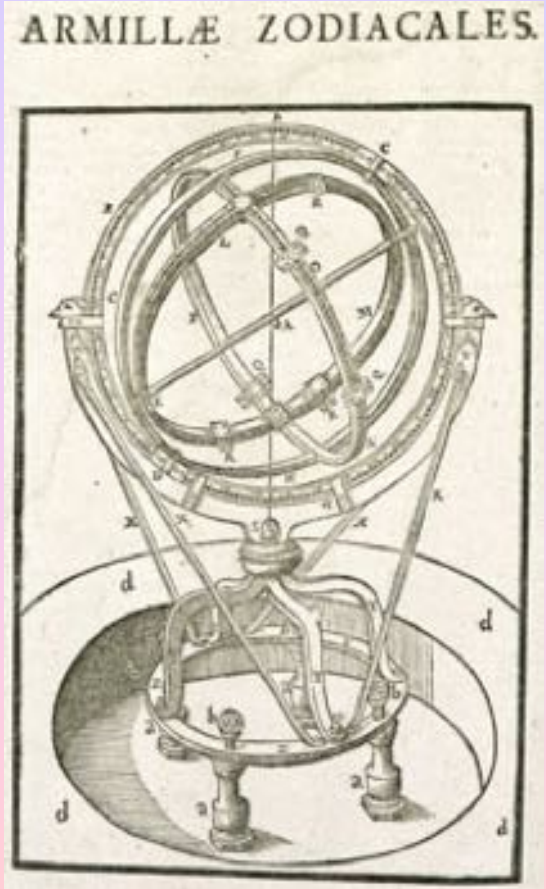


Quadrante mural do Observatório de Tycho Brahe da Ilha de Ven (Dinamarca)

Quadrante Azimutal



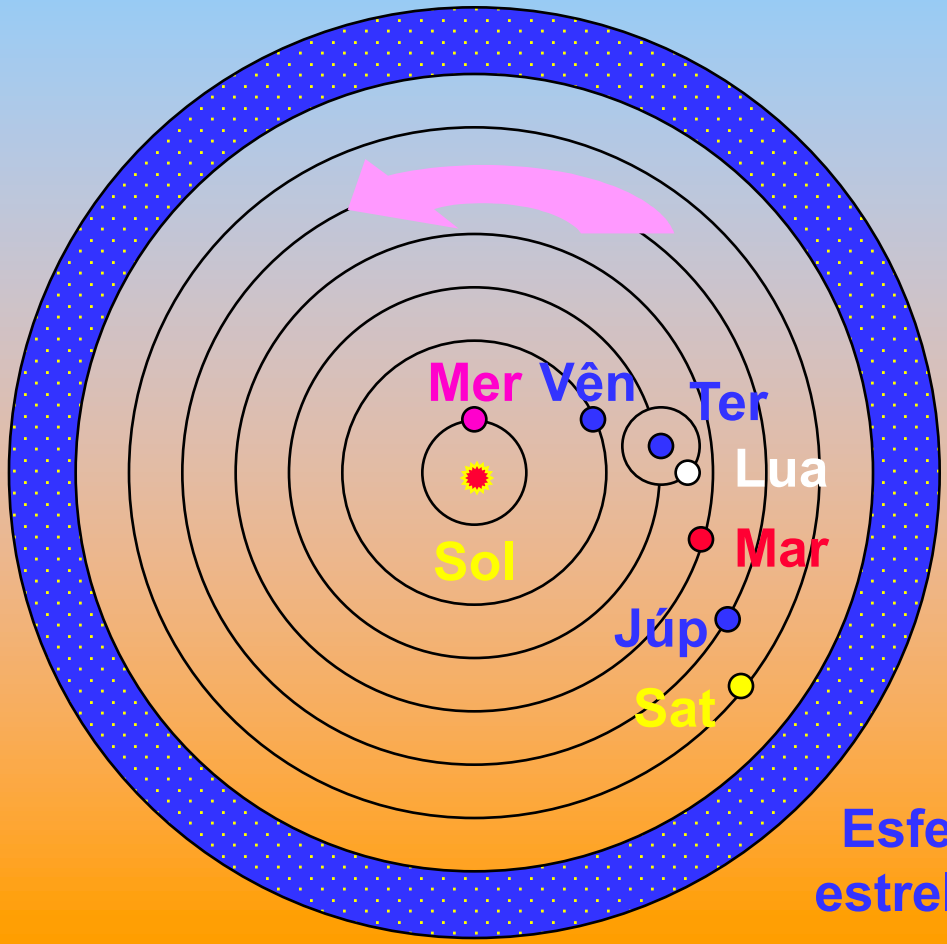
Extraído de uma obra de Tycho Brahe



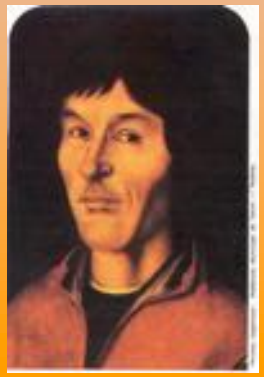
Esfera armilar moderna

Sistema Heliocêntrico

(Copérnico, séc. XVI)



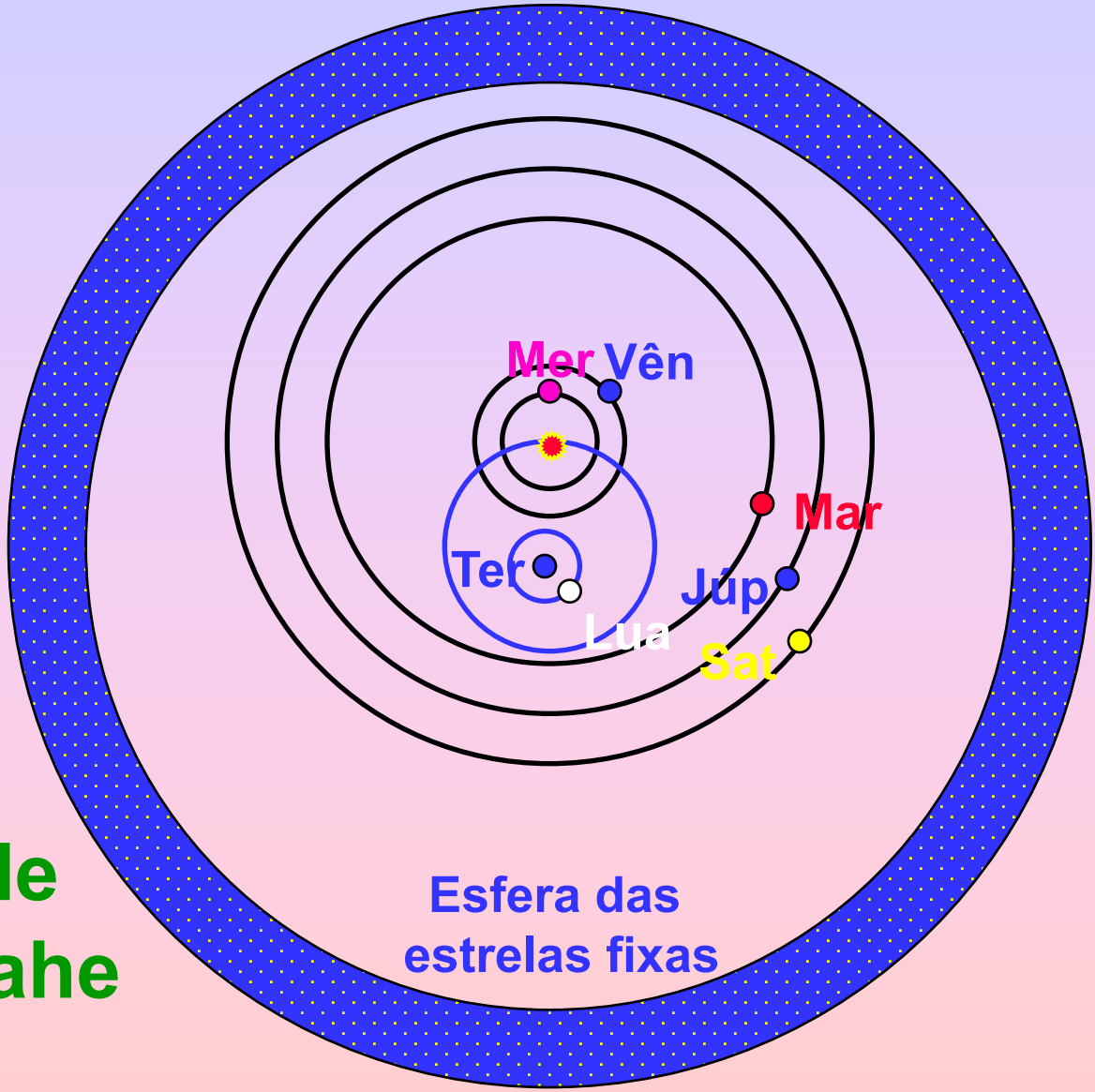
Copérnico
(Polônia)
1473 - 1543



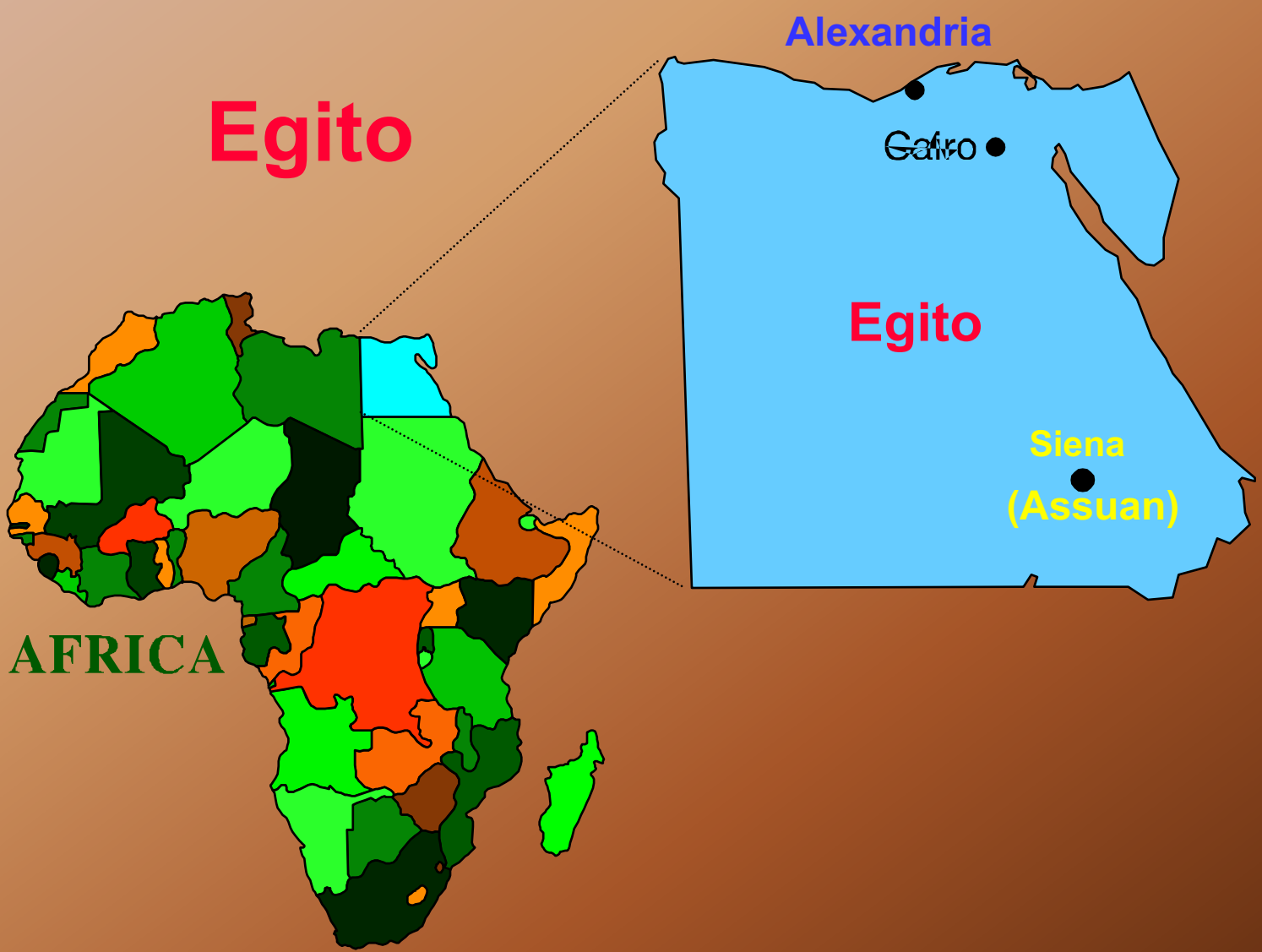
Sistema Heliocêntrico

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

Sistema de Tycho Brahe
(séc. XVI)

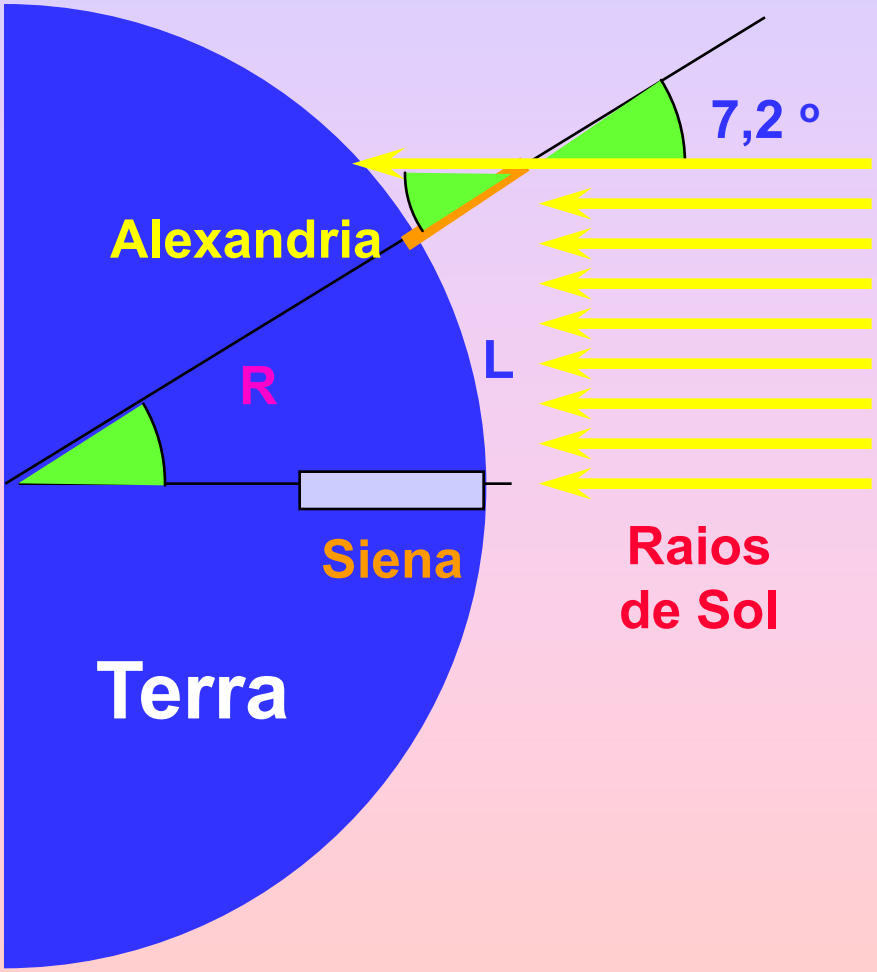


Distâncias no Sistema solar


Egito
Alexandria
Cairo
Egito
Siena
(Assuan)
AFRICA

Raio da Terra

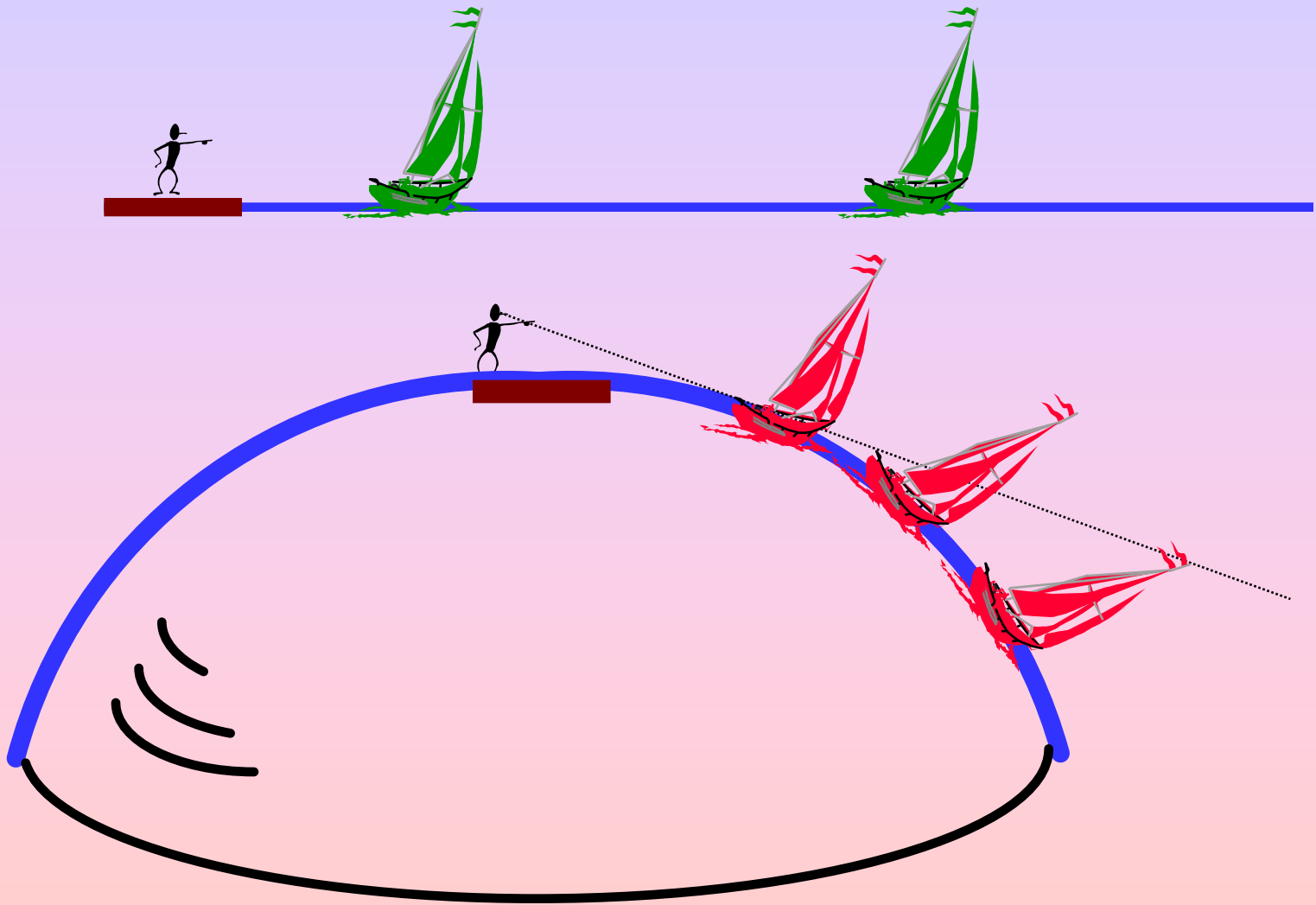
Eratóstenes
276 a.C. – 196 a.C.



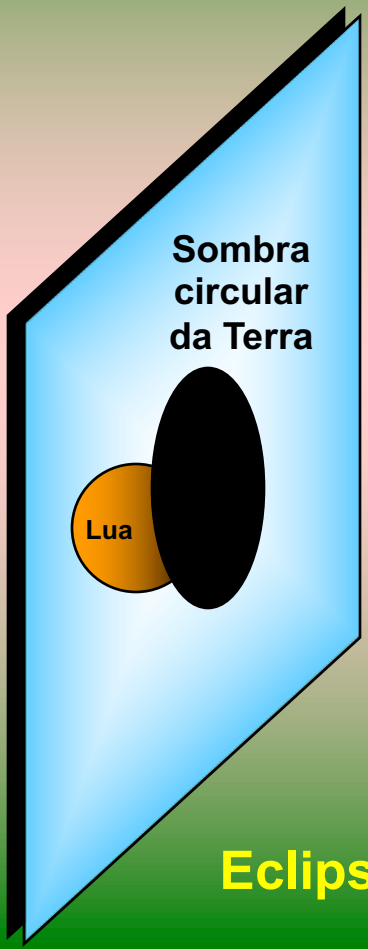
$$360\,° \_\_\_\_ 2\pi R$$
$$7{,}2\,° \_\_\_\_ L$$

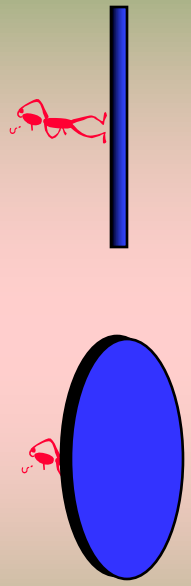
Mas... já se sabia que a Terra era esférica naquela época?

Esfericidade da Terra



Terra plana?



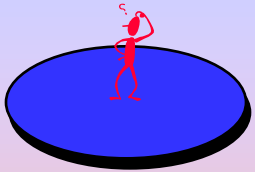


Terra plana

Eclipse lunar à meia-noite

Funciona!

Terra não é plana!

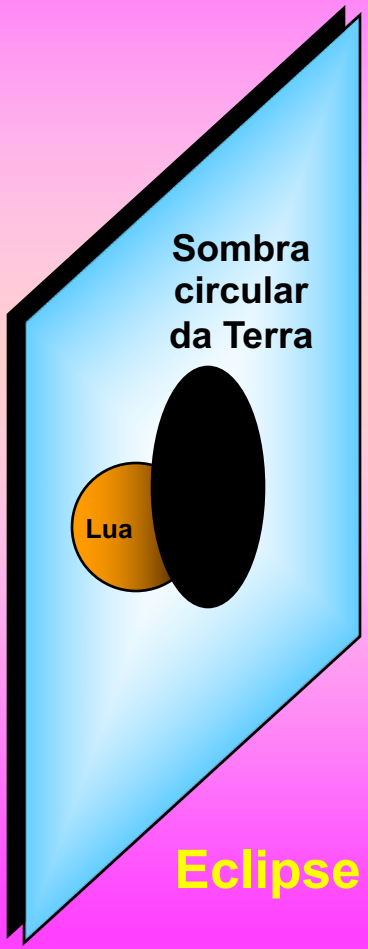


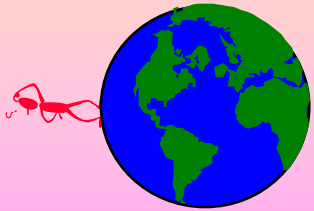
Terra plana

Eclipse lunar ao nascer ou ao ocaso do Sol

Não funciona!

Terra tem que ser esférica!





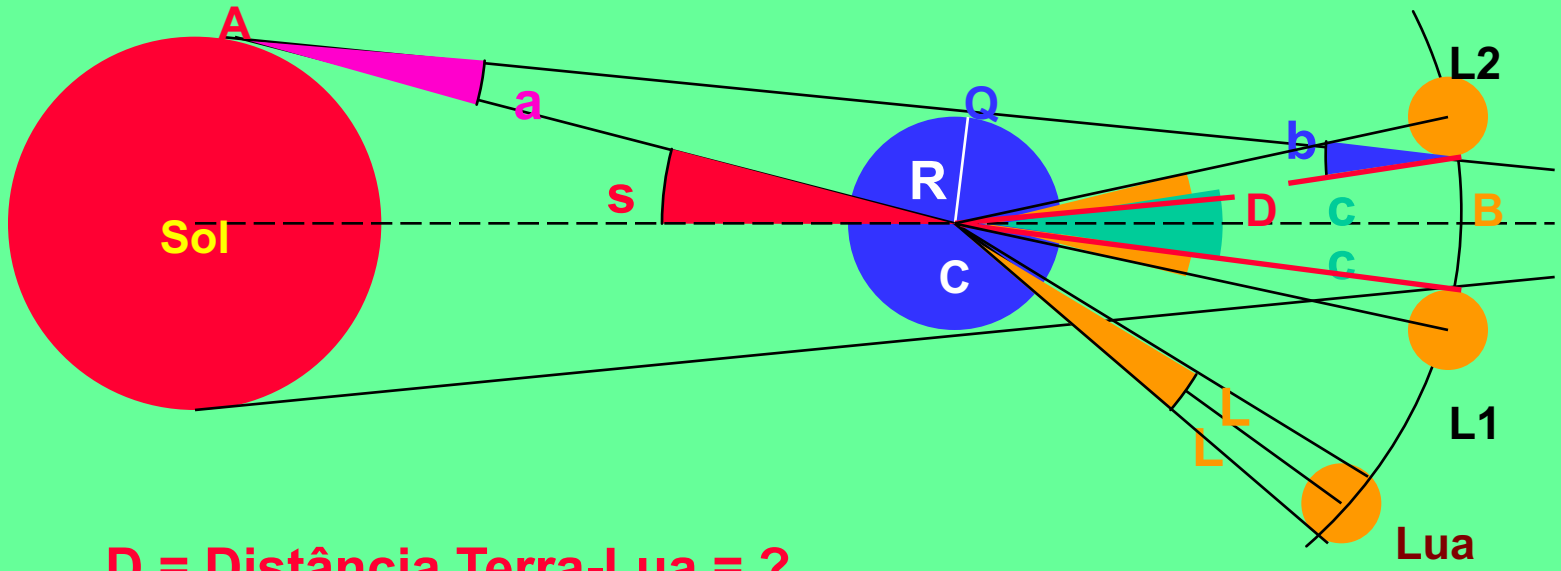
Terra esférica

Eclipse lunar a qualquer hora

Funciona!

Distância da Terra à Lua

(Hiparcos, séc. II a .C.)



D = Distância Terra-Lua = ?

R = raio da Terra

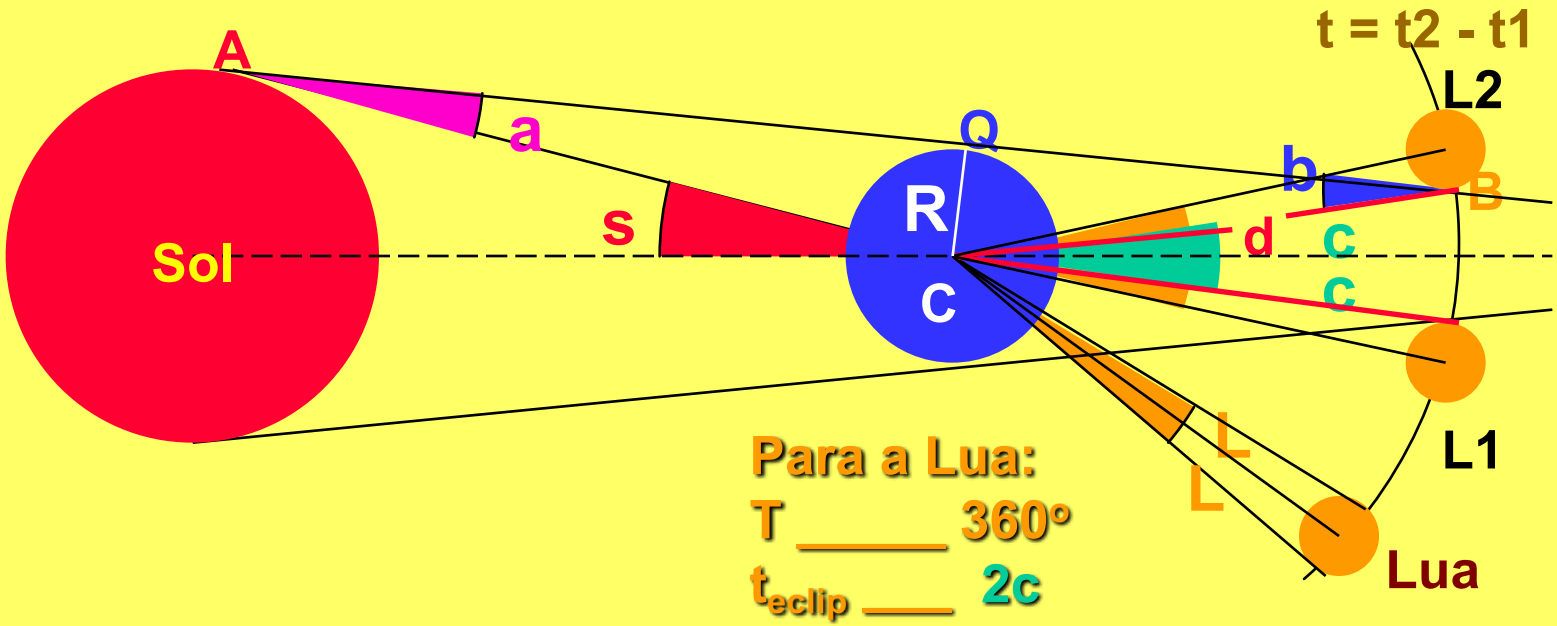
L = semi-diâmetro angular da Lua ~16' (medido)

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: $a + b + x = 180^o$

Ângulo raso em C: $s + x + c = 180^o$

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

$$a + b = s + c$$

$$a \sim 0$$

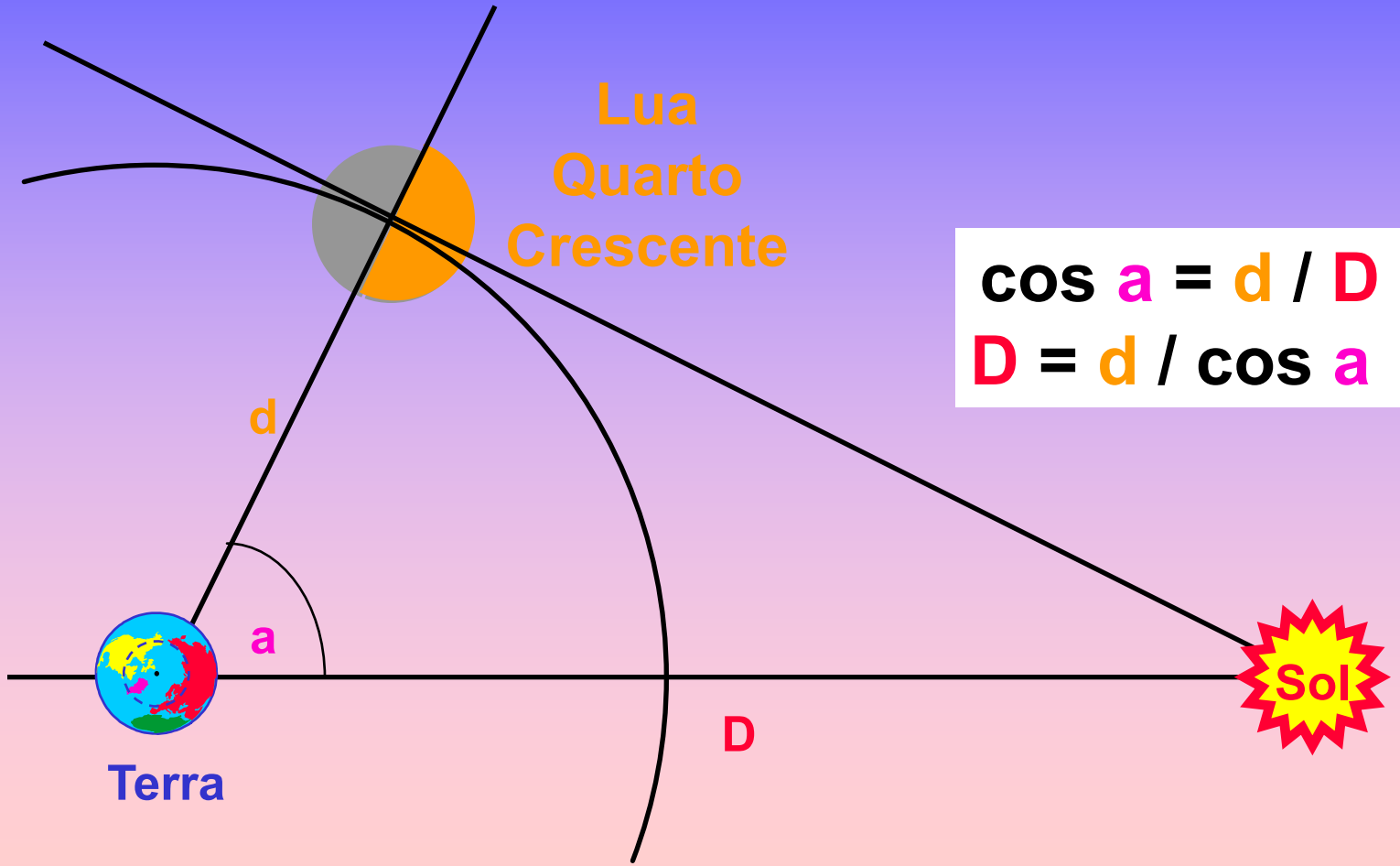
$$b = s + c$$

No triângulo BCQ: $\text{sen } b = R / d$

Logo: $d = R / \text{sen } b$

Distância da Terra ao Sol

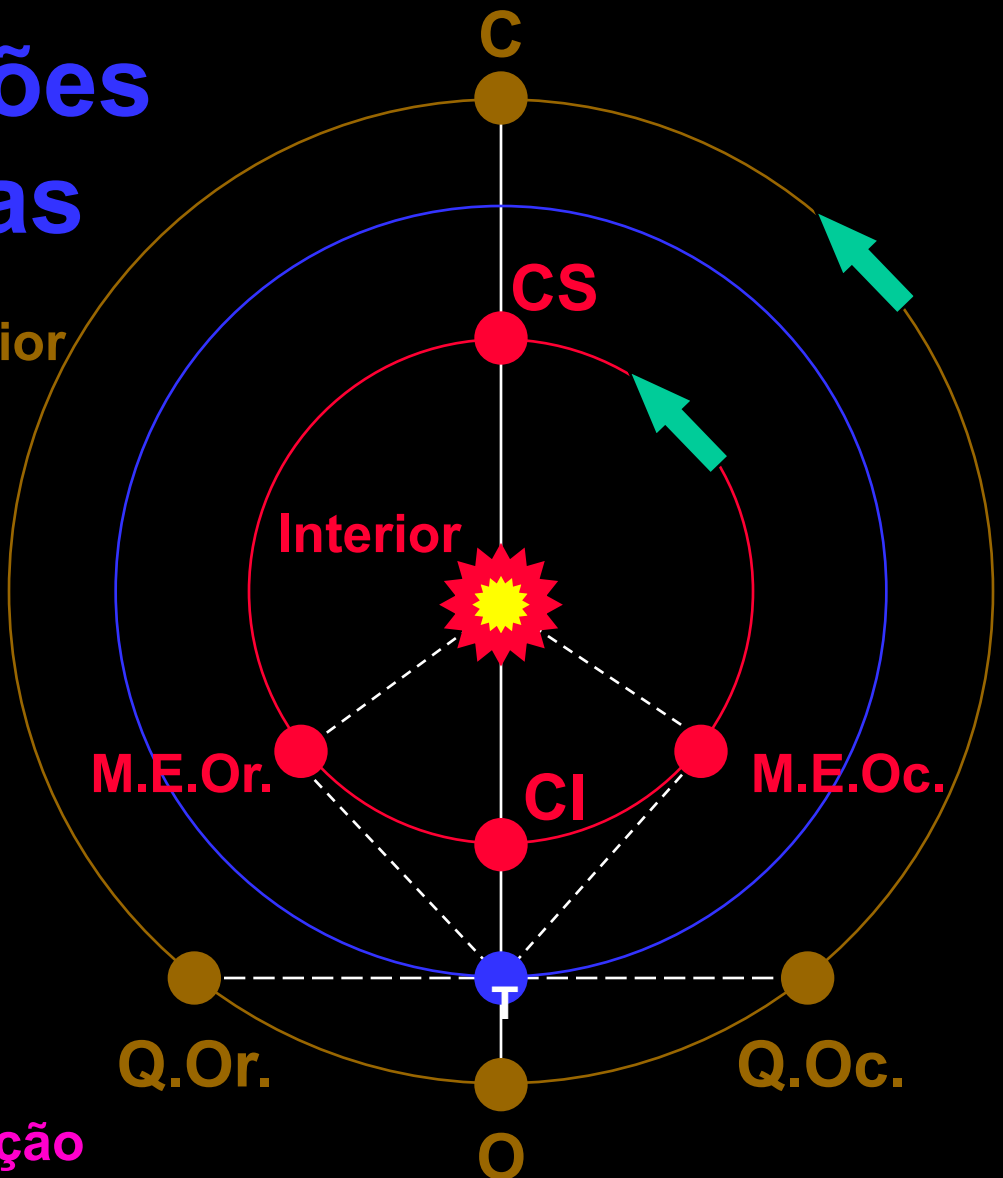
(Aristarco, grego, 320 a.C. – 250 a.C.)



$$\cos a = d / D$$

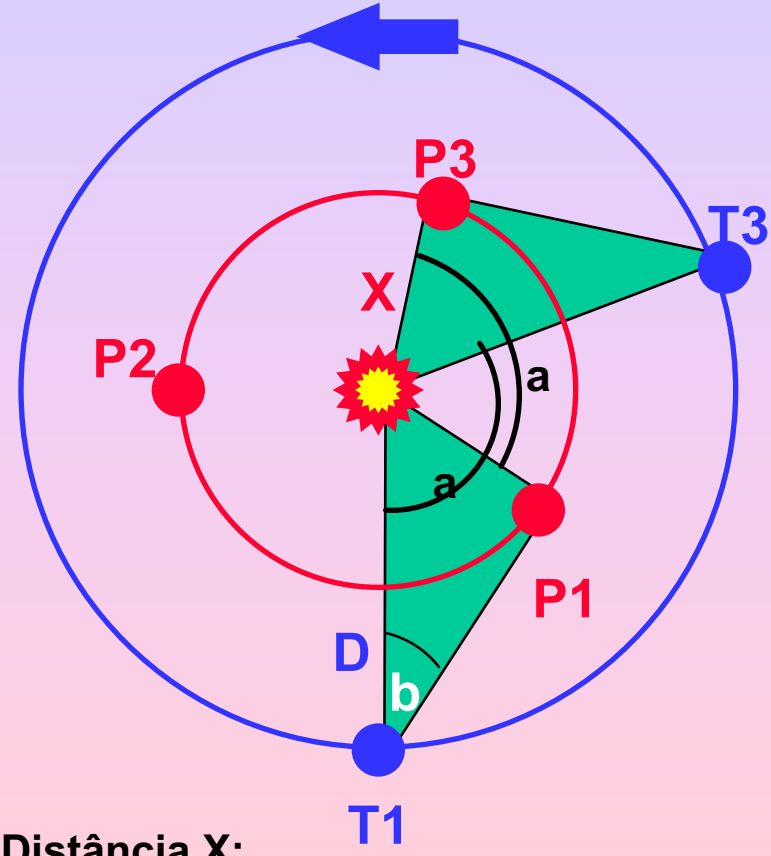
$$D = d / \cos a$$

Configurações Planetárias



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

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



Distância X:
Na máxima elongação
sen b = X / D
X = D . sen b

Períodos: em dois períodos sinódicos sucessivos

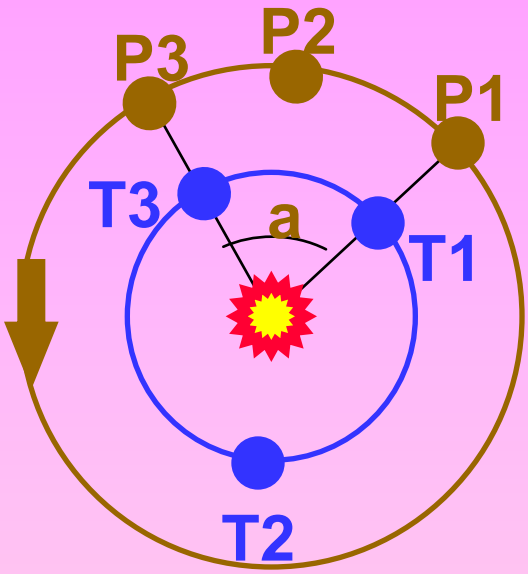
S = t3 - t1 = Per. Sinódico
T = ? = Per. Orbital
A = 365,25 (Orb. da Terra)

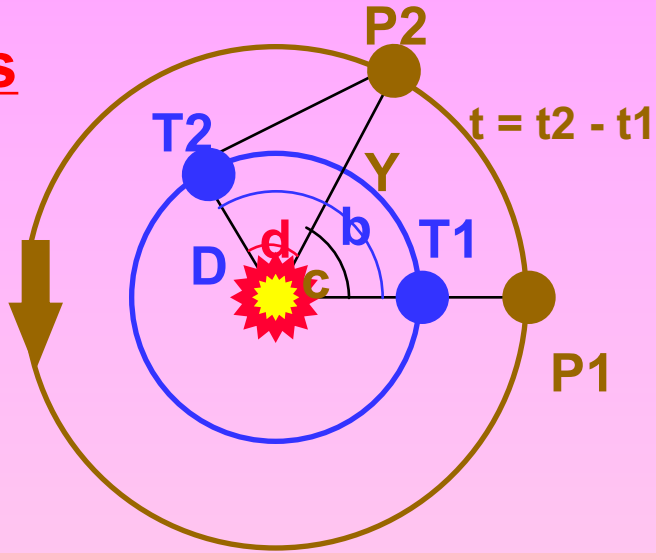
Terra
A ____ 360^0
S ____ a

Planeta
S ____ 360 + a
T ____ 360^0

1/T = 1/A + 1/S

Planetas Exteriores





Período: em duas oposições sucessivas

Terra
A ___ 360 ^{0}
S ___ 360 + a

Planeta
S ___ a
T ___ 360 ^{0}

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

Raio orbital: duma oposição à próxima quadratura

Terra
A ___ 360 ^{0}
t ___ b

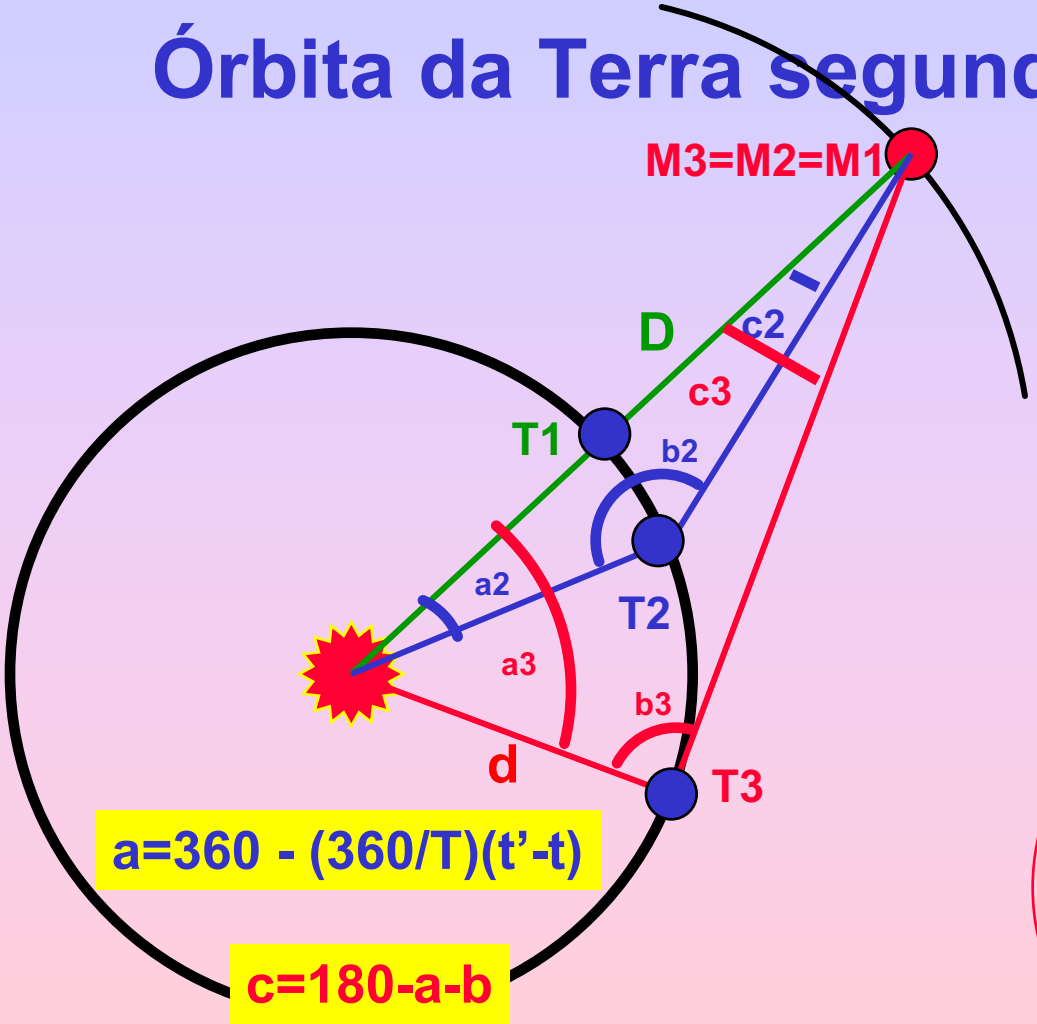
Planeta
T ___ 360 ^{0}
t ____ c

$$d = b - c$$
$$\cos d = D / Y$$
$$Y = D / \cos d$$

Mas será que as órbita dos planetas são mesmo circulares?

Johann Kepler
1571 - 1630

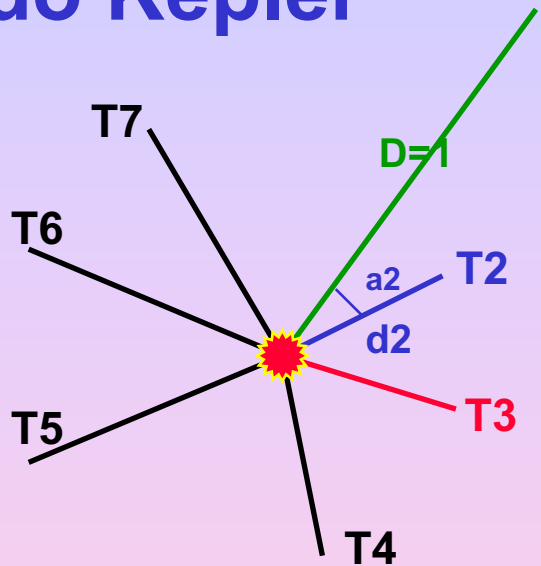
Órbita da Terra segundo Kepler

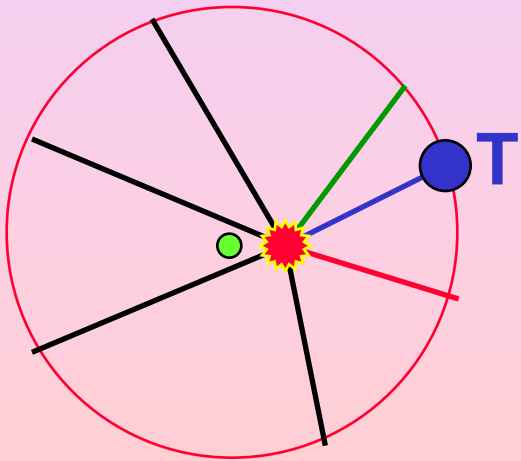


$a = 360 - (360/T)(t' - t)$

$c = 180 - a - b$

$d / \sin(C) = D / \sin(b)$





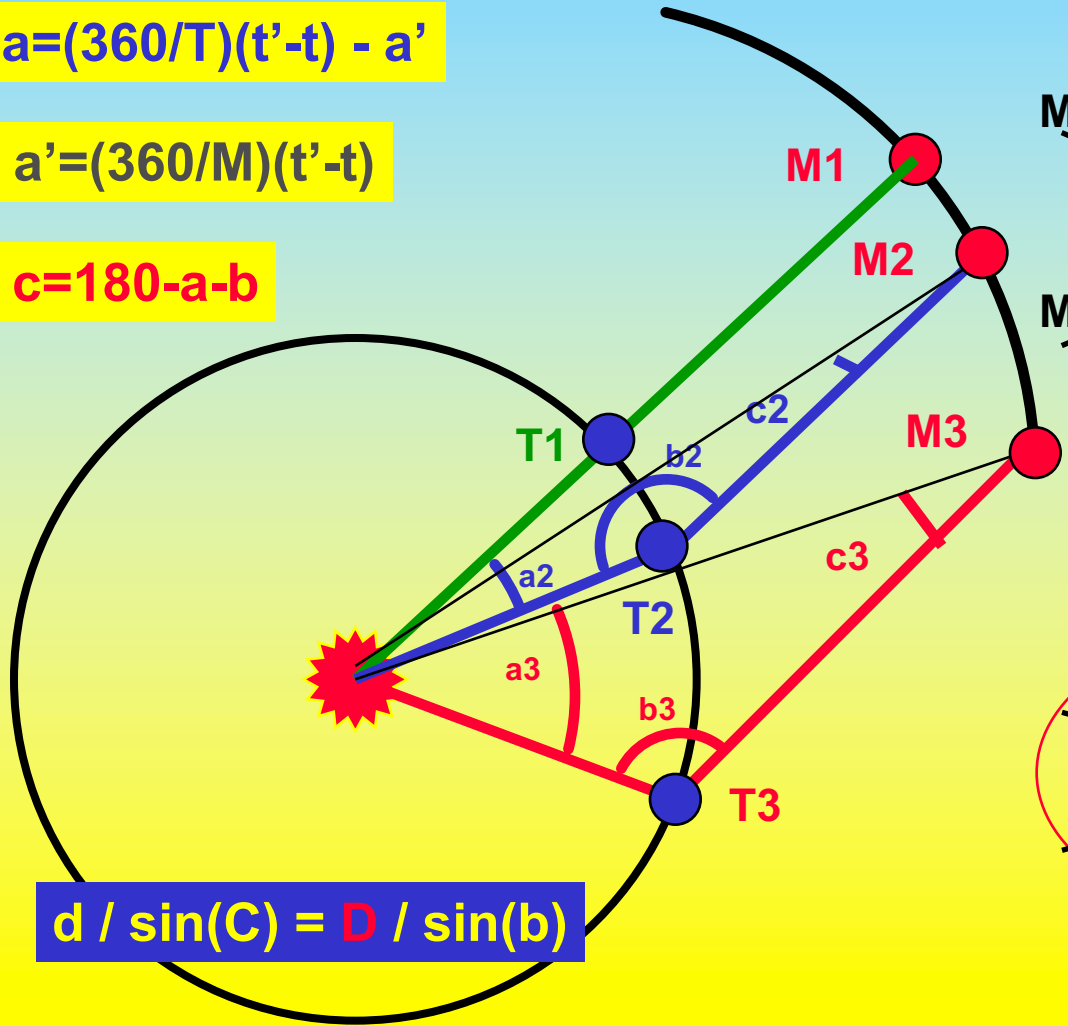
Circunferência excêntrica ?

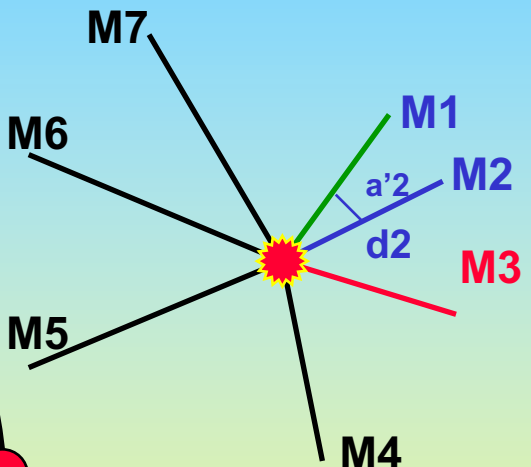
Órbita de Marte segundo Kepler

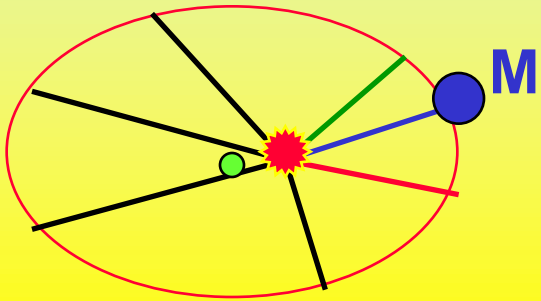
$a=(360/T)(t'-t) - a'$

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

$c=180-a-b$





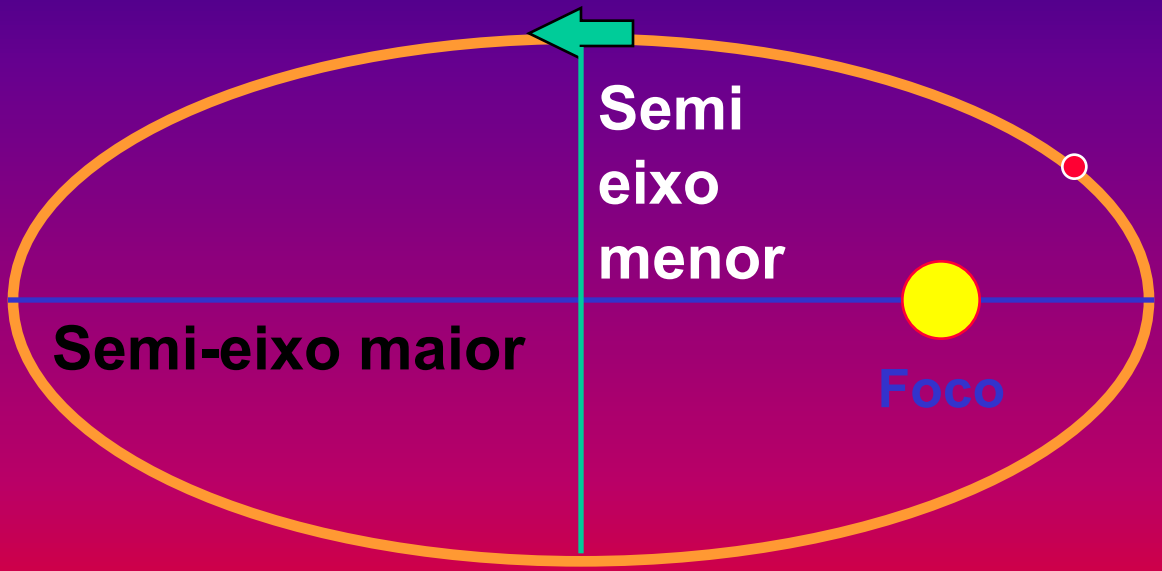


$d / \sin(C) = D / \sin(b)$

Elipse !

Leis de Kepler

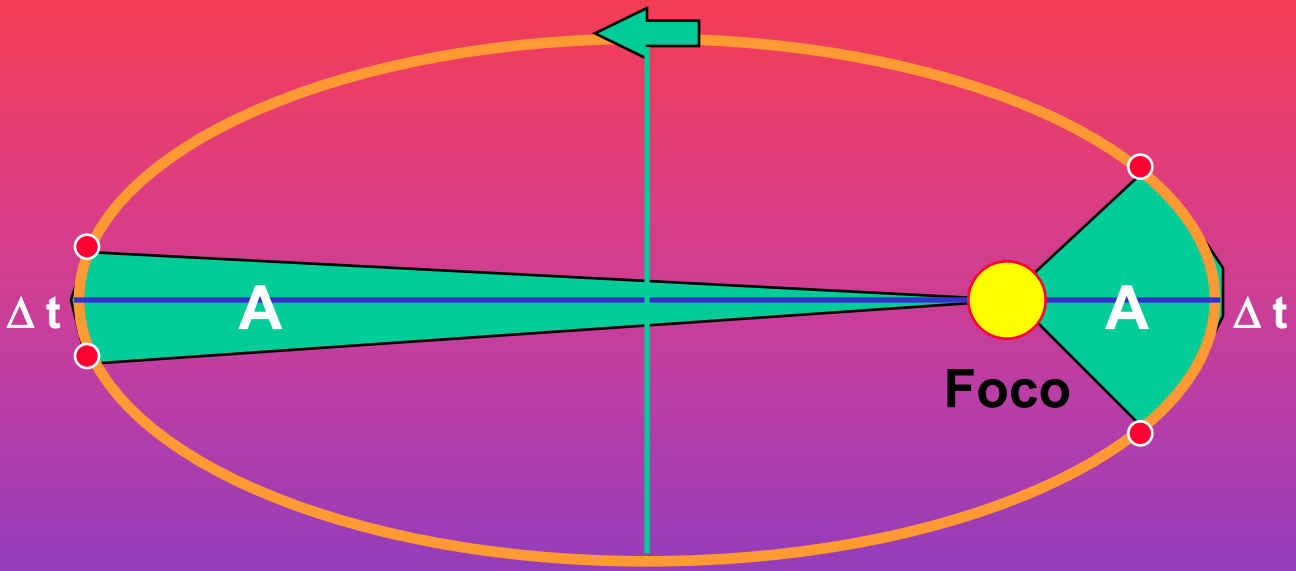
Primeira Lei de Kepler
(1571 - 1630)



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

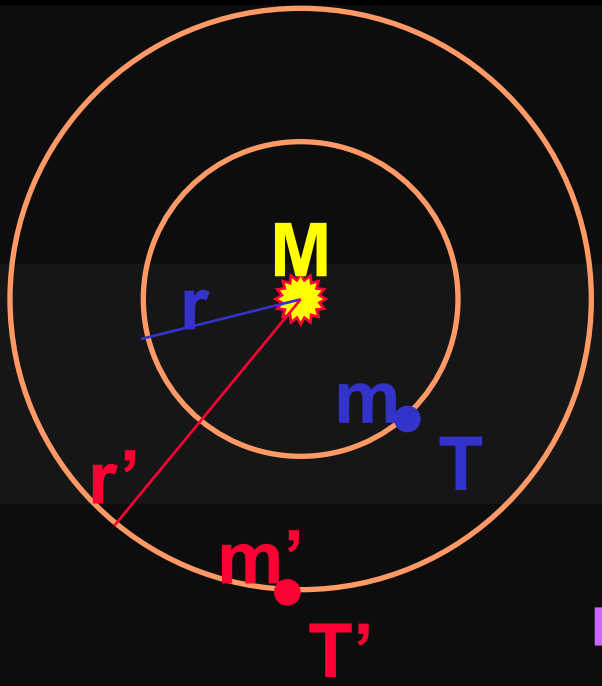
Segunda Lei de Kepler

(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

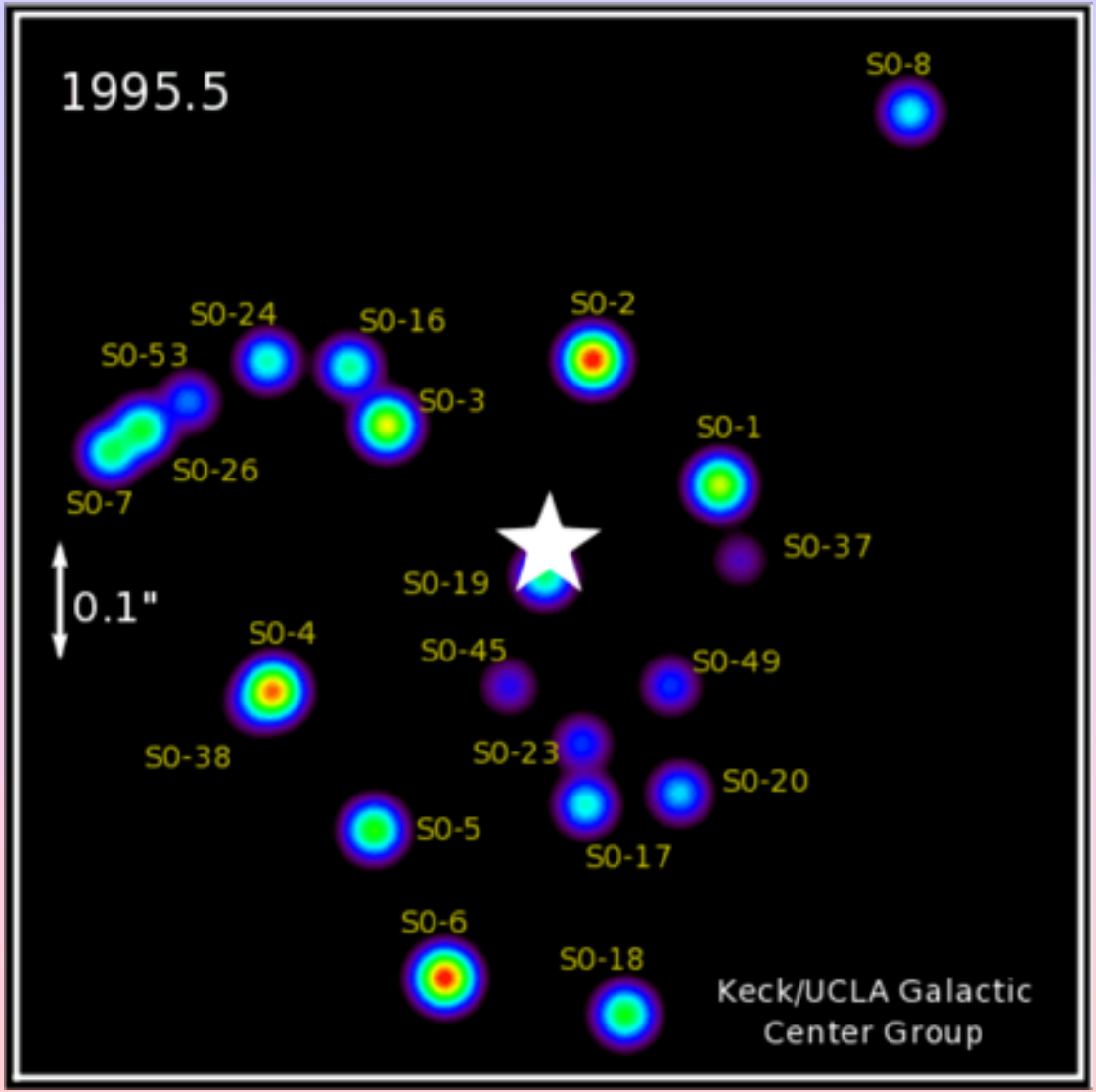


$$\left(r / r' \right)^3 = \left(T / T' \right)^2$$

Expressão correta:

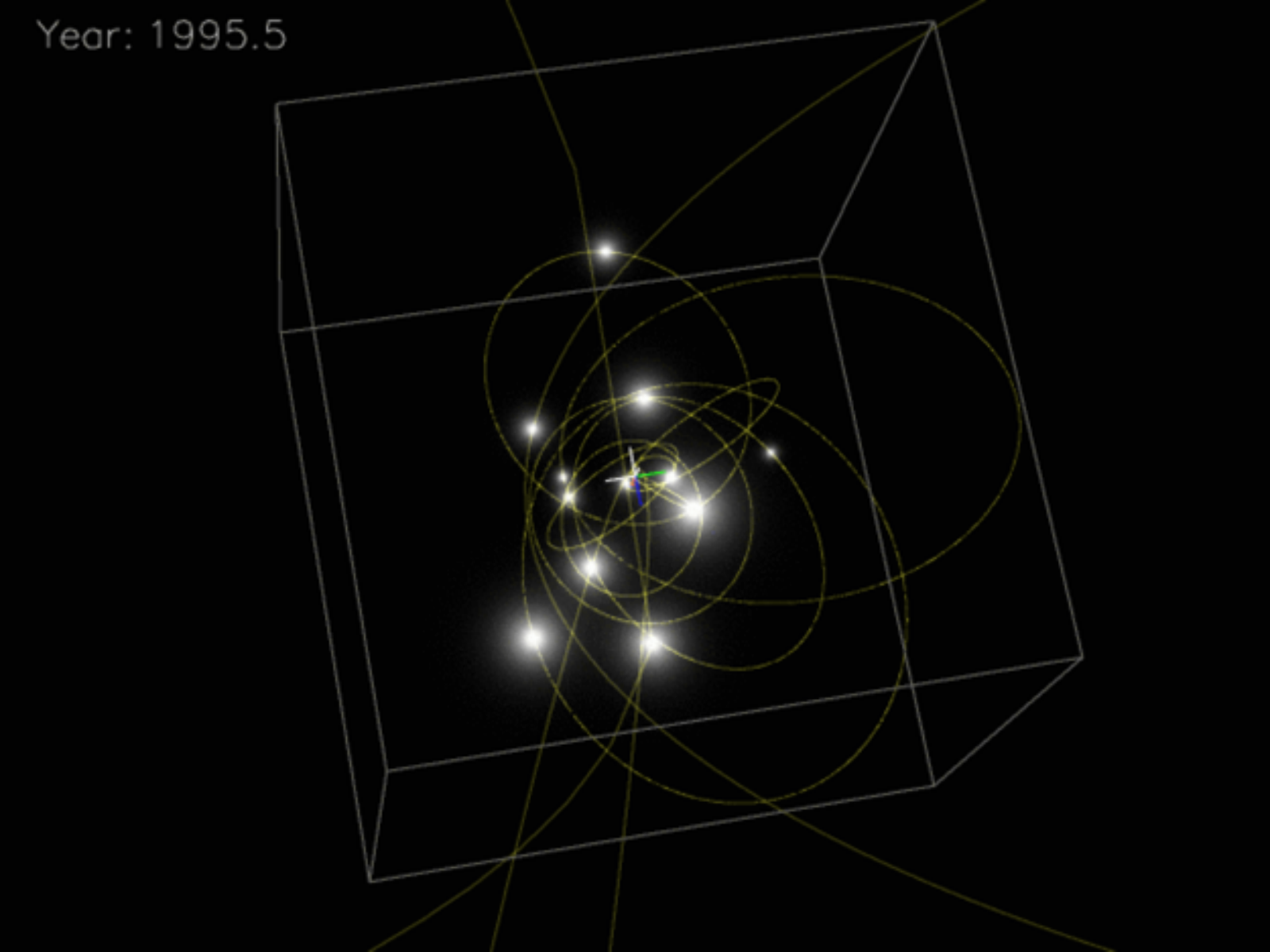
$$\left(r / r' \right)^3 = \left(\left(M + m \right) / \left(M + m' \right) \right) \times \left(T / T' \right)^2$$

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



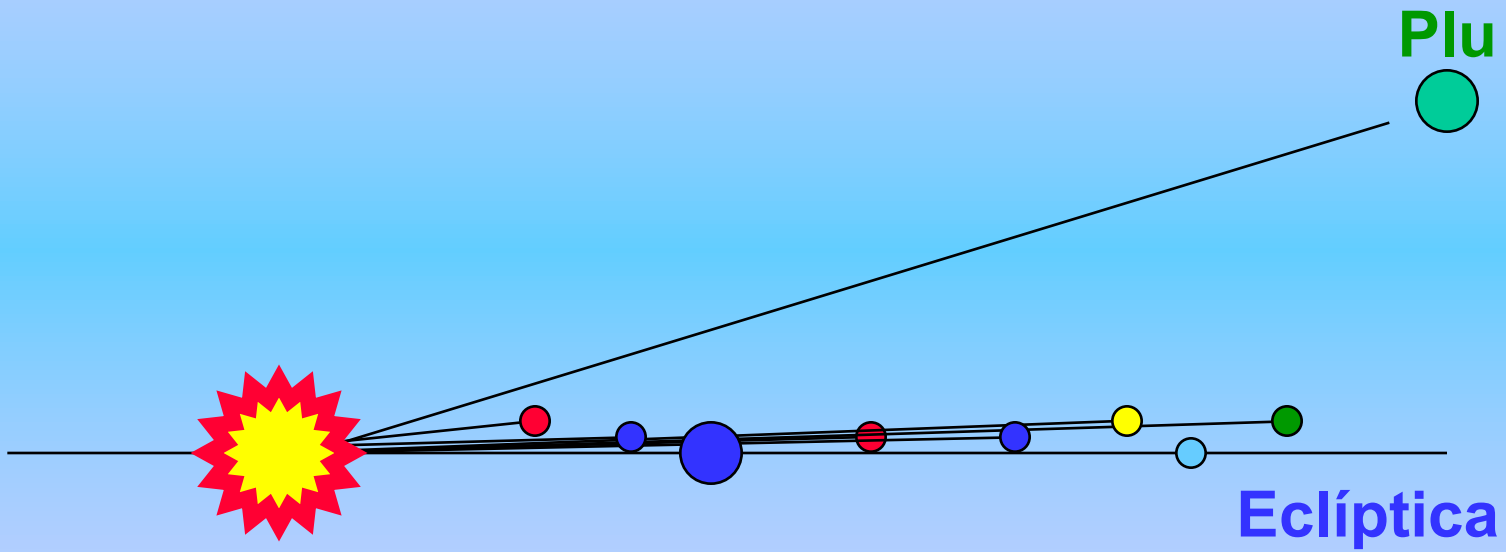
As leis de Kepler dum modo que ele jamais teria pensado:

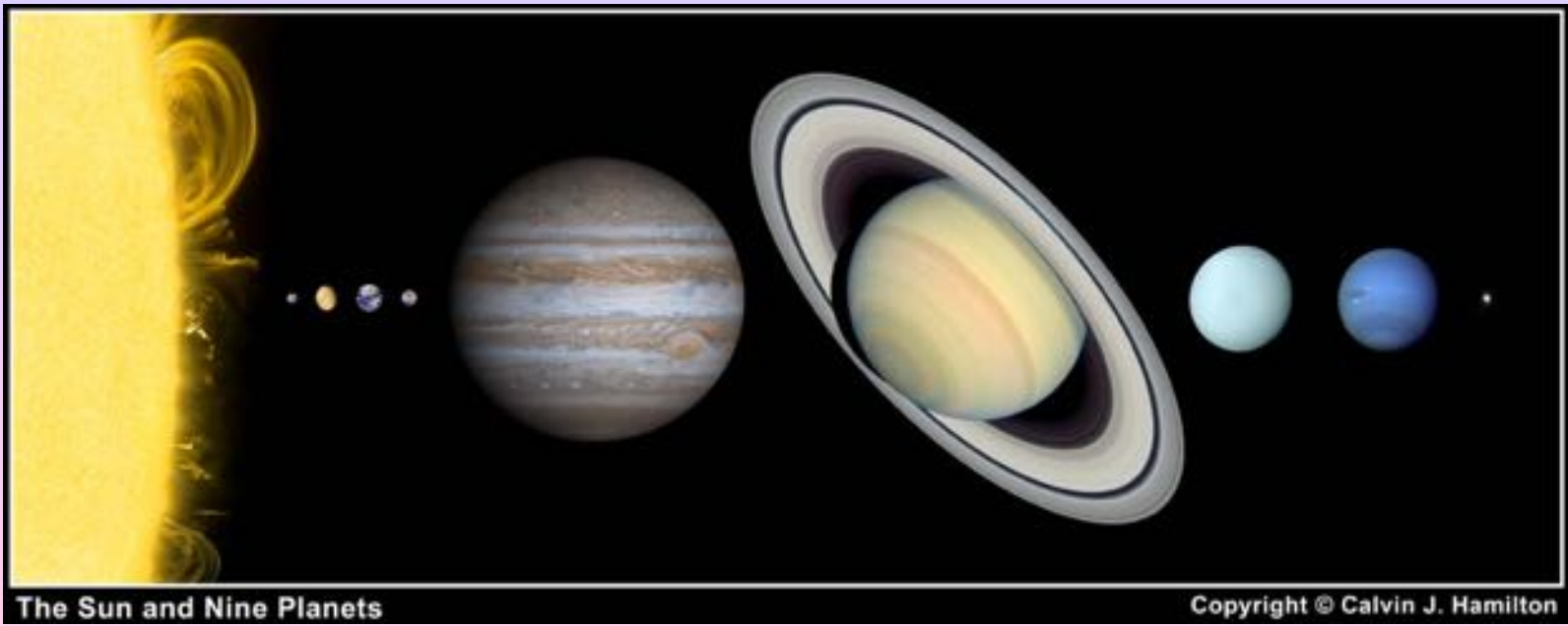
O cálculo da massa do Buraco Negro central da Galáxia, que é de 3.3 milhões de $M_{\odot}$


Year: 1995.5

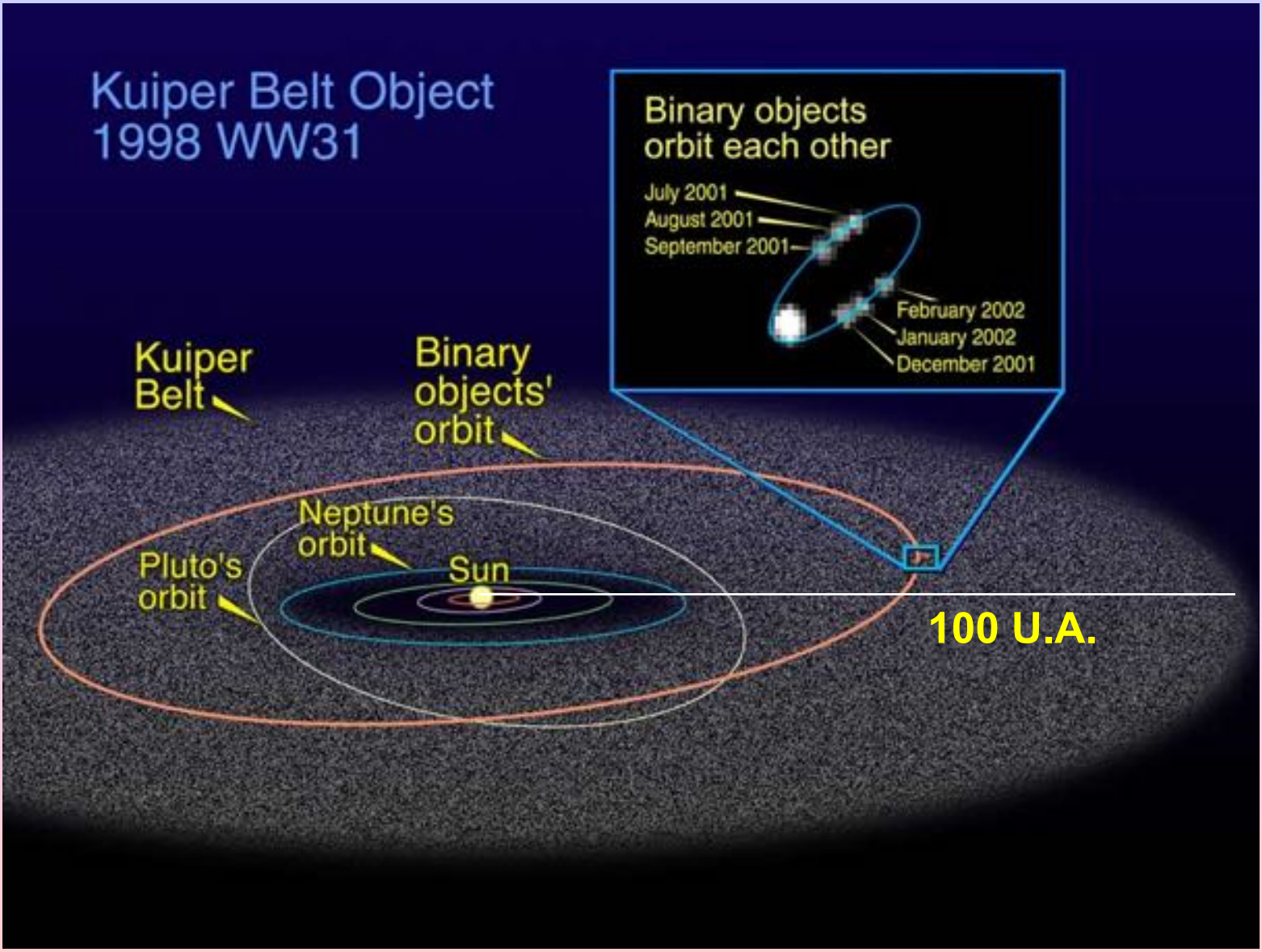
Estrutura atualmente conhecida do Sistema Planetário

Órbitas não coplanares





The Sun and Nine Planets


Kuiper Belt Object
1998 WW31
Binary objects
orbit each other
July 2001
August 2001
September 2001
February 2002
January 2002
December 2001
Kuiper
Belt
Binary
objects'
orbit
Neptune's
orbit
Pluto's
orbit
Sun
100 U.A.

50.000 U.A.