Coordenadas

Bibliography: Any book (or chapter) on astronomical coordinates.

Slides from Prof. Roberto Boczko + myself (Elementos de Astronomia):

http://www.astro.iag.usp.br/~jorge/aga205/

Prof. Jorge Meléndez

Cataratas do Iguaçu

http://www.twanight.org

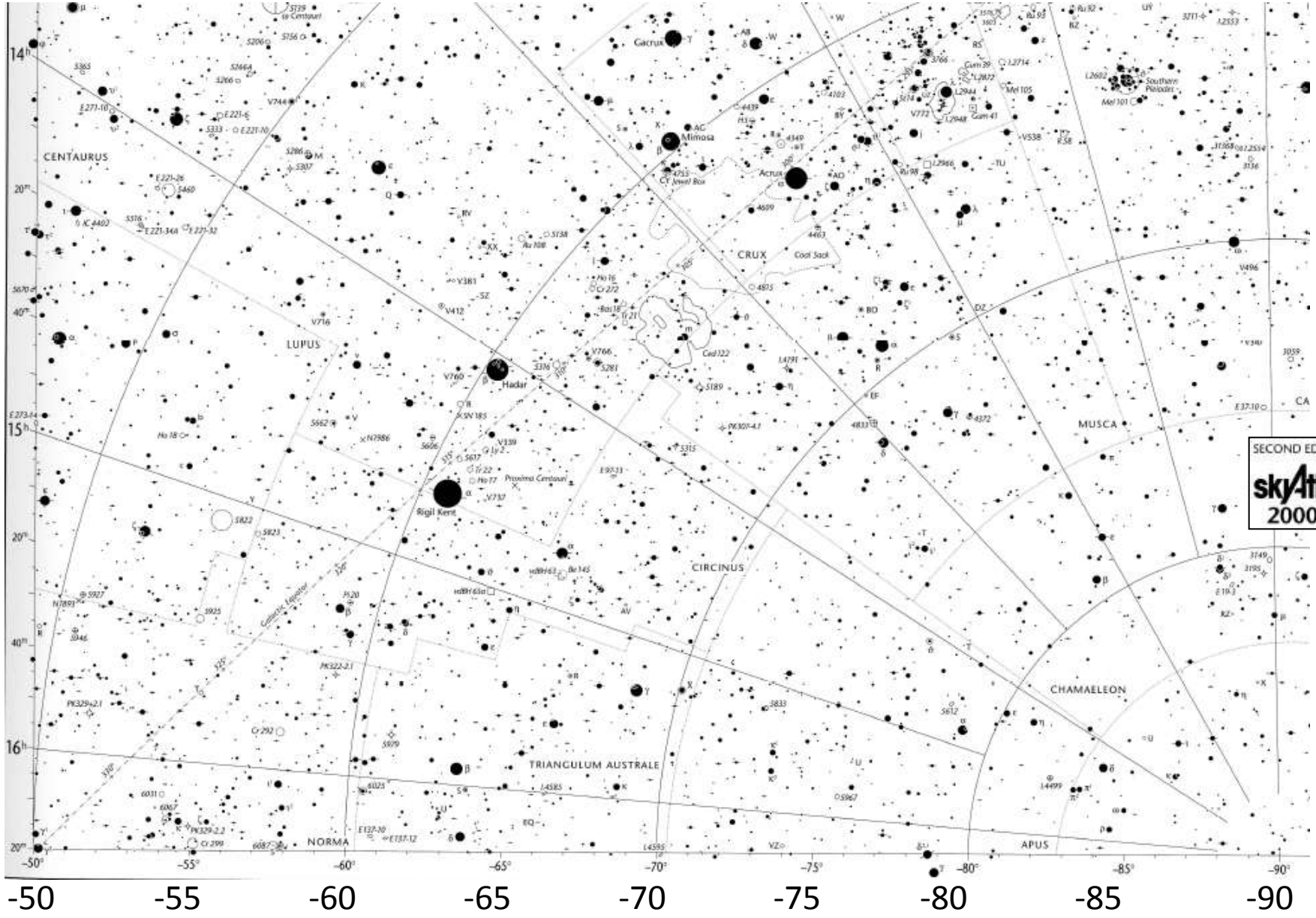
http://apod.nasa.gov/apod/ap100514.html

Cataratas do Iguaçu

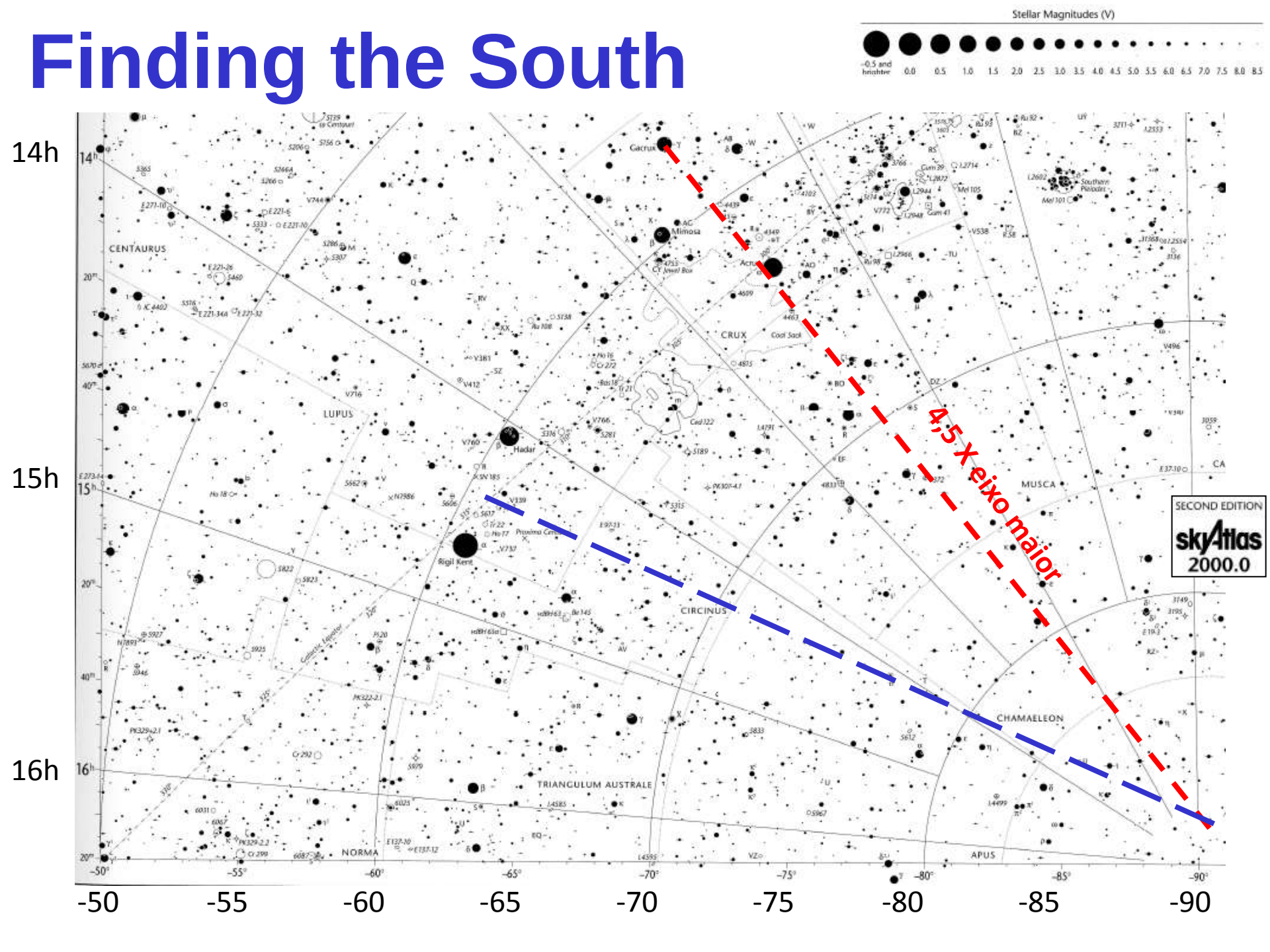
http://www.twanight.org

http://apod.nasa.gov/apod/ap100514.html

Finding the South

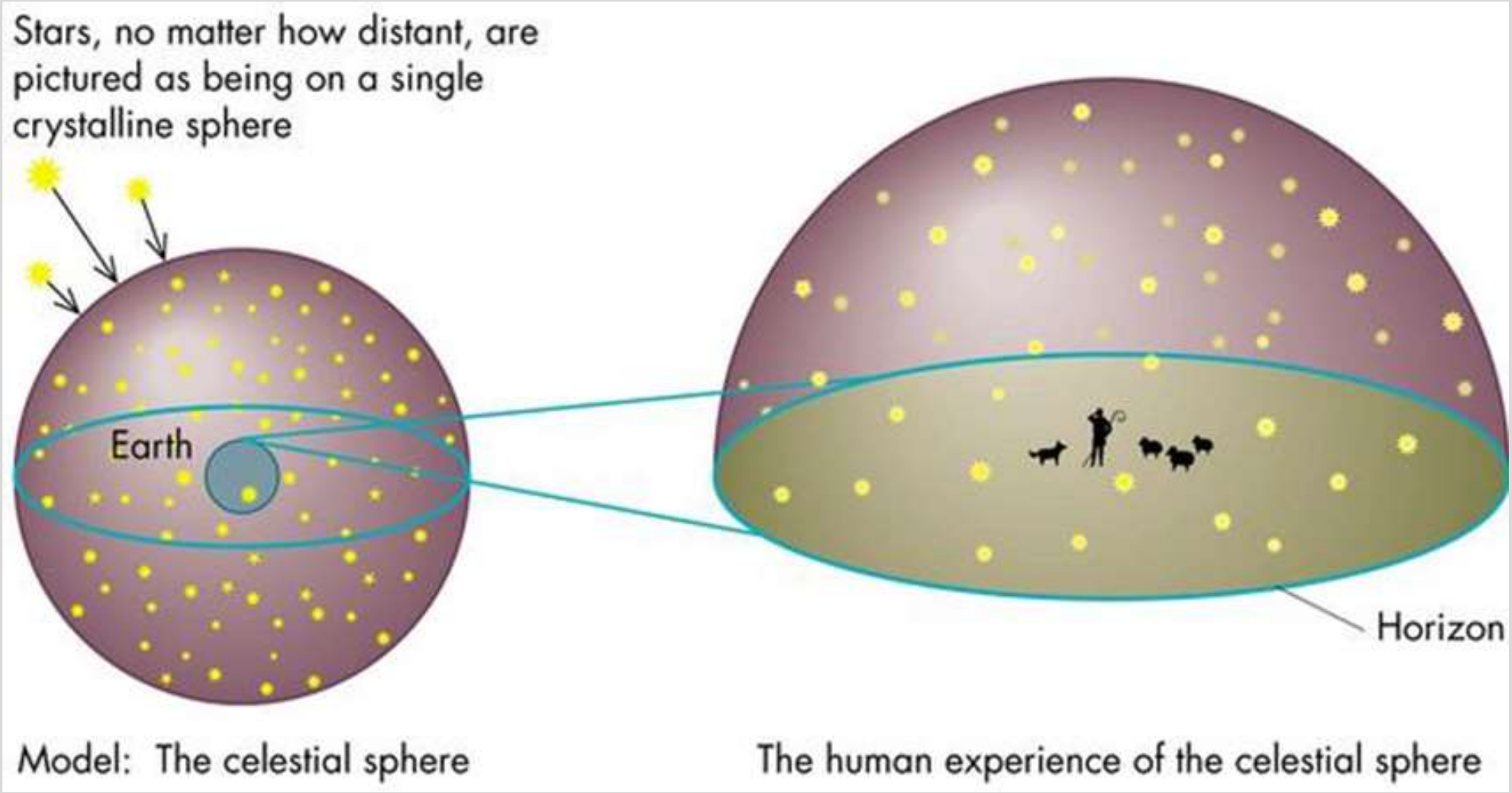


Finding the South

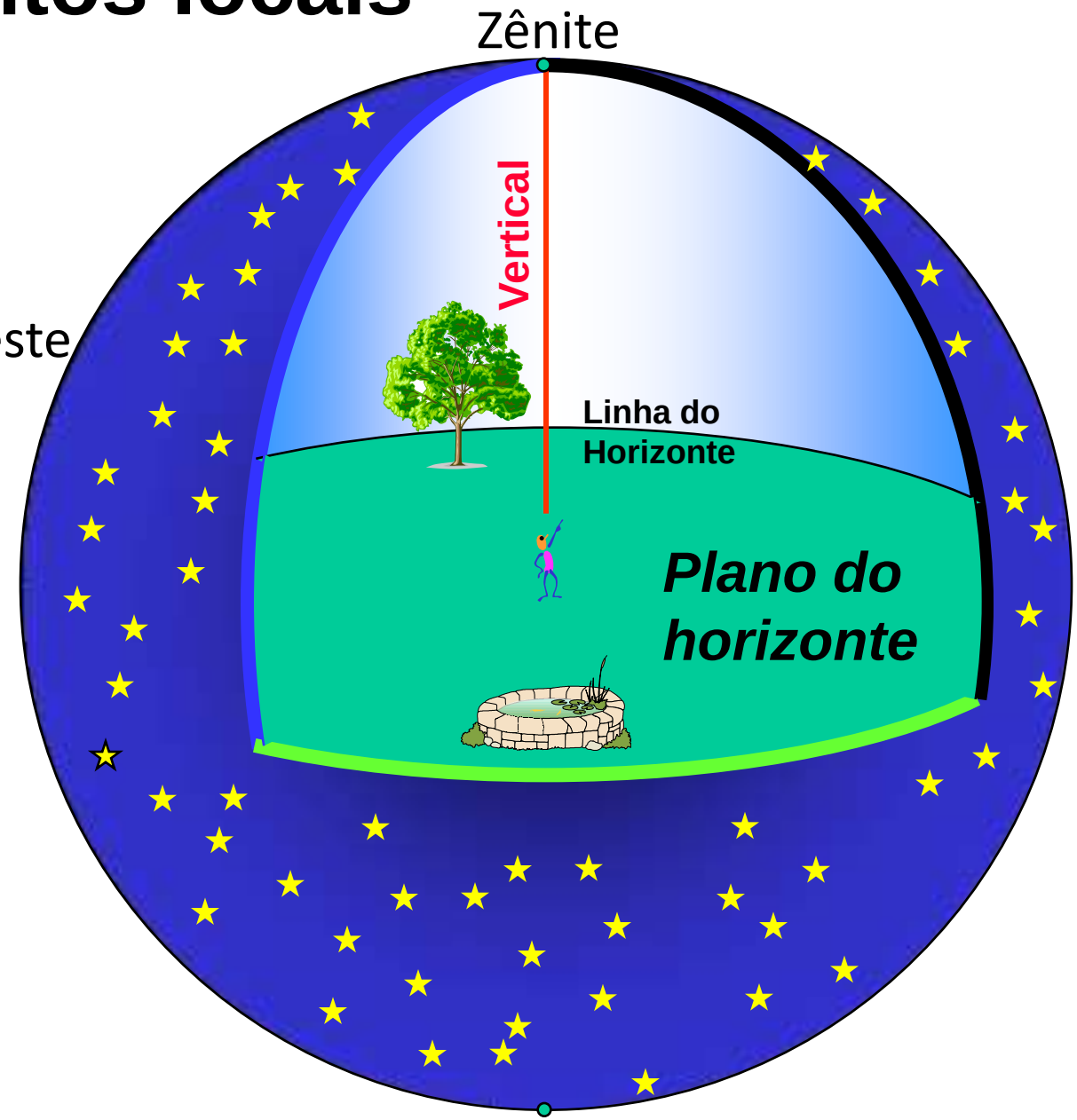


Esfera Celeste

Aparente superfície esférica na qual parecem estar os astros



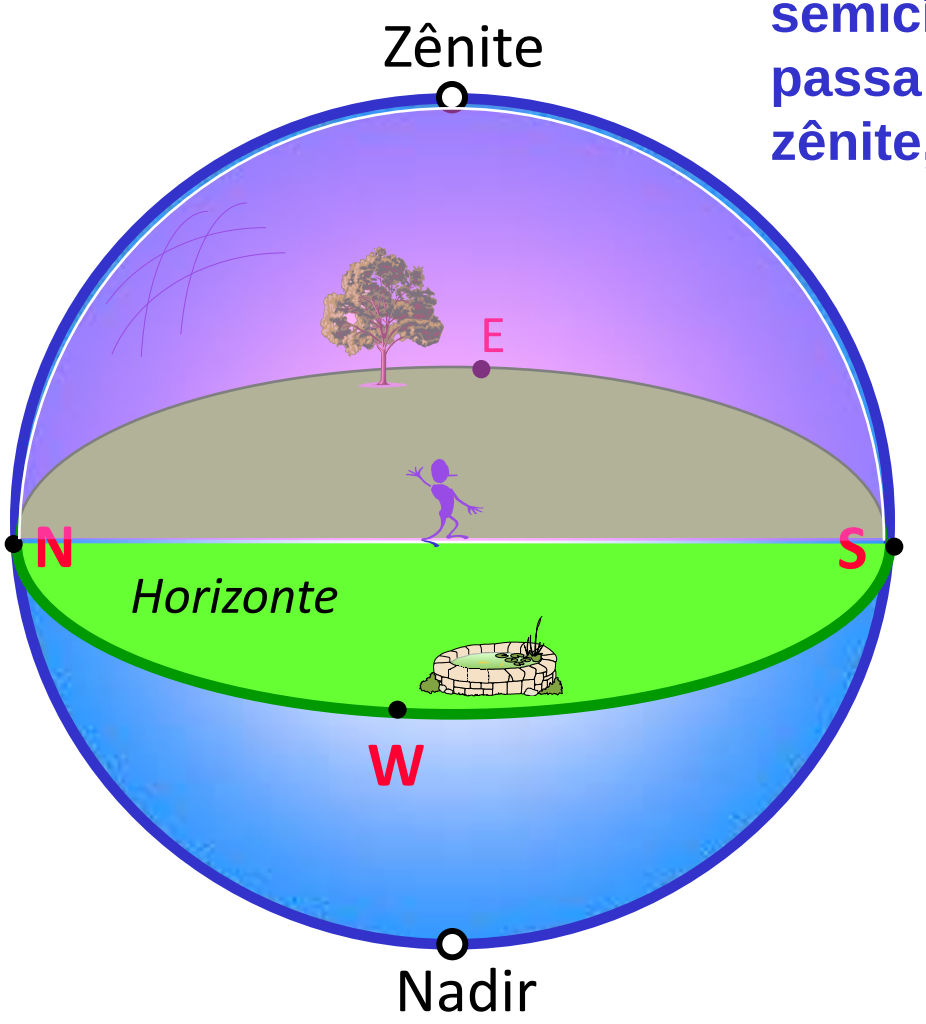
Elementos locais



Slide adapted from Prof. Boczko

Meridiano Local

Meridiano local é o semicírculo vertical que passa pelos pontos zênite, N e S.



Slide adapted from Prof. Boczko

Sistema Altazimutal

Azimute (A): N E S O(W)

Altura (h): -90º a +90º

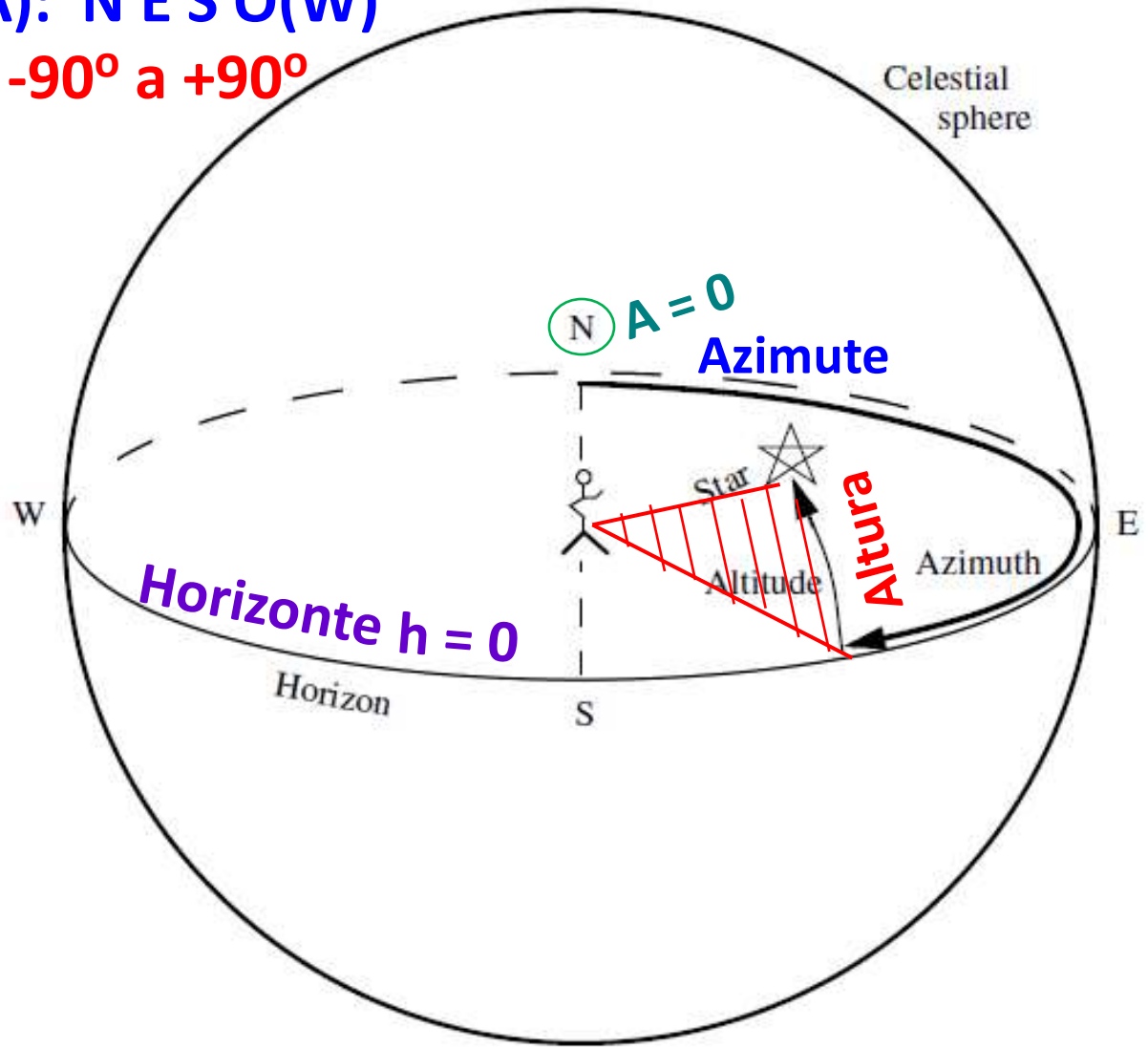
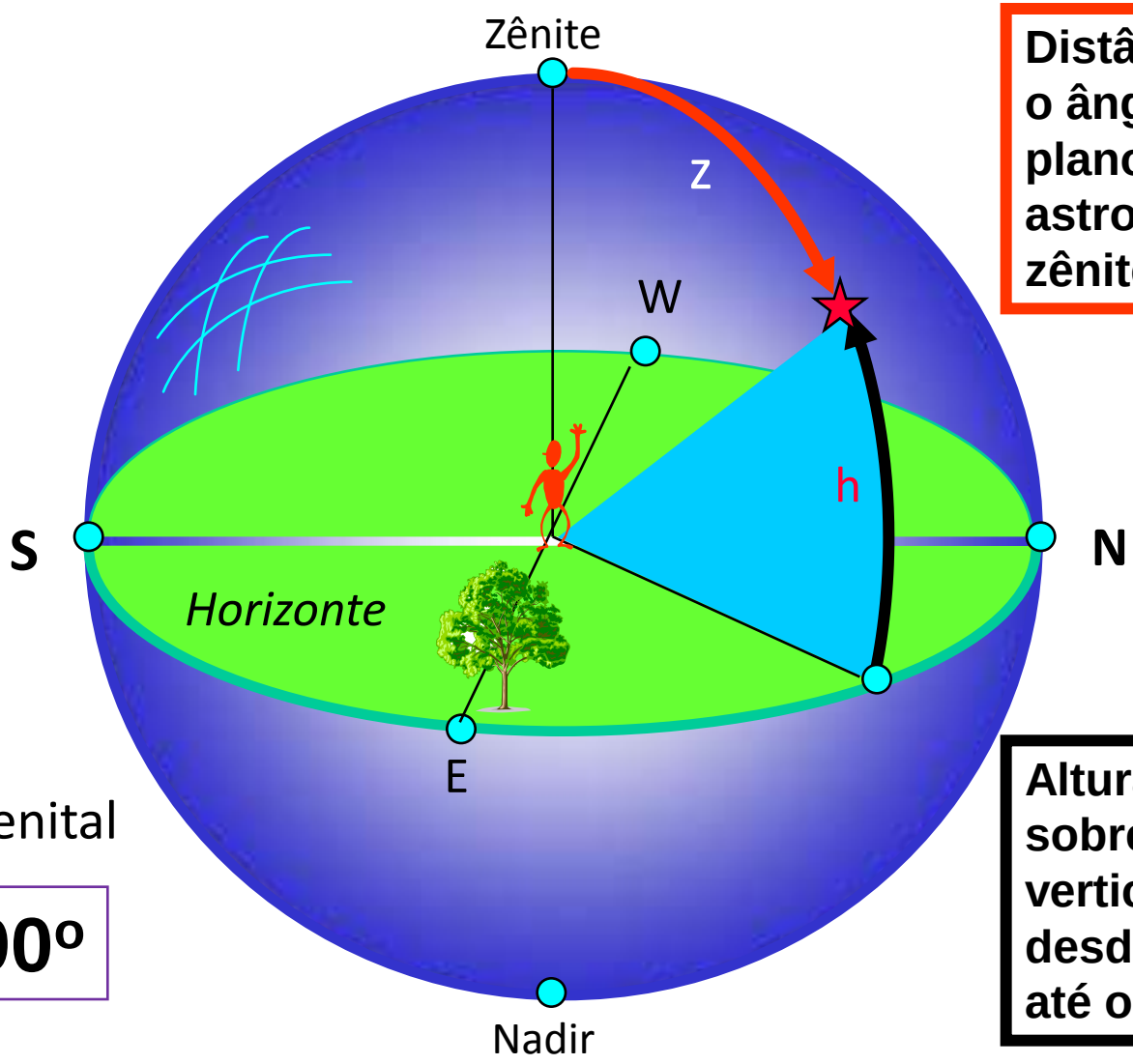


Fig. 3.2 from Astronomy Methods

Altura e distância zenital



Distância zenital é o ângulo sobre o plano vertical do astro, desde o zênite até o astro.

h = altura

z = distância zenital

h + z = 90º

Altura é o ângulo sobre o plano vertical do astro, desde o horizonte até o astro.

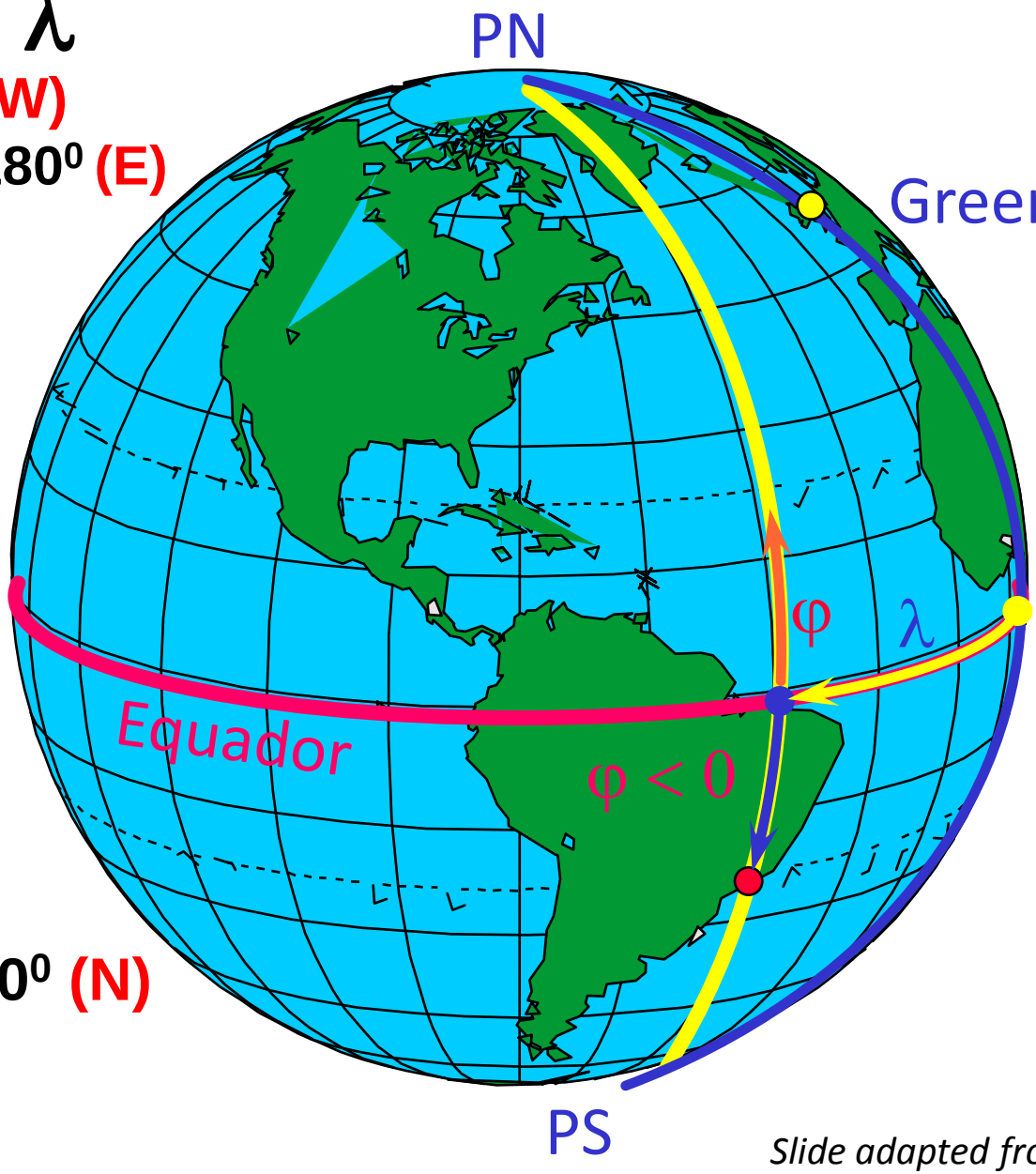
Slide adapted from Prof. Boczko

Sistema Geográfico

Longitude λ

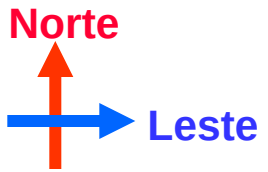
$0 \leq \lambda \leq +180^0$ (E, W)

(W) $-180^0 \leq \lambda \leq +180^0$ (E)



Latitude φ

(S) $-90^0 \leq \varphi \leq +90^0$ (N)



Slide adapted from Prof. Boczko

How to find the local latitude?

The altitude of the pole is the latitude of the observer

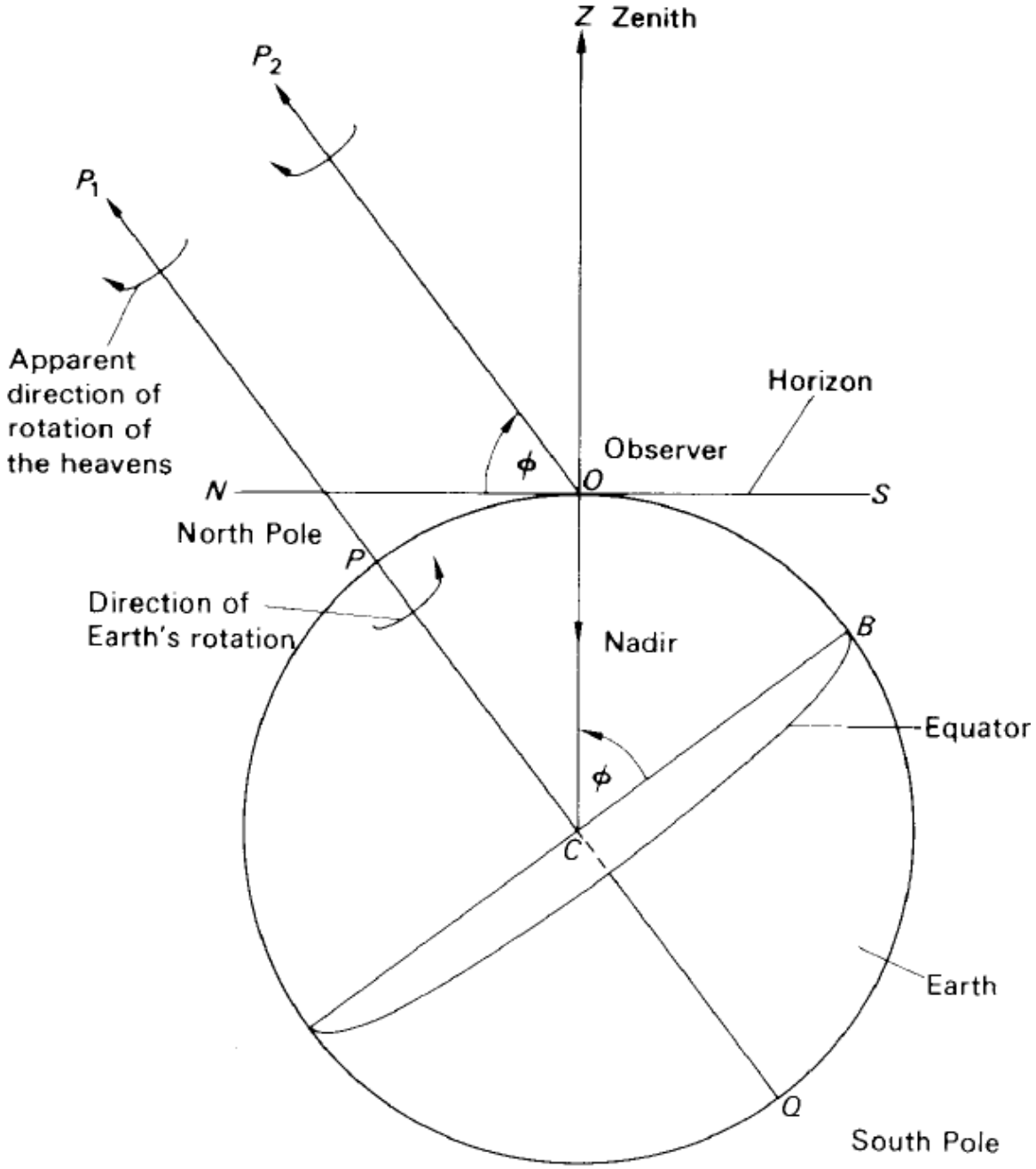
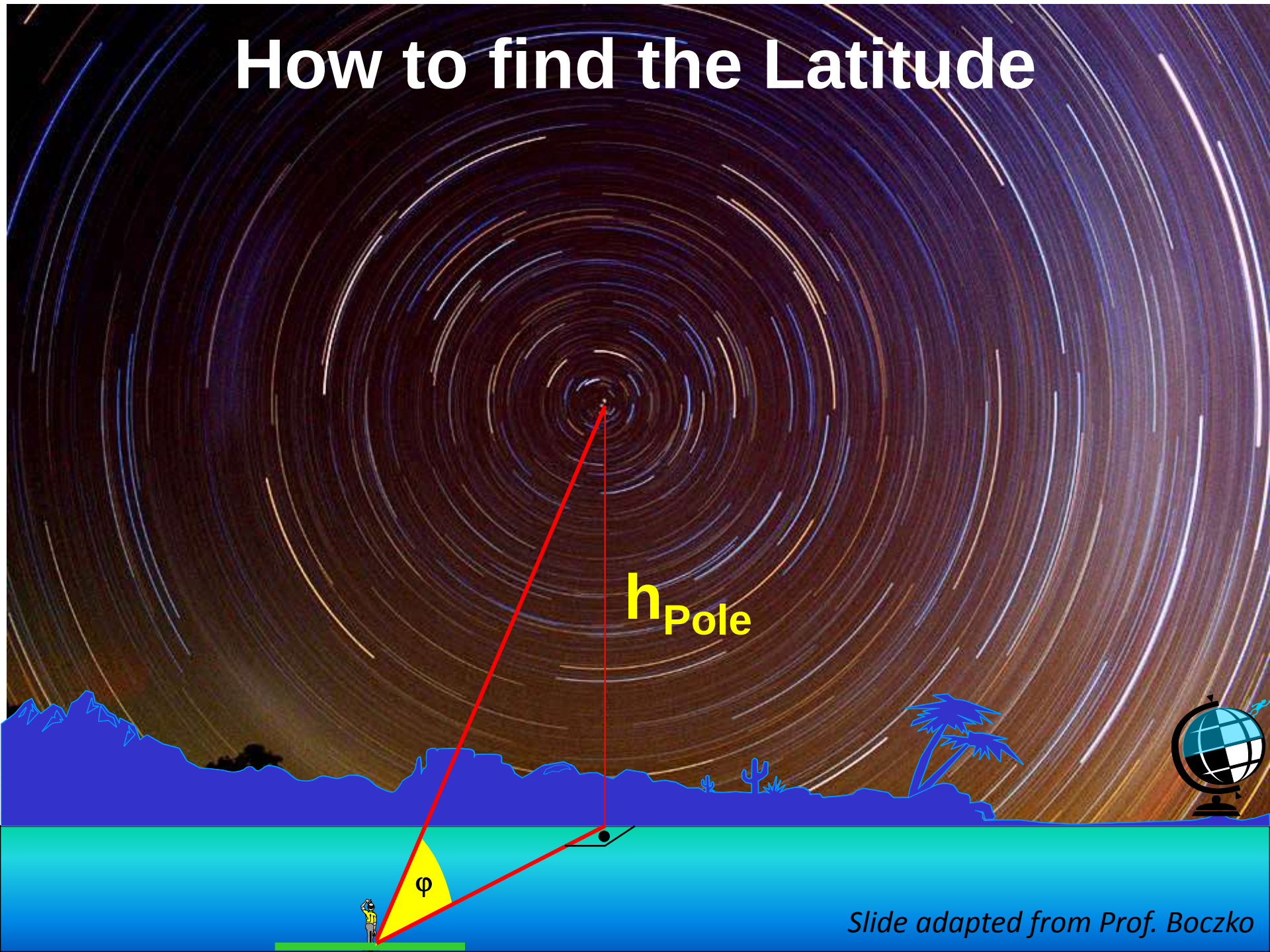


Fig.8.1 from Roy & Clarke

How to find the Latitude



Slide adapted from Prof. Boczko

La Silla/ESO (3,6m telescope) 29.2612° S, 70.7313° W
on 2014/01/12 © J. Meléndez

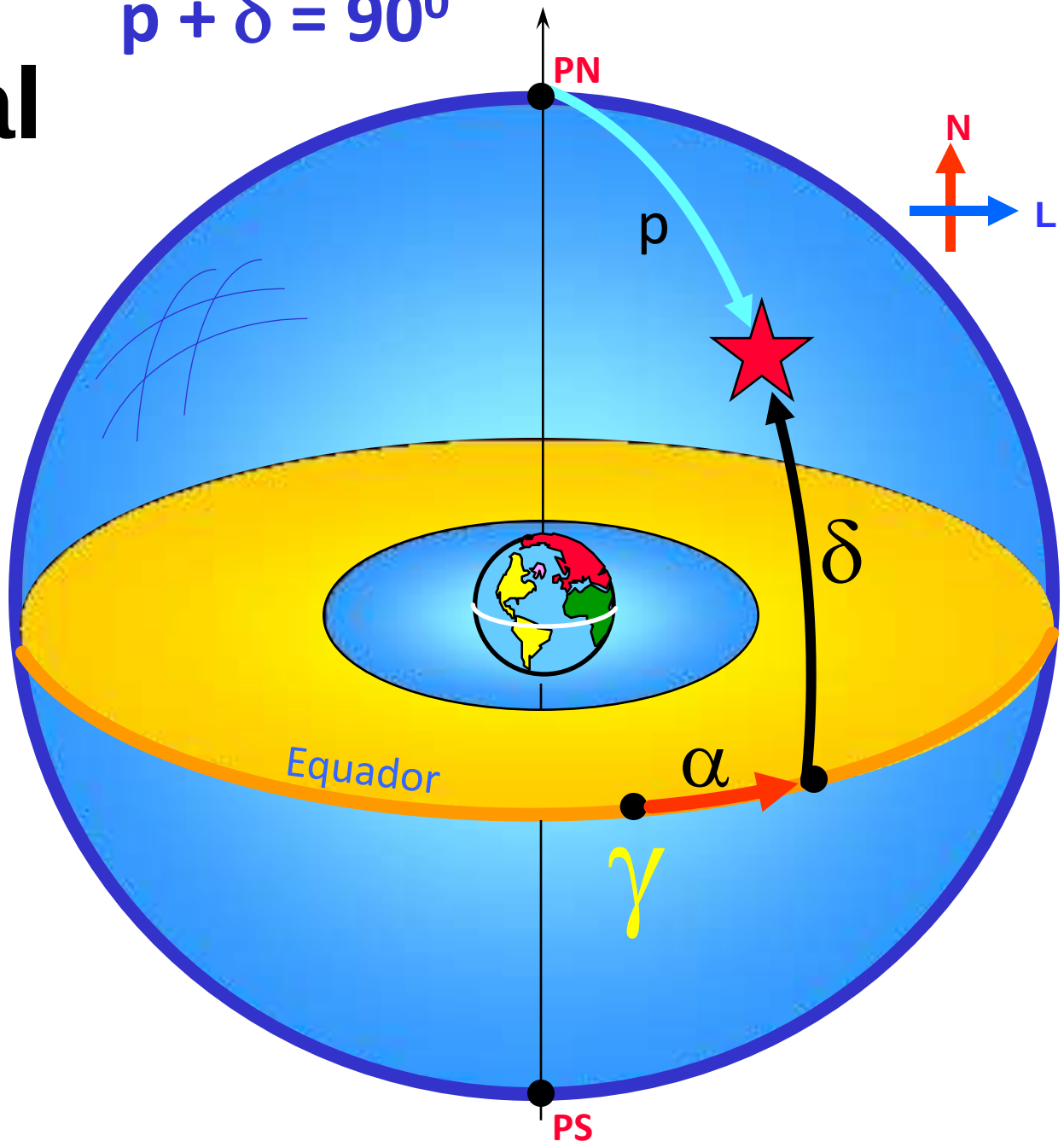
Sistema Equatorial

(α , δ)

α = ascensão reta

δ = declinação

p = distância polar



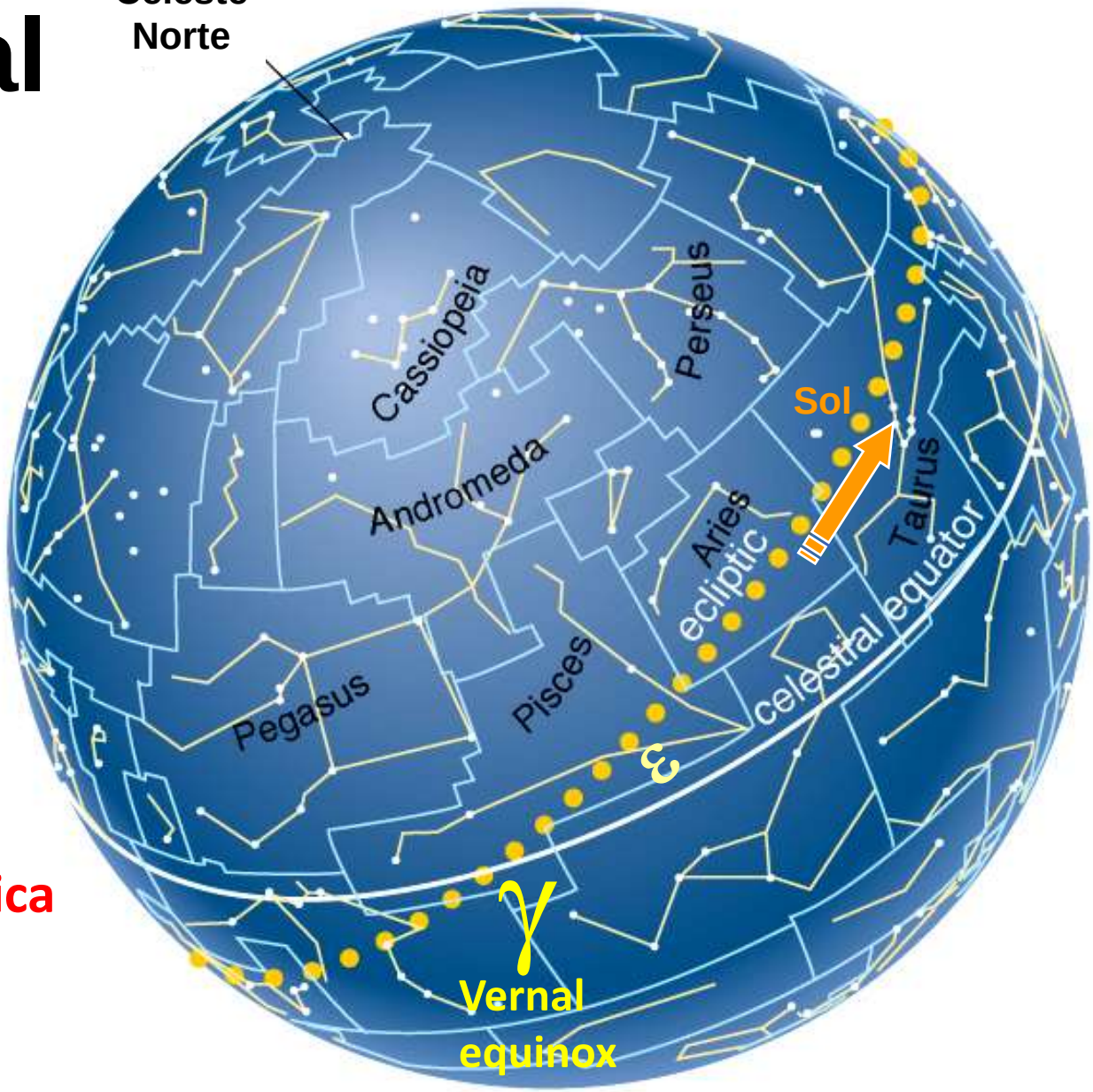
Slide adapted from Prof. Boczko

Sistema Equatorial

Zero point for R.A. : intersection of ecliptic & equator

Obliquidade da eclíptica

$\varepsilon \cong 23^{o}\ 27'\ 08''$



Equatorial coordinates

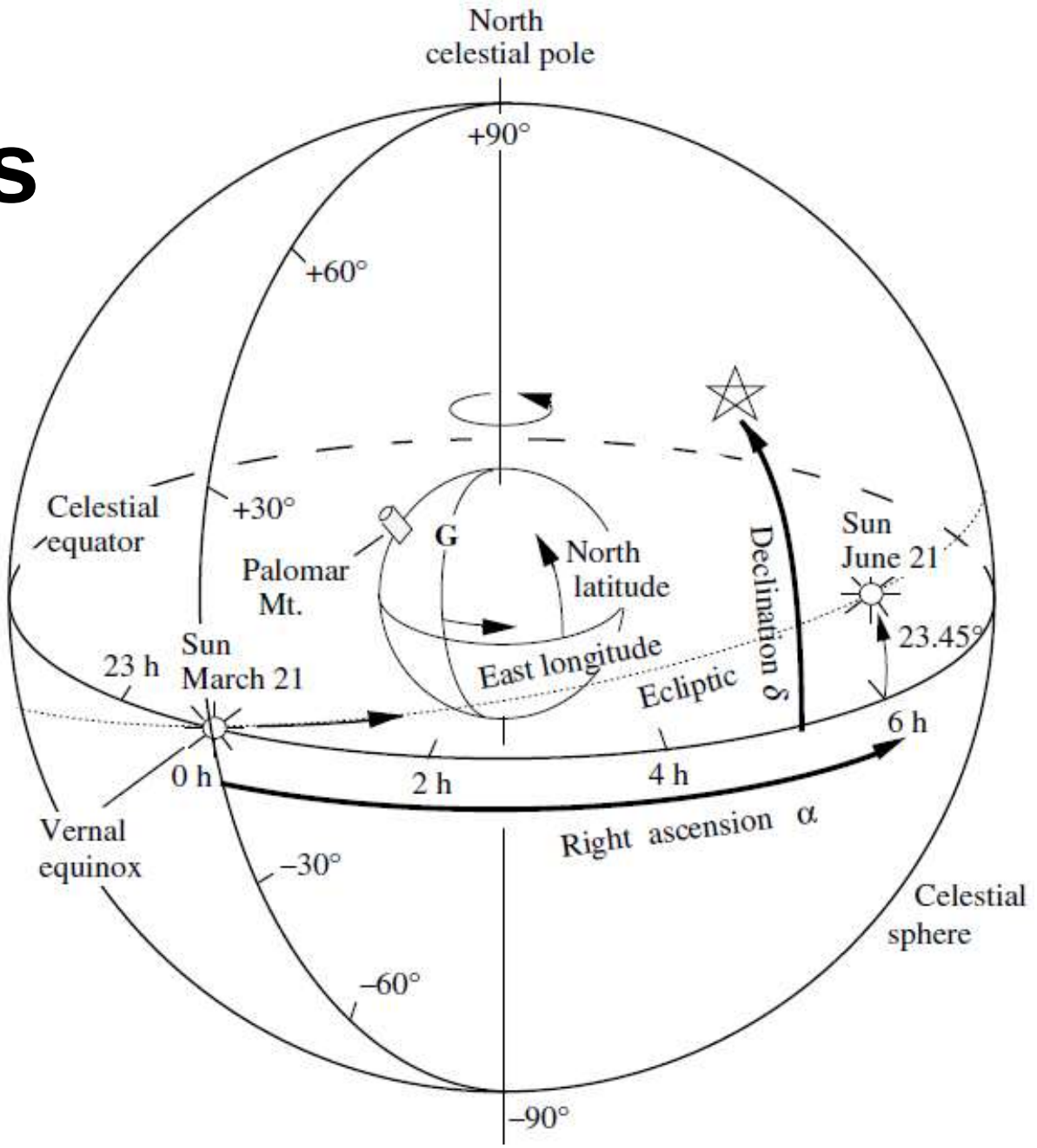


Fig. 3.1 from Astronomy Methods

Unidades

Ascensão reta

$0^0 \leq \alpha < 360^0$

Declinação

(S) $-90^0 \leq \delta \leq +90^0$ (N)

Definição

1 hora $\equiv 15^0$

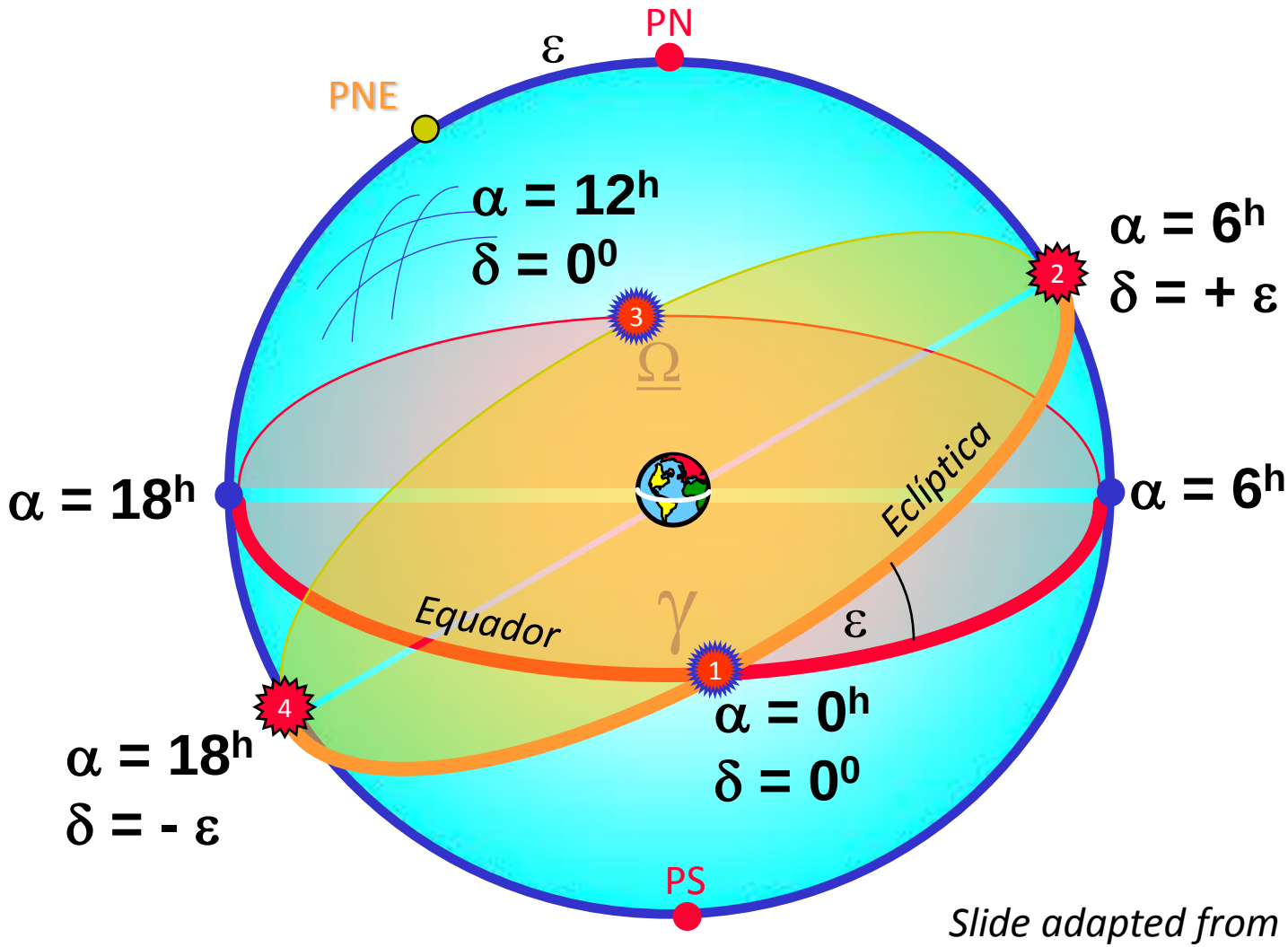
Distância polar

$0^h \leq \alpha < 24^h$

(N) $0^0 \leq p \leq +180^0$ (S)

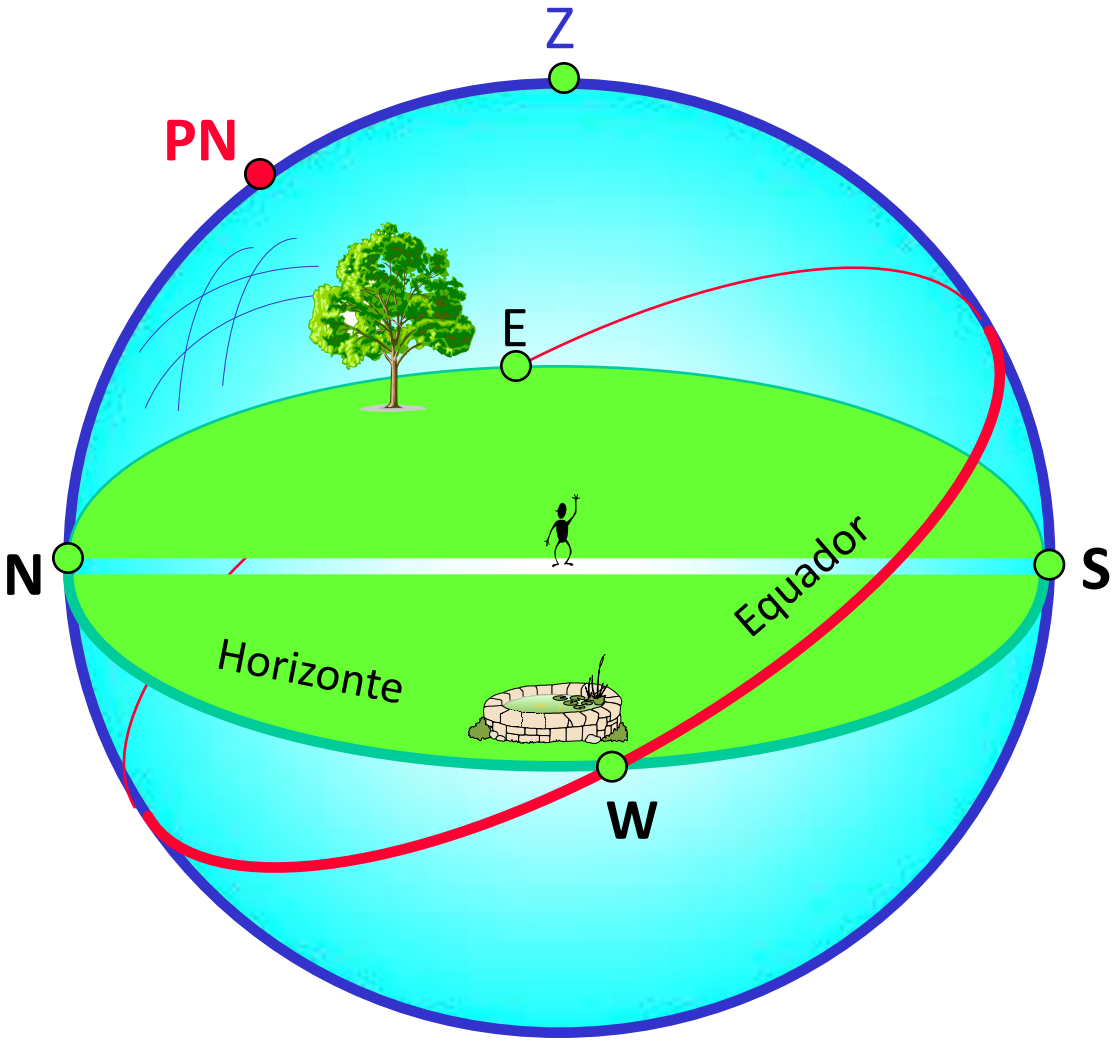
Slide adapted from Prof. Boczko

Coordenadas equatoriais particulares do Sol



Slide adapted from Prof. Boczko

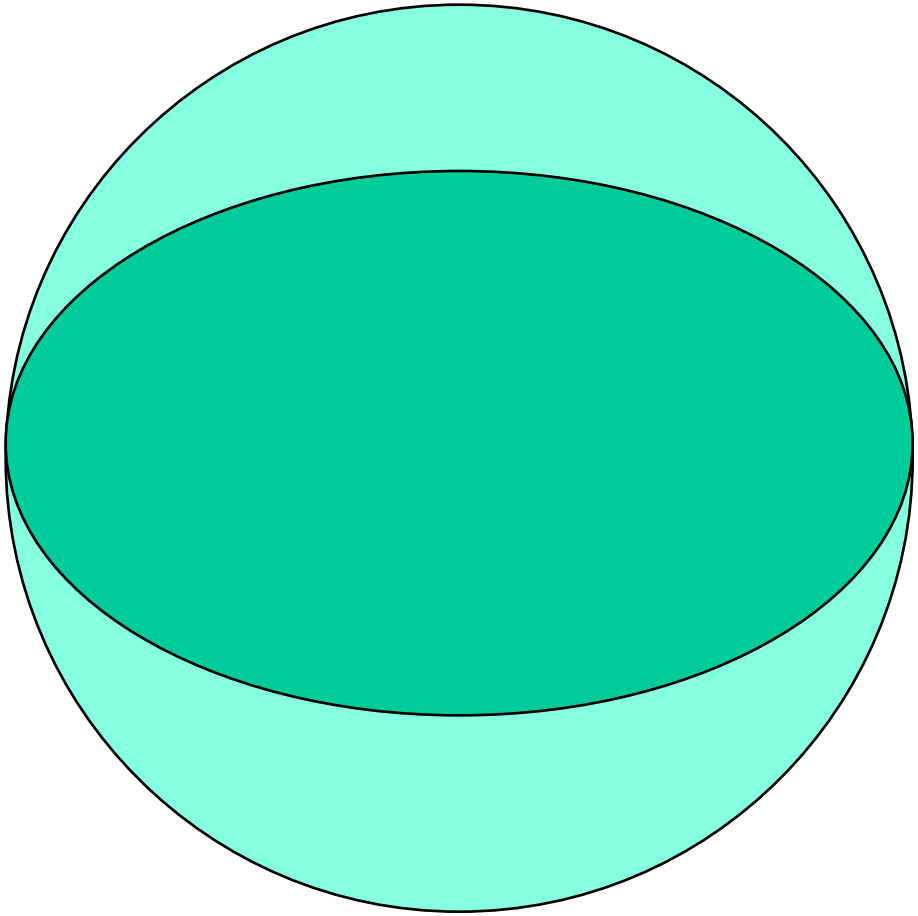
Sistema Horizontal e Equatorial para Observador no HN



Slide adapted from Prof. Boczko

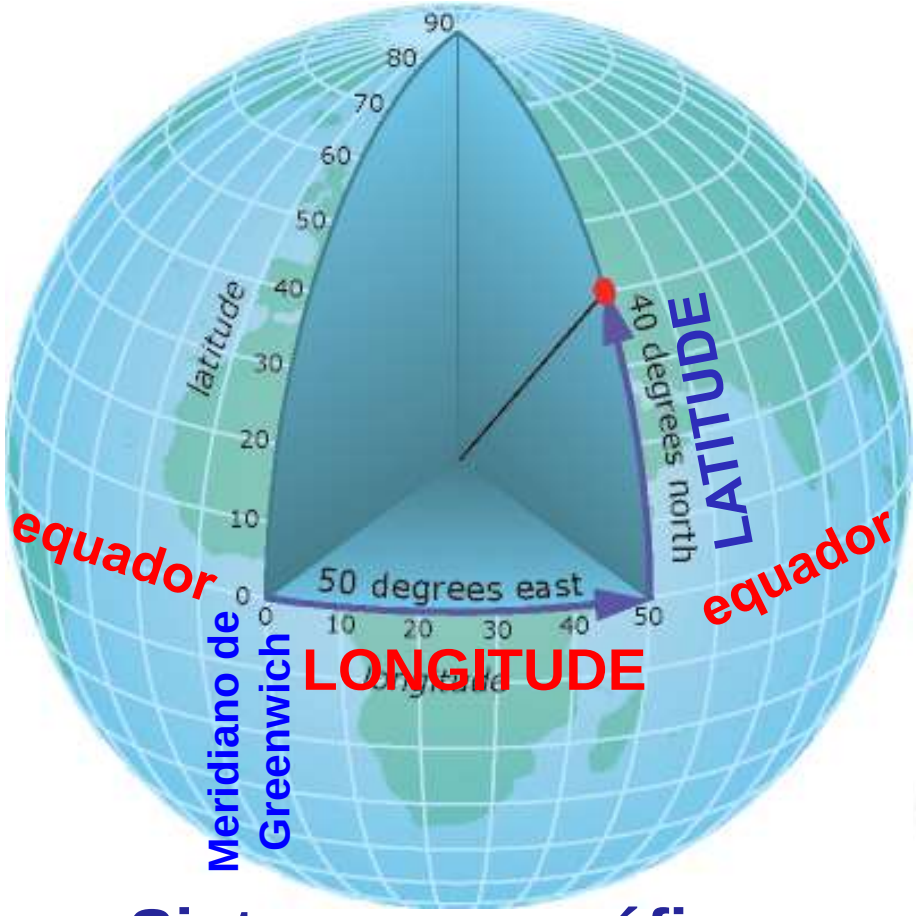
Do it yourself :

What is the declination of the Zenith in São Paulo?

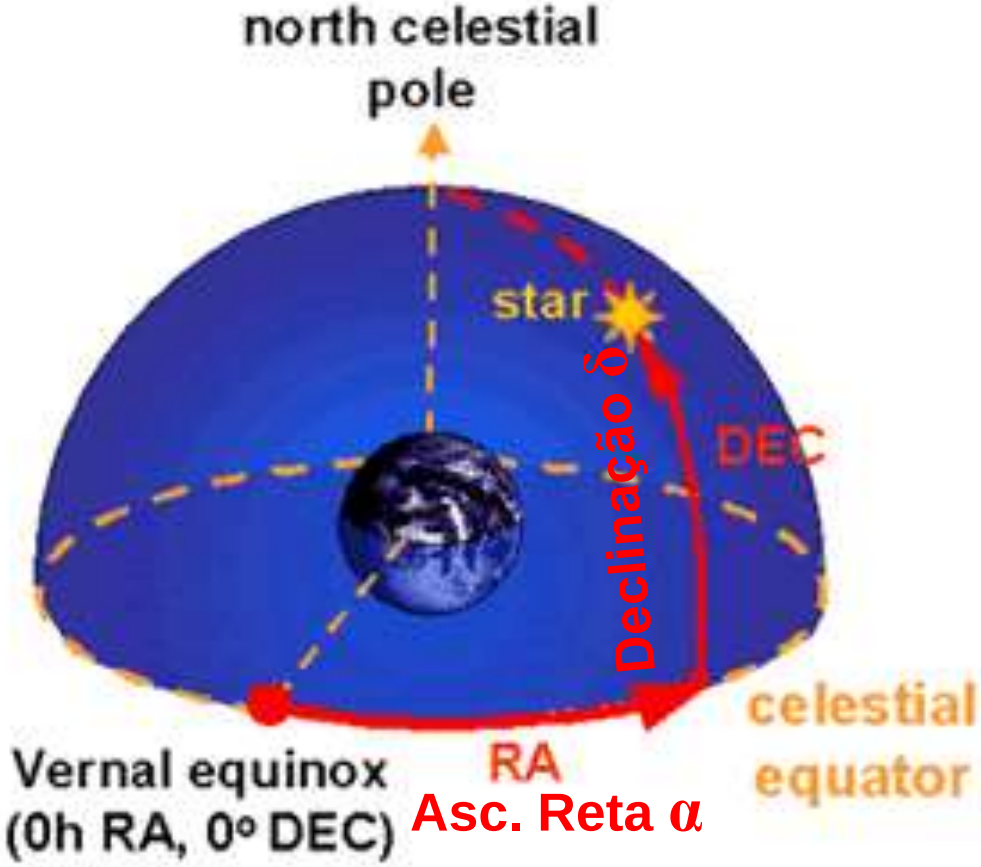


Sistema de Coordenadas Horário

Sistemas de coordenadas GEOGRÁFICAS e EQUATORIAIS

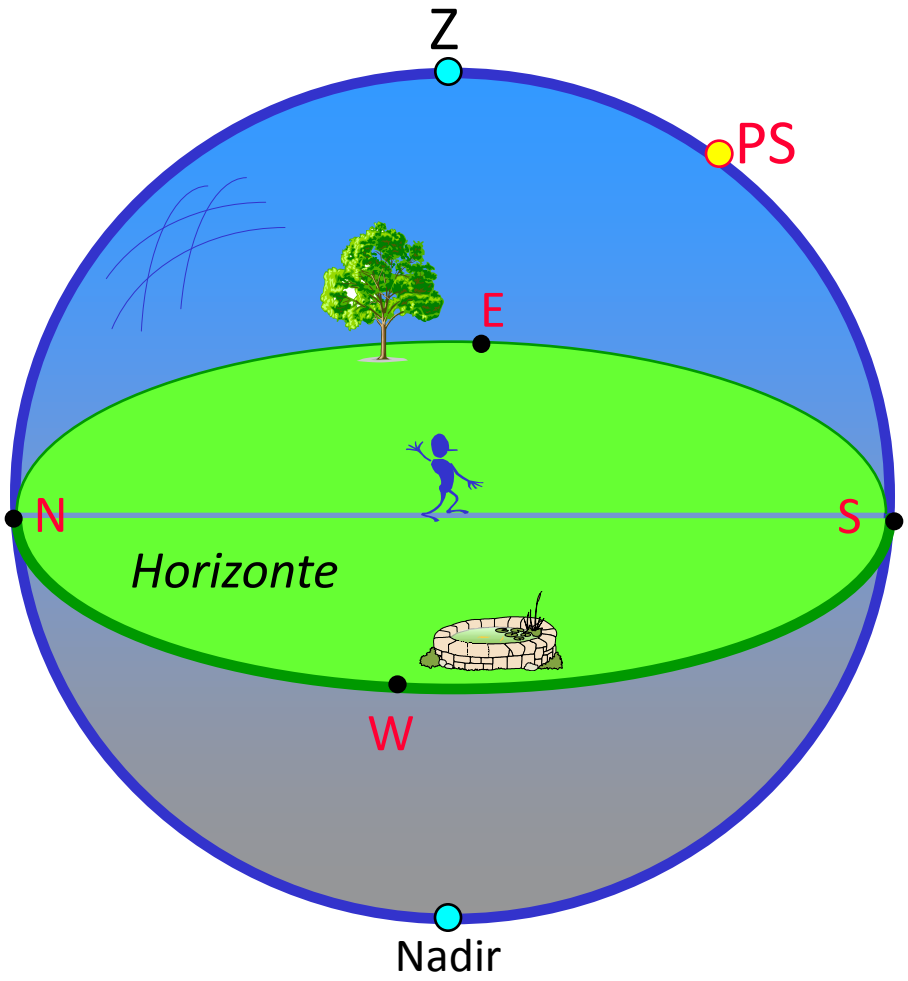


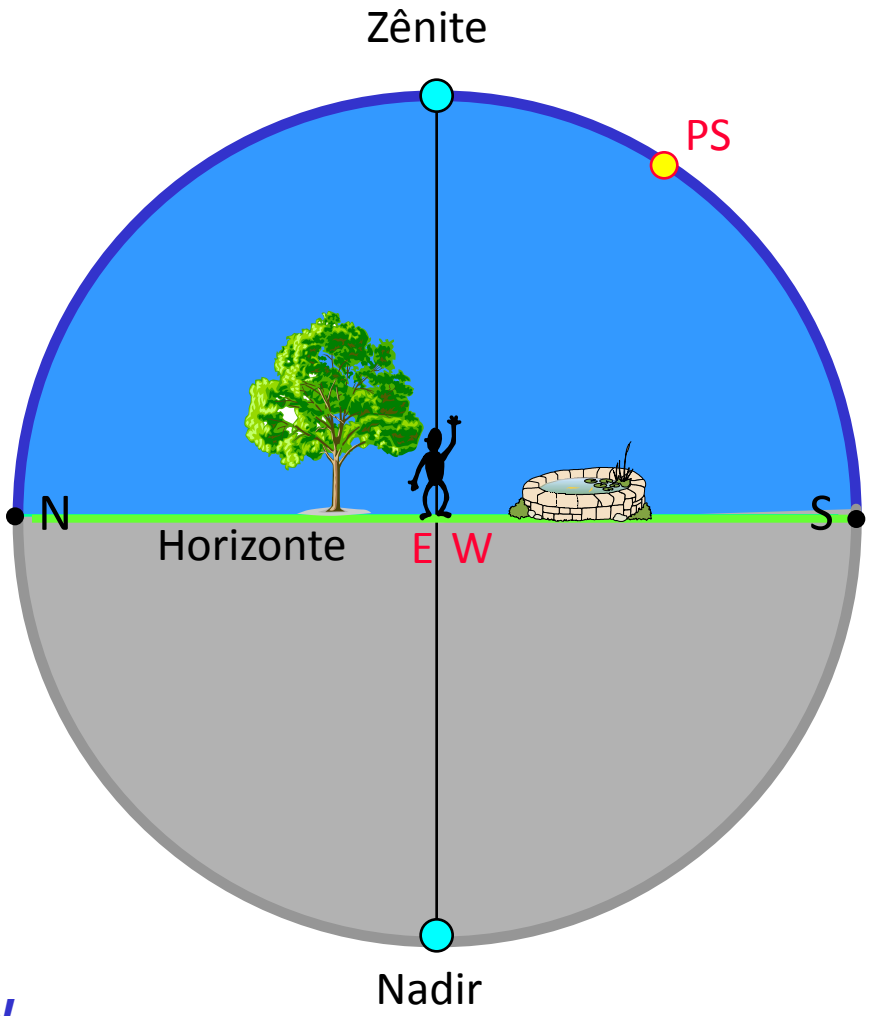
Sistema geográfico



Sistema equatorial

Meridiano Local e Projeção



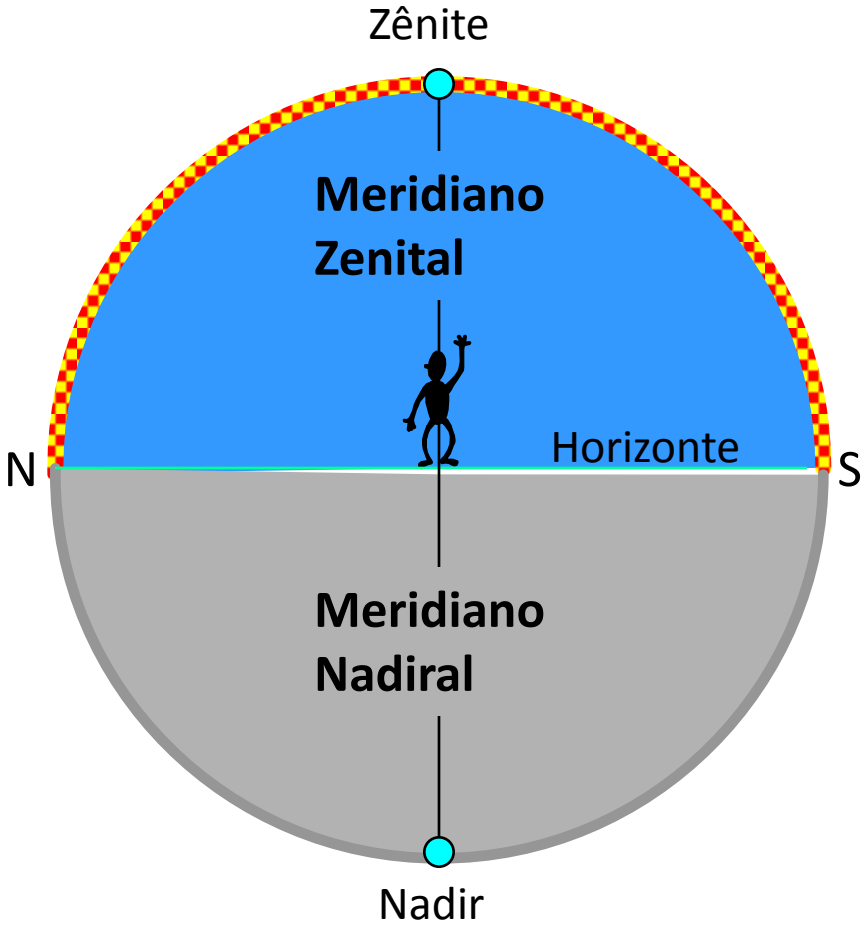


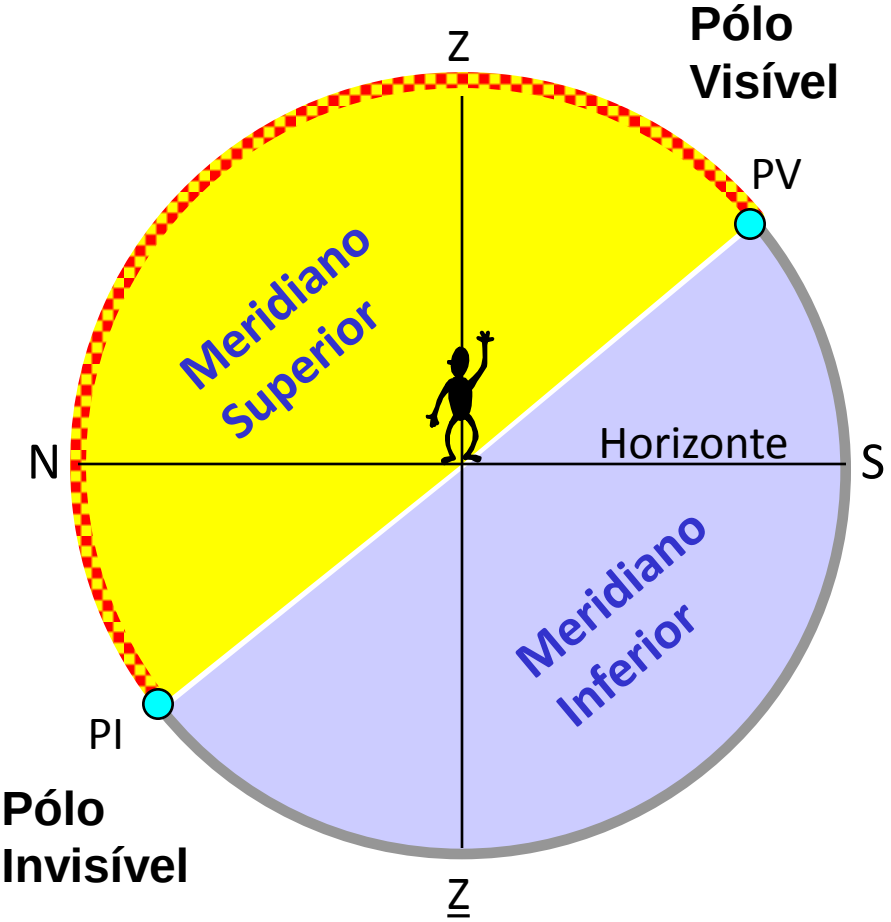
Foco de projeção: W_∞
Projeção cilíndrica ortogonal
Plano de projeção: plano meridiano

Slide adapted from Prof. Boczko

Slide adapted from Prof. Boczko

Tipos de Meridiano





Meridiano Superior : Polos e Z

Sistema Horário

É um sistema mixto

uma coordenada constante:

declinação δ

uma coordenada variável:

ângulo horário H

(medido sobre o equador desde o meridiano local até o círculo horário que passa pelo astro)

Sistema Horário

ângulo horário
(medido sobre o equador desde o meridiano local até o círculo horário do astro)

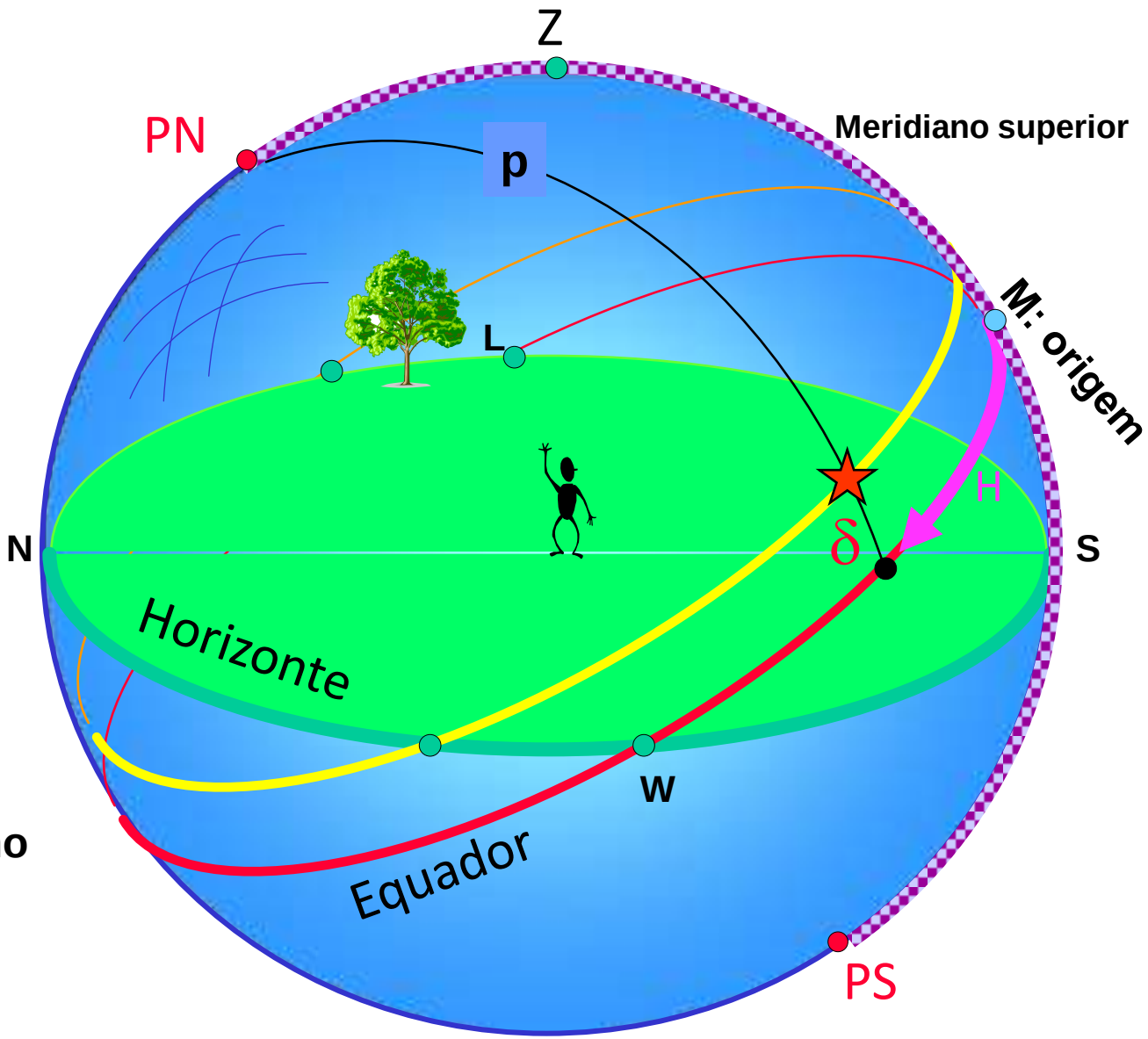
H = ângulo horário

δ = declinação

p = distância polar

★(H , δ)

Observador no hemisfério N



Slide adapted from Prof. Boczko

Unidades

Ângulo horário

(E) $-180^0 \leq H \leq +180^0$ **(W)**

Declinação

(S) $-90^0 \leq \delta \leq +90^0$ **(N)**

$0^0 \leq p \leq +180^0$

Definição

1 hora ≡ 15^0

(E) $-12^h \leq H \leq +12^h$ **(W)**

1 h = 15°

1 m = 15'

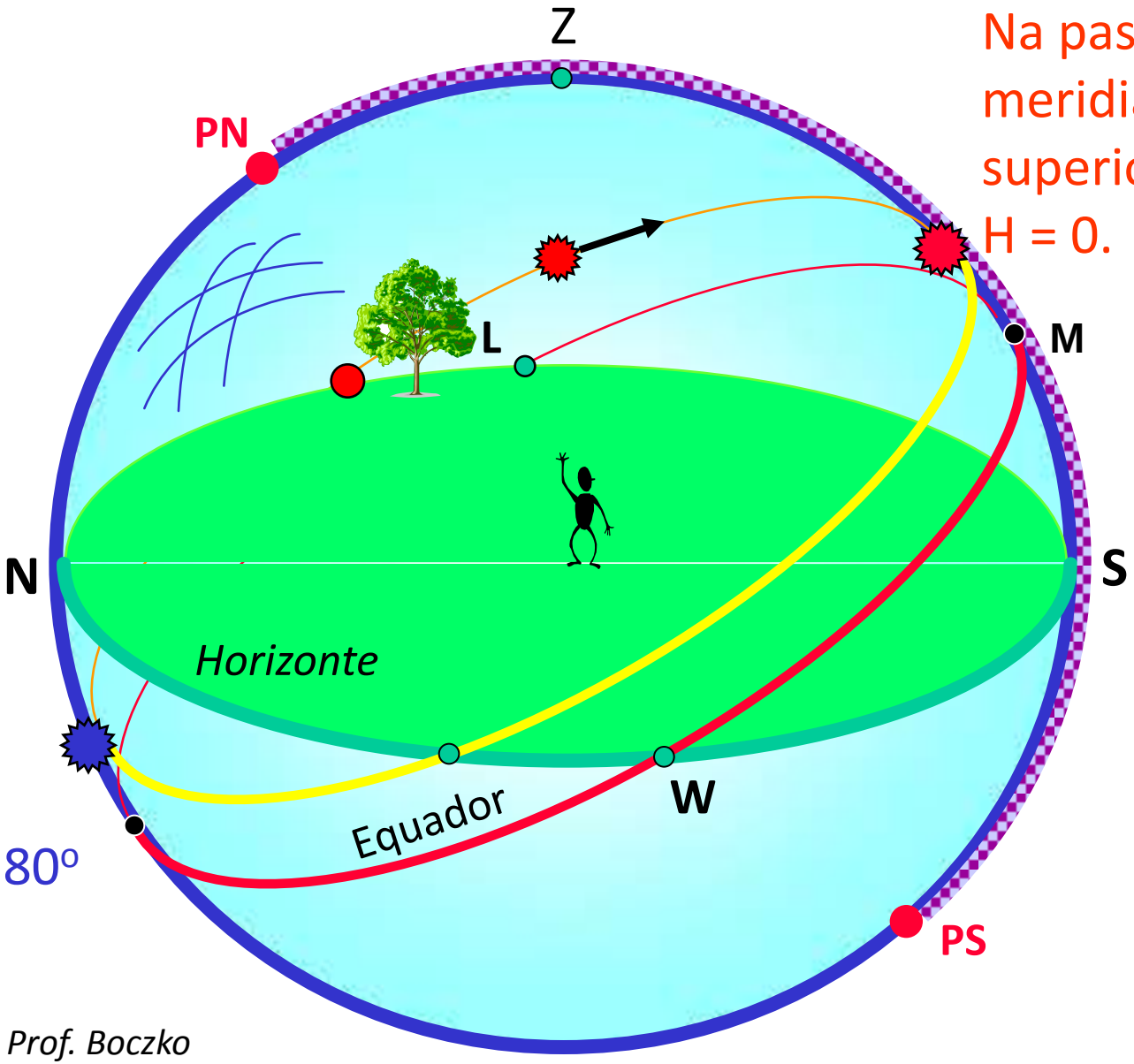
1 s = 15"

Do it yourself

3h 20m = ^{0} ‘ “?

$-30^{0},5$ = h m s ?

Culminação ou passagem meridiana

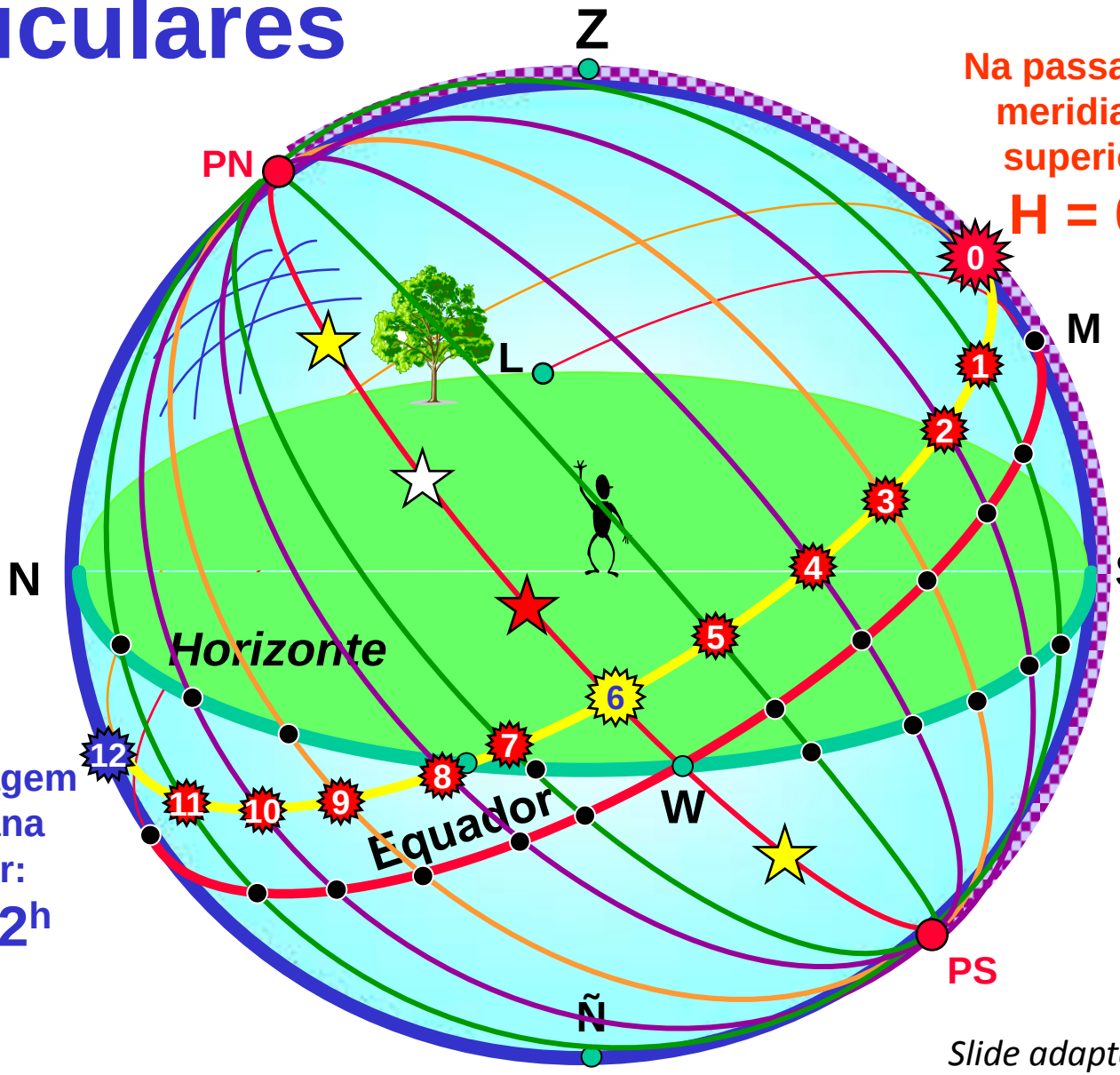


Na passagem meridiana superior: H = 0.

Na passagem meridiana inferior: H = 180º

Slide adapted from Prof. Boczko

Ângulos horários particulares



Na passagem meridiana superior:

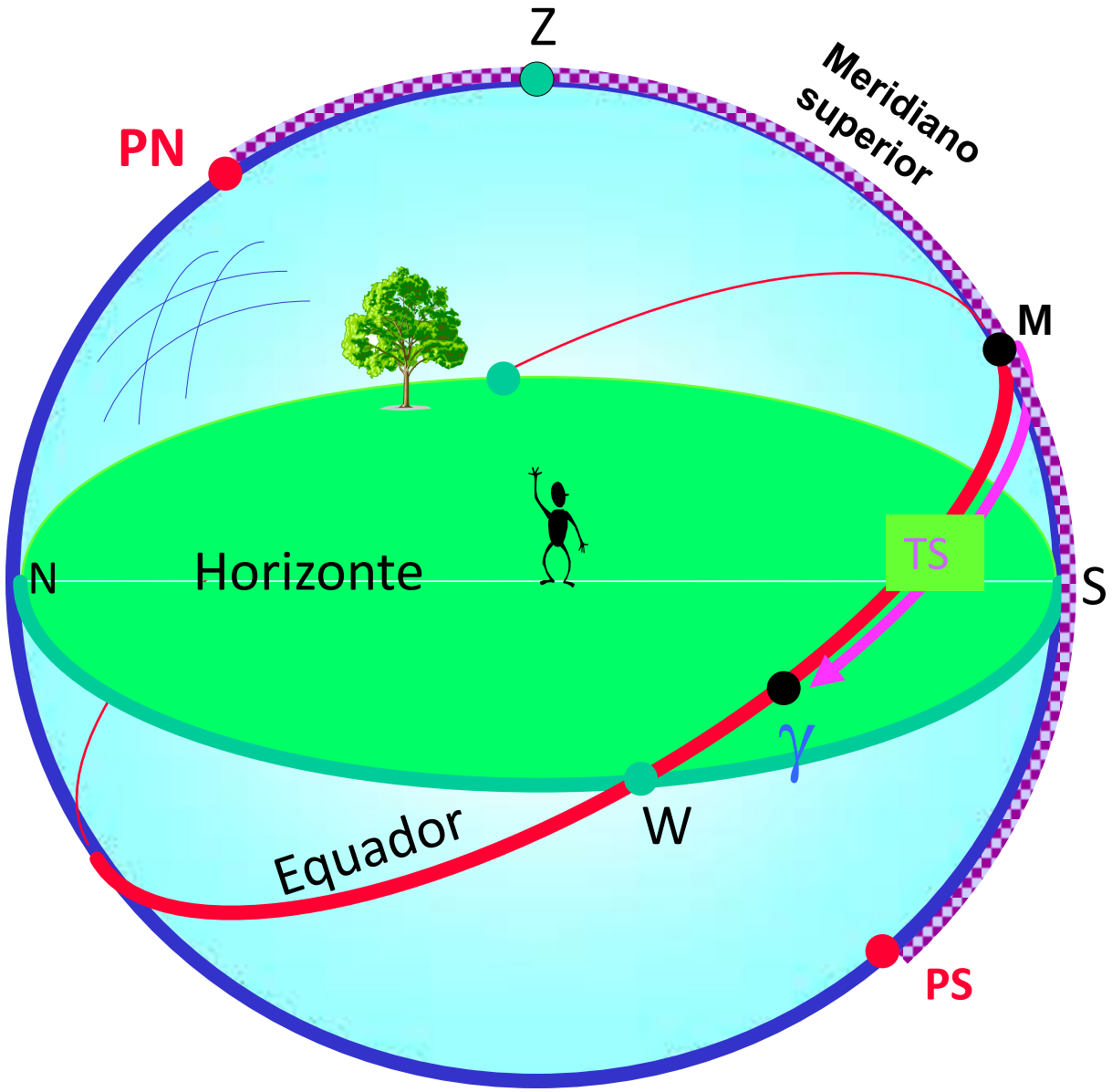
$H = 0.$

Na passagem meridiana inferior:

$H = 12^h$

Slide adapted from Prof. Boczko

Tempo sideral



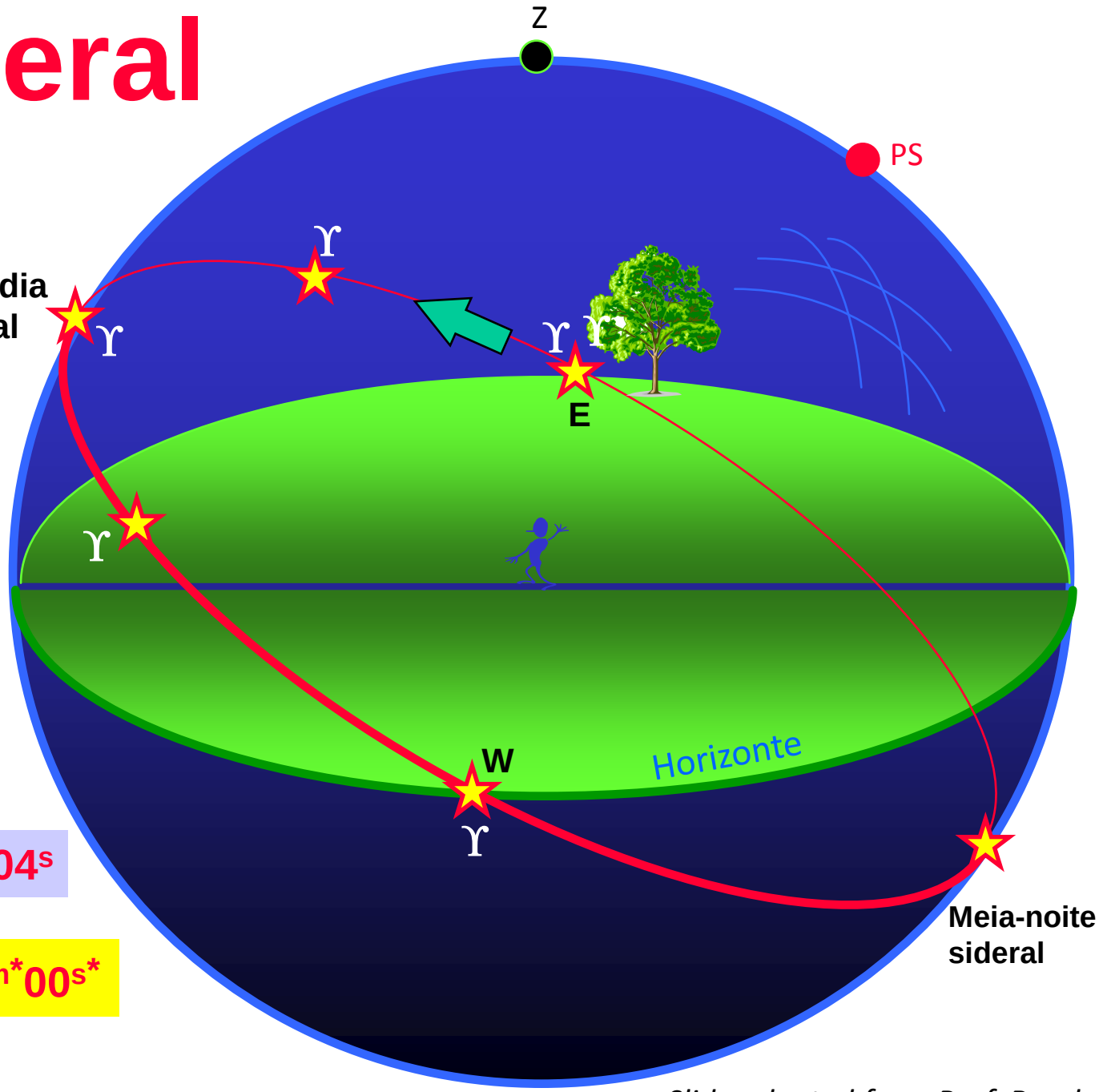
Tempo sideral é o ângulo horário do ponto γ

$TS \equiv H_{\gamma}$

Slide adapted from Prof. Boczko

Dia sideral

Dia sideral:
Intervalo de tempo para que o Ponto Gama passe duas vezes sucessivas por um dado meridiano do local.



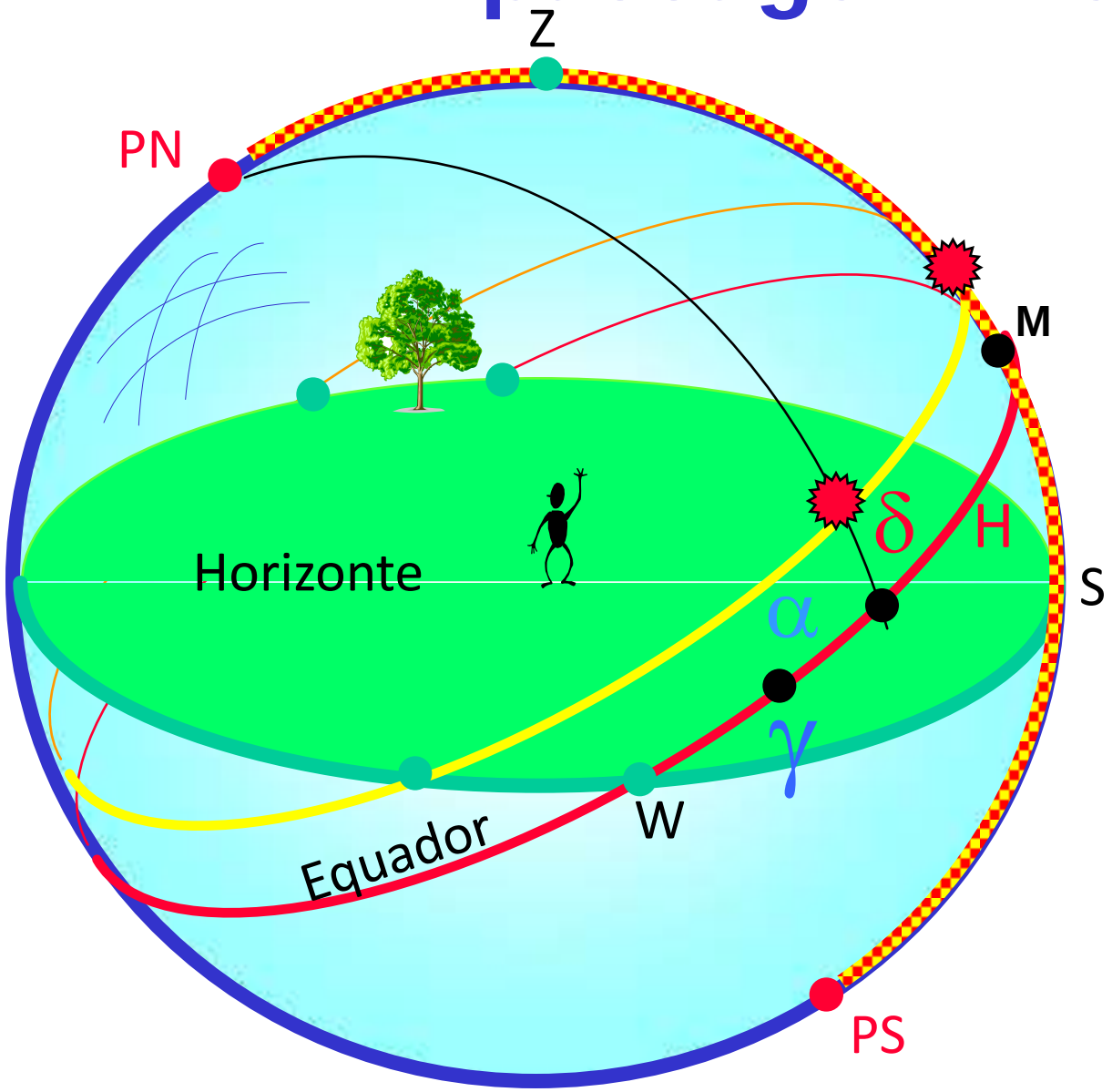
Dia sideral ≅ $23^h56^m04^s$

Dia sideral ≡ $24^{h*}00^{m*}00^{s*}$

*** : siderais**

Slide adapted from Prof. Boczko

Obtendo a Ascensão Reta na passagem meridiana



$TS = H_{\gamma}$

$TS = \alpha + H$

Na passagem meridiana superior:

$H = 0$

Logo:

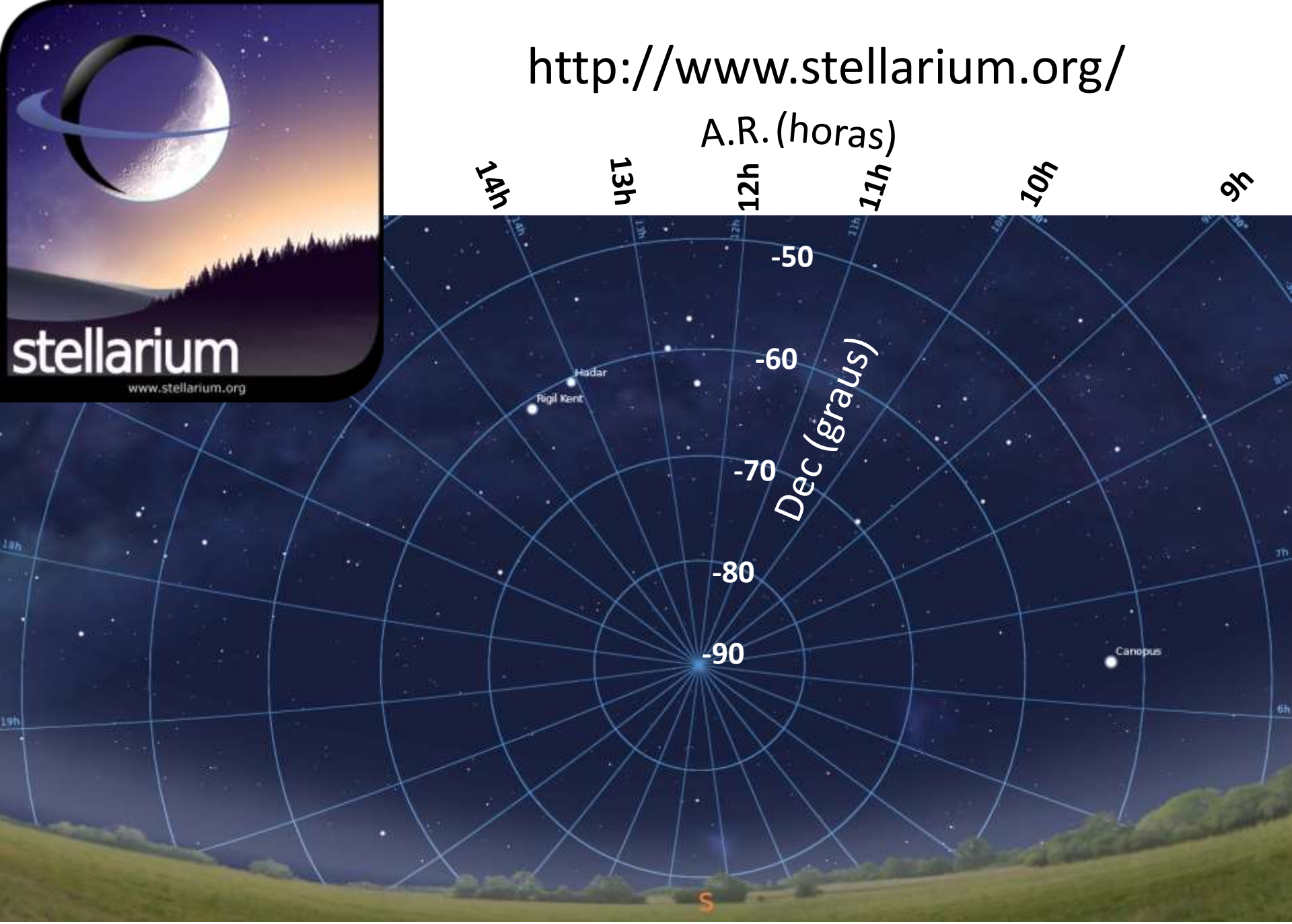
$\alpha = TS_{PMS}$

Slide adapted from Prof. Boczko

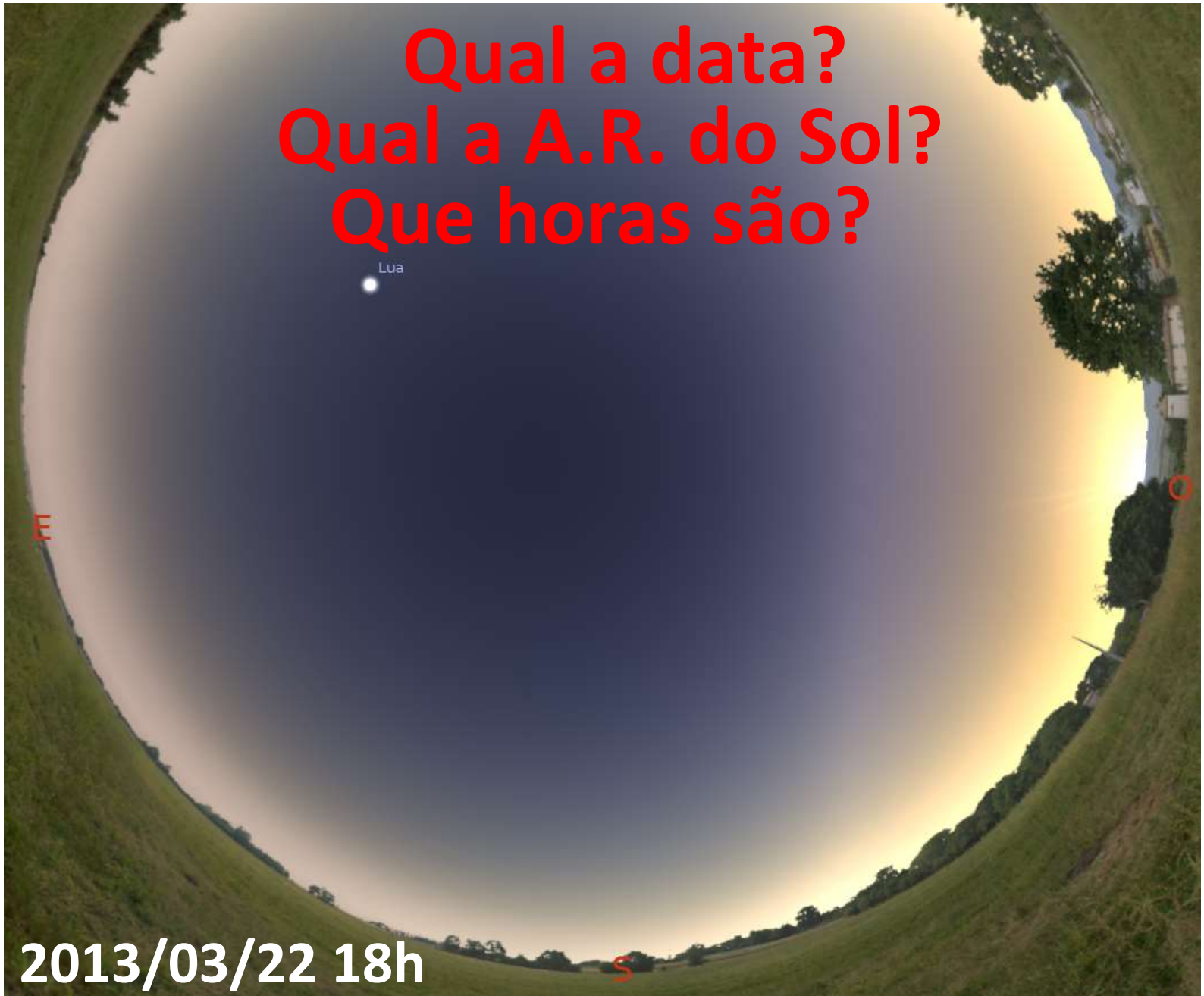
Círculo Meridiano de Valinhos

Prof. Rama

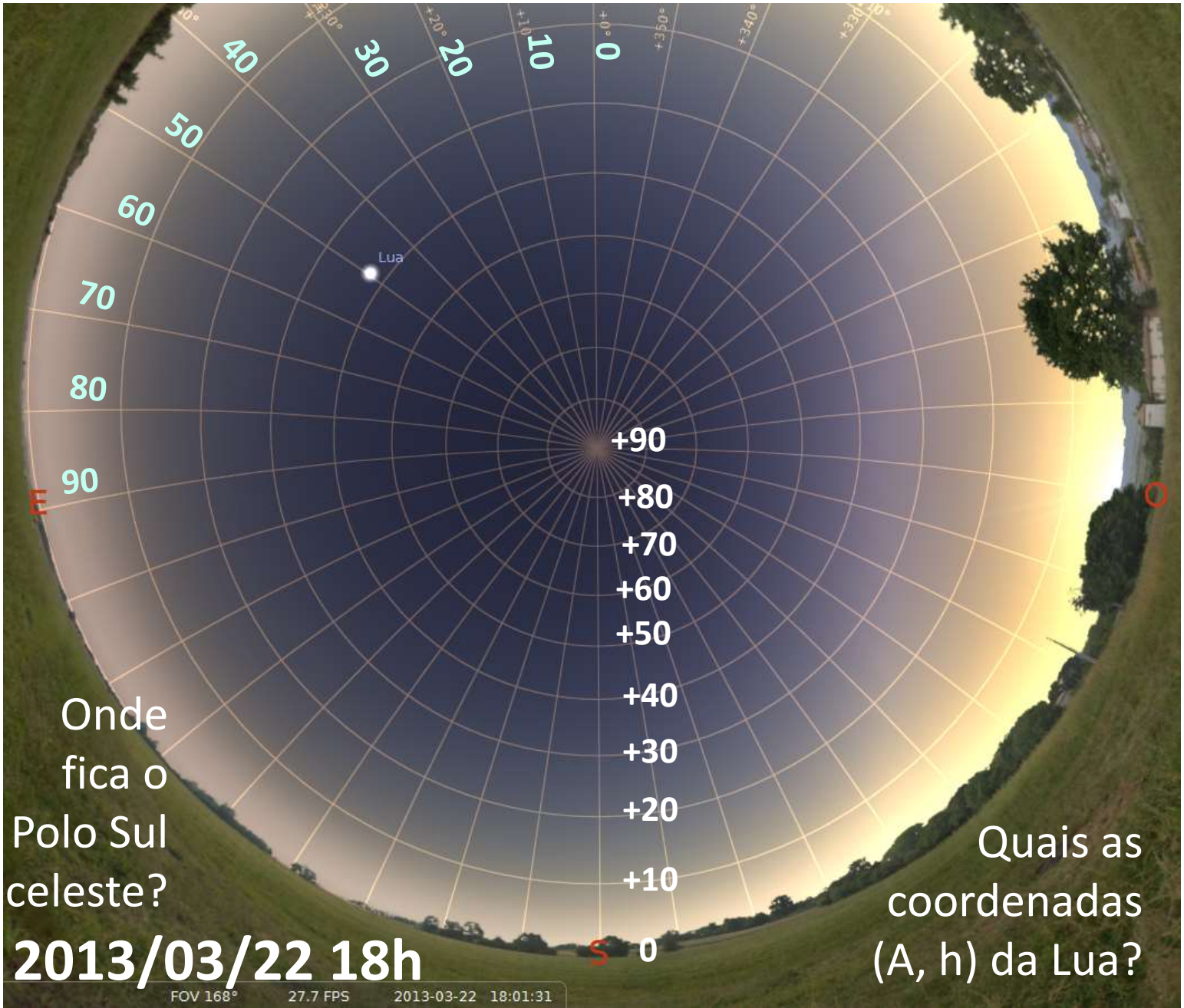
http://www.stellarium.org/



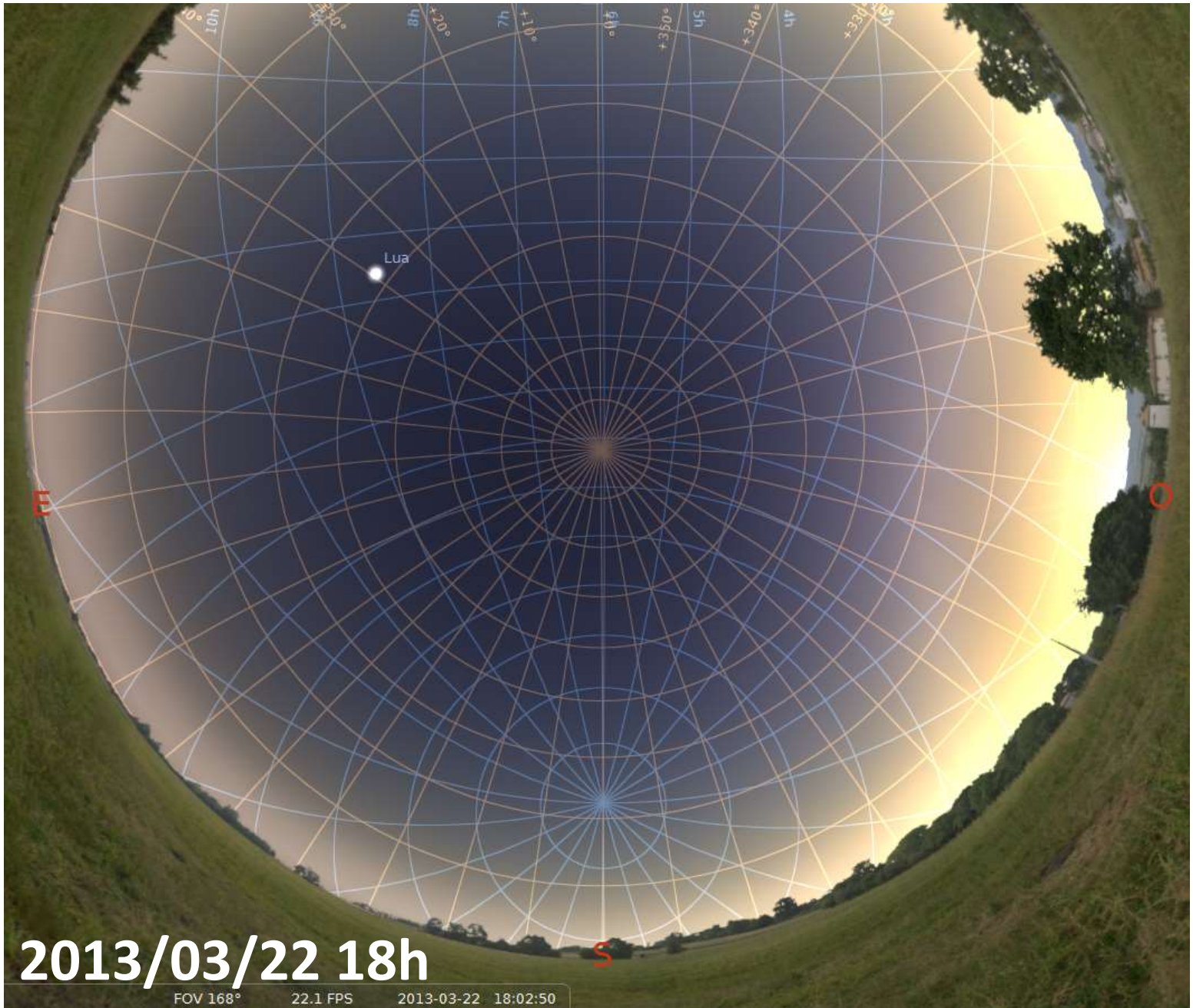
Céu desde o OPD



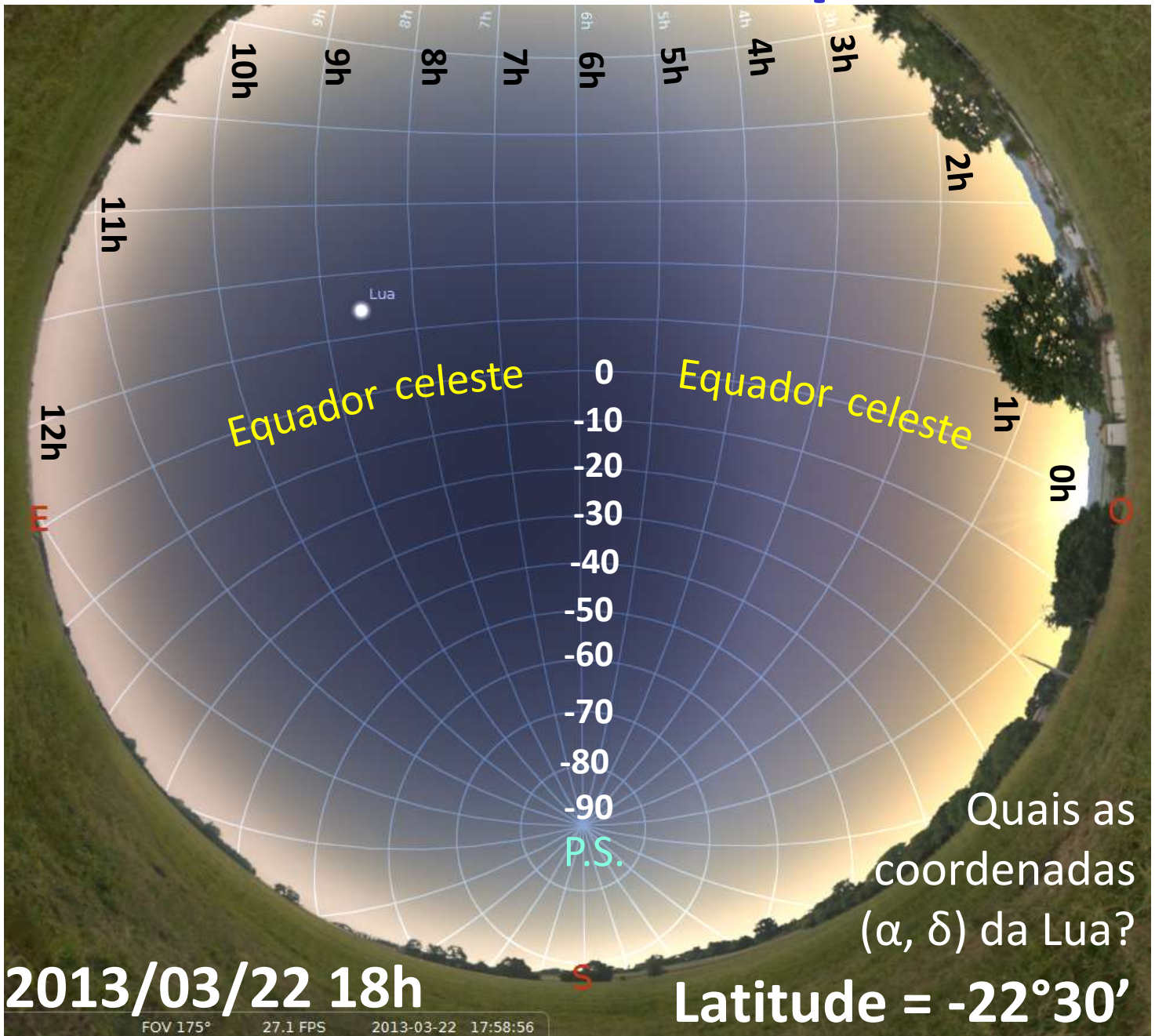
Céu desde o OPD: altazimutal

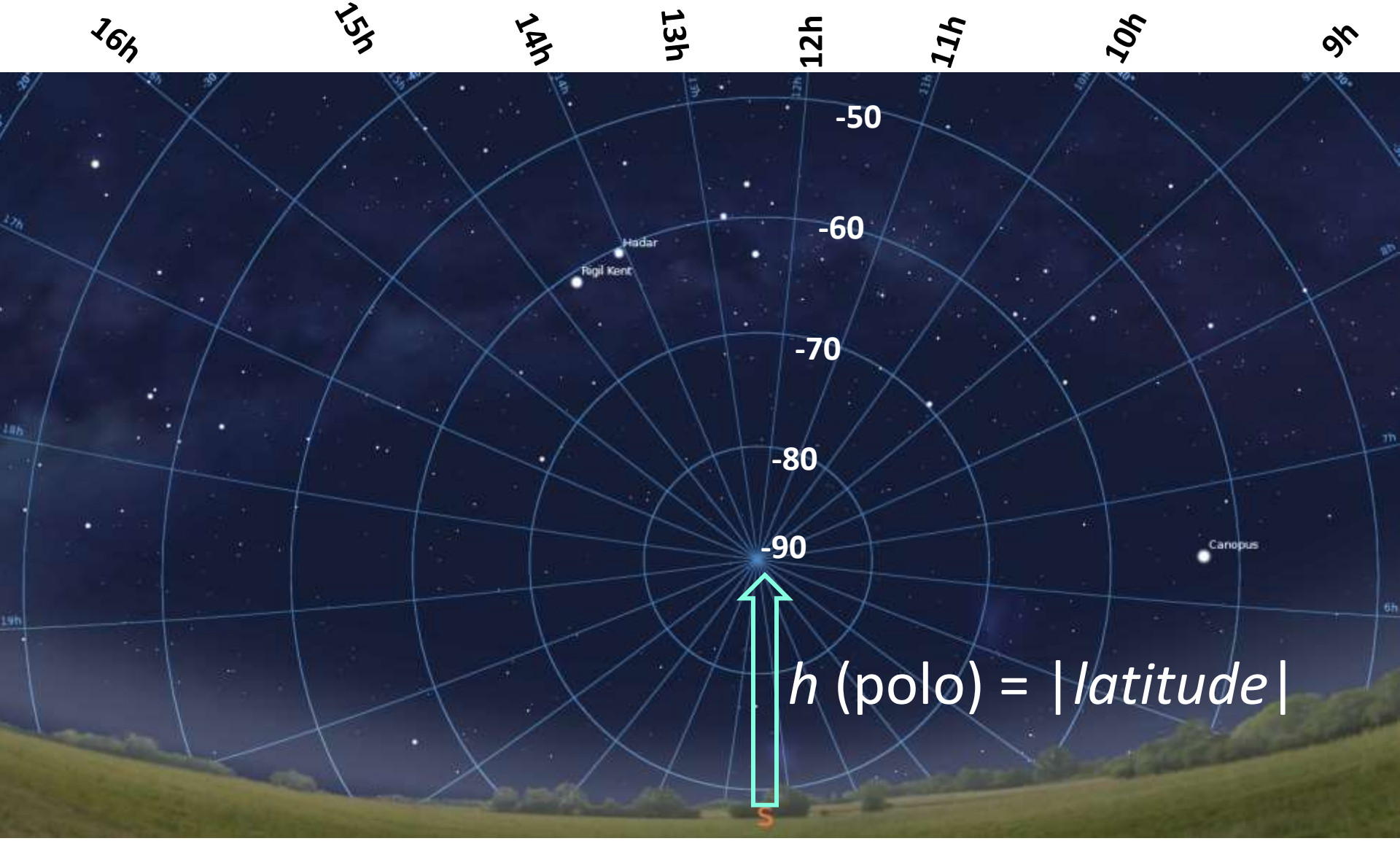


Céu desde o OPD: altazimutal+equatorial

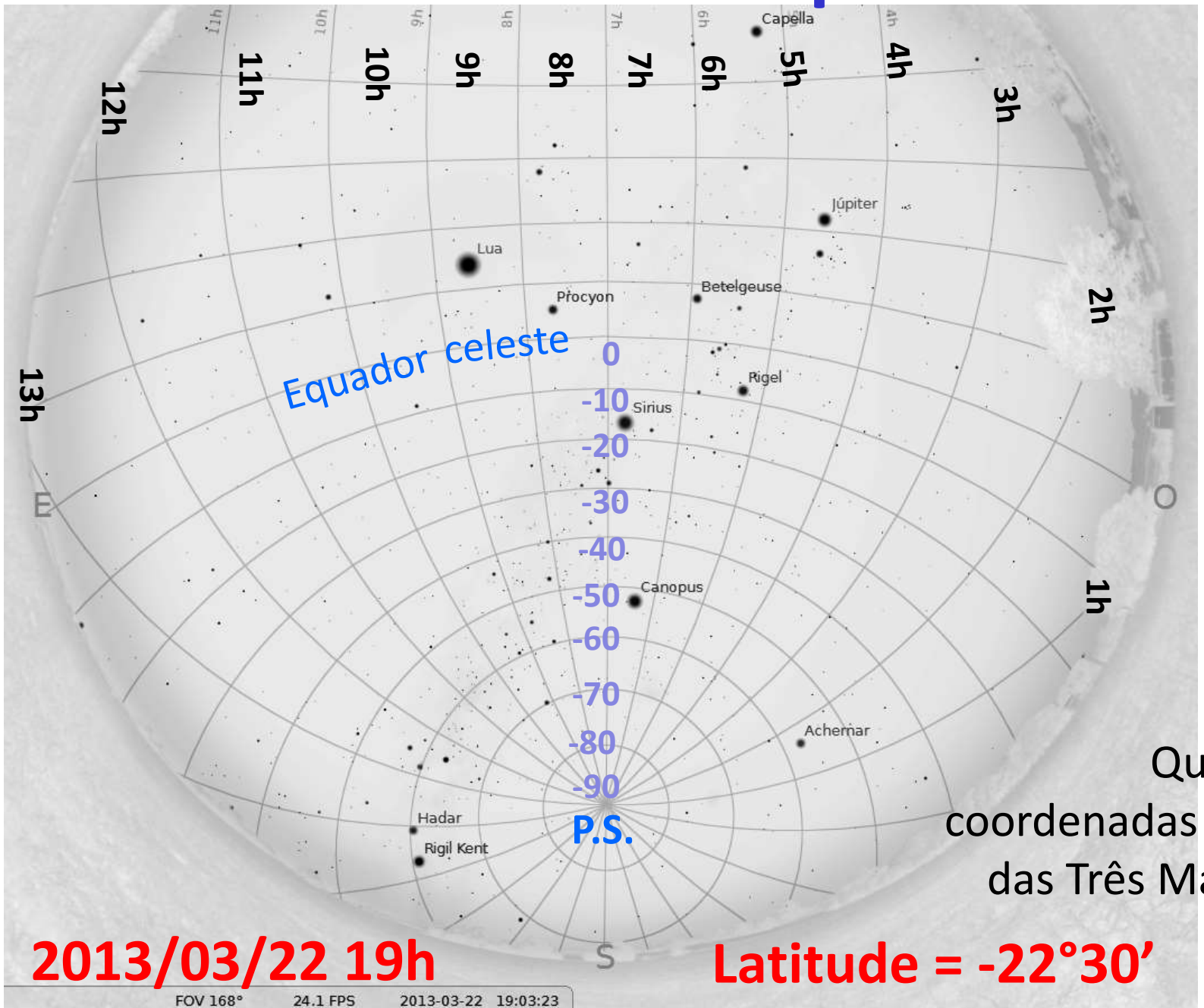


Céu desde o OPD: equatorial




16h
15h
14h
13h
12h
11h
10h
9h
-50
-60
-70
-80
-90
Hadar
Rigil Kent
Canopus
S
h (polo) = |latitude|

Céu desde o OPD: equatorial

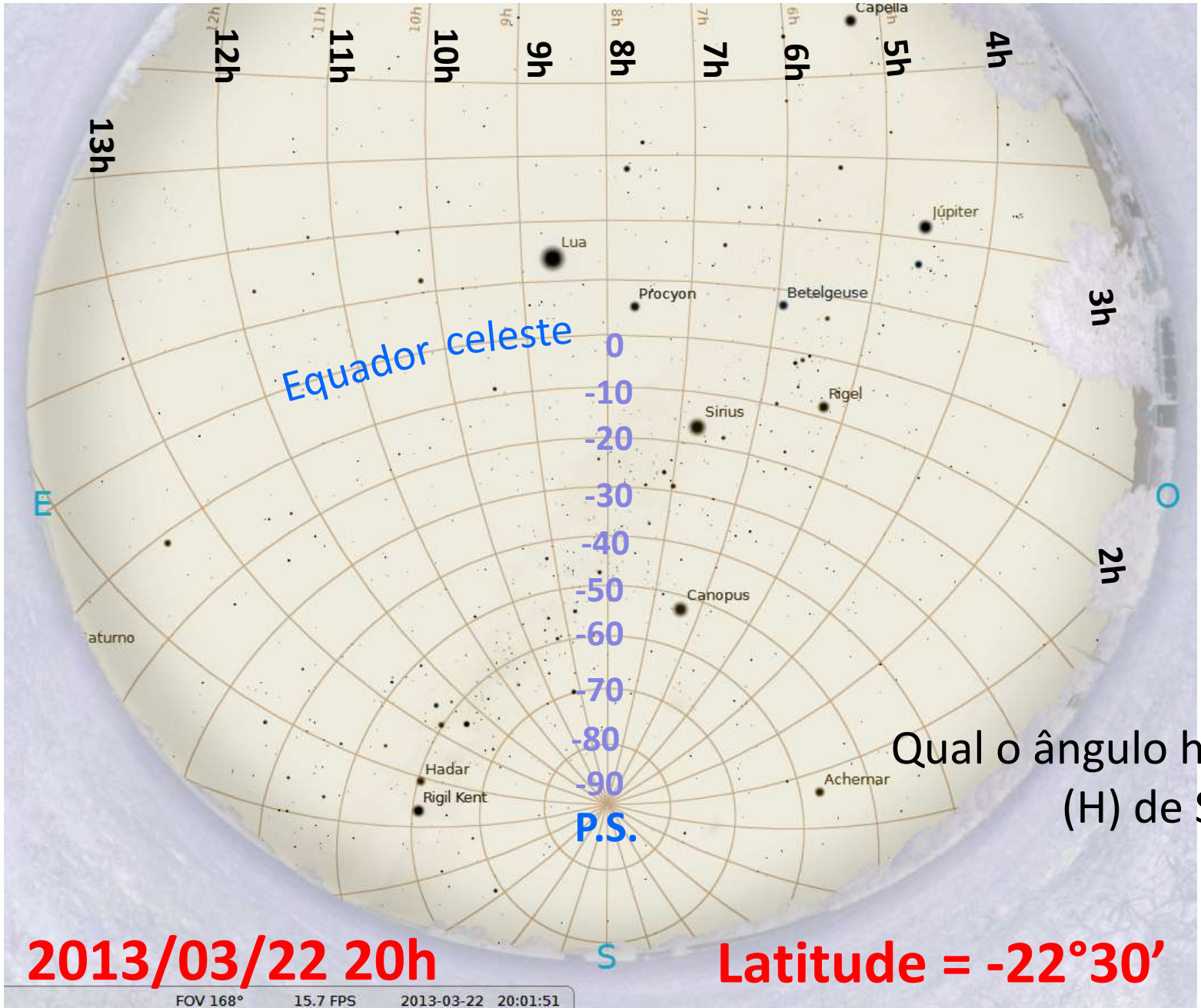


Quais as coordenadas (α, δ) das Três Marias?

2013/03/22 19h

Latitude = -22°30'

Céu desde o OPD: equatorial

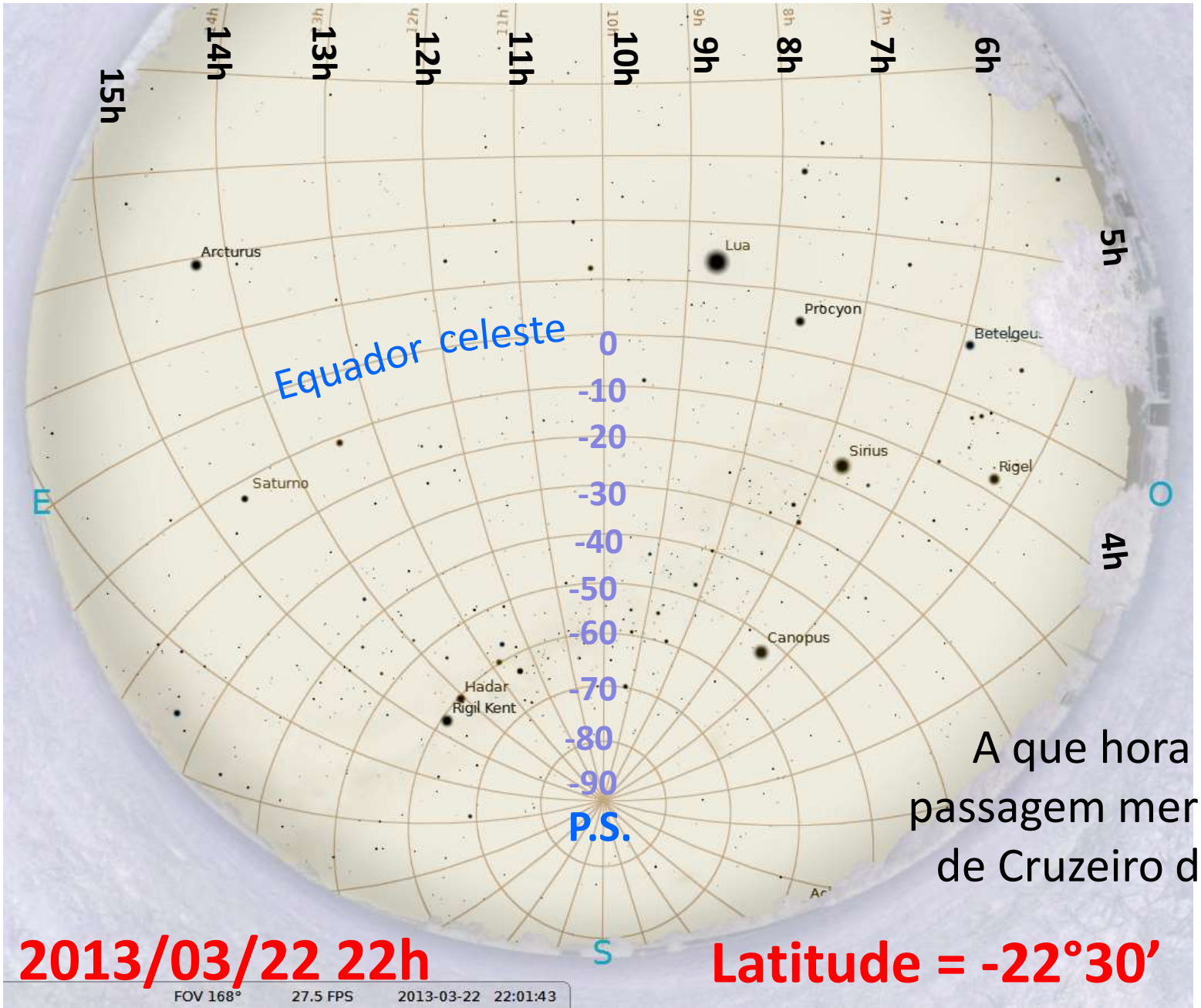


Qual o ângulo horario (H) de Sirius?

2013/03/22 20h

Latitude = -22°30'

Céu desde o OPD: equatorial

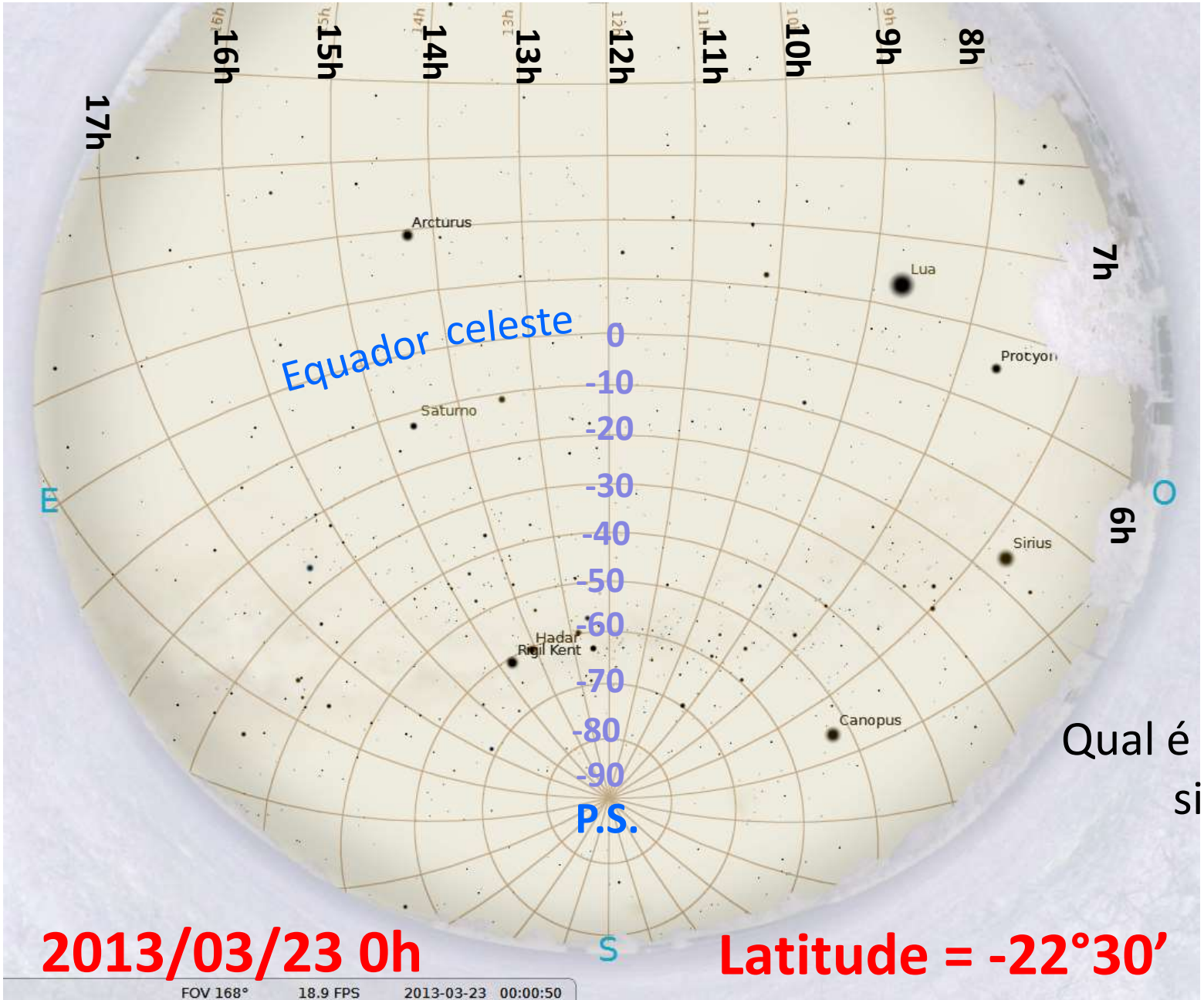


A que hora será a passagem meridiana de Cruzeiro do Sul?

2013/03/22 22h

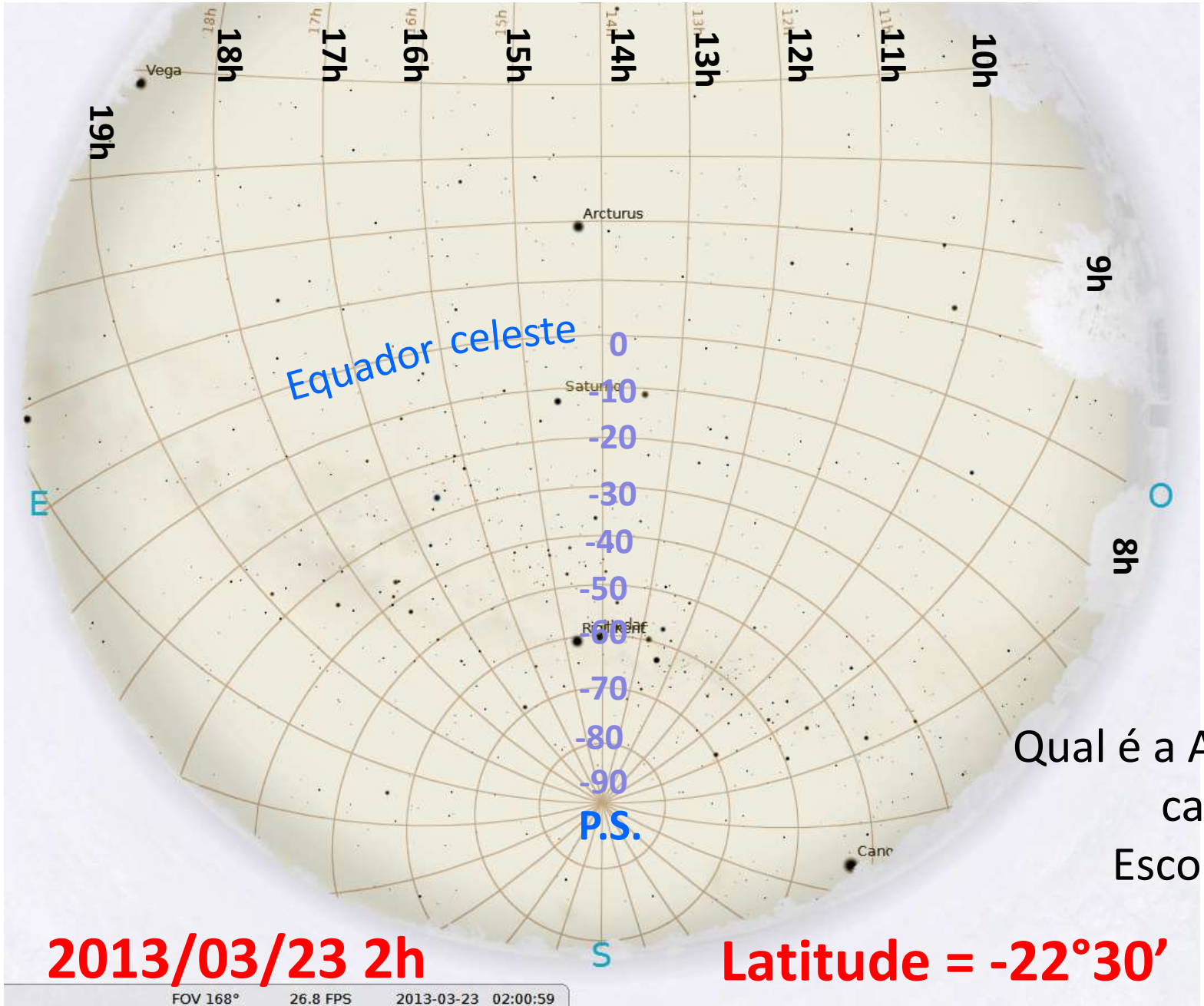
Latitude = -22°30'

Céu desde o OPD: equatorial



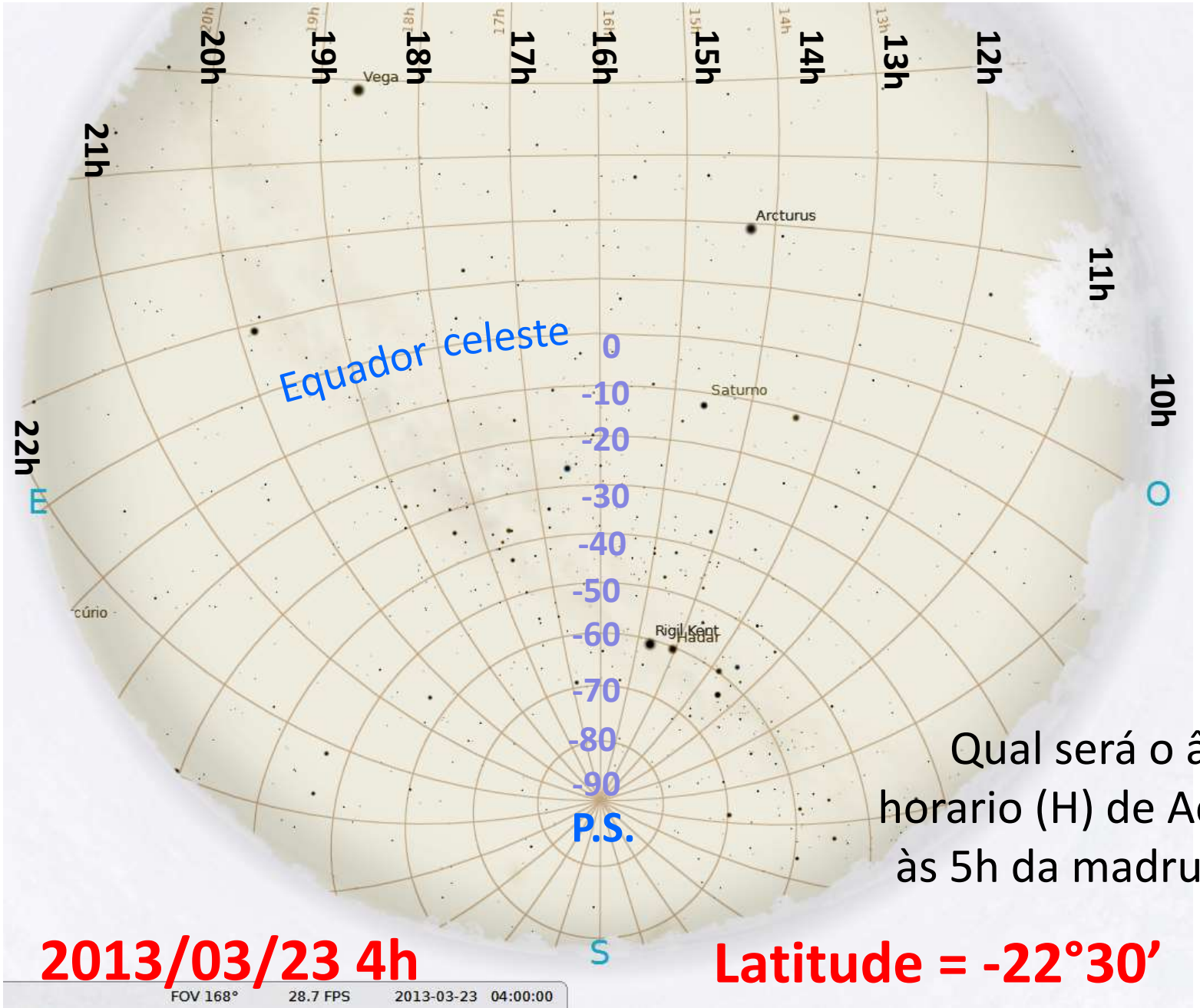
Qual é a hora sideral?

Céu desde o OPD: equatorial



Qual é a A.R. da calda do Escorpião?

Céu desde o OPD: equatorial

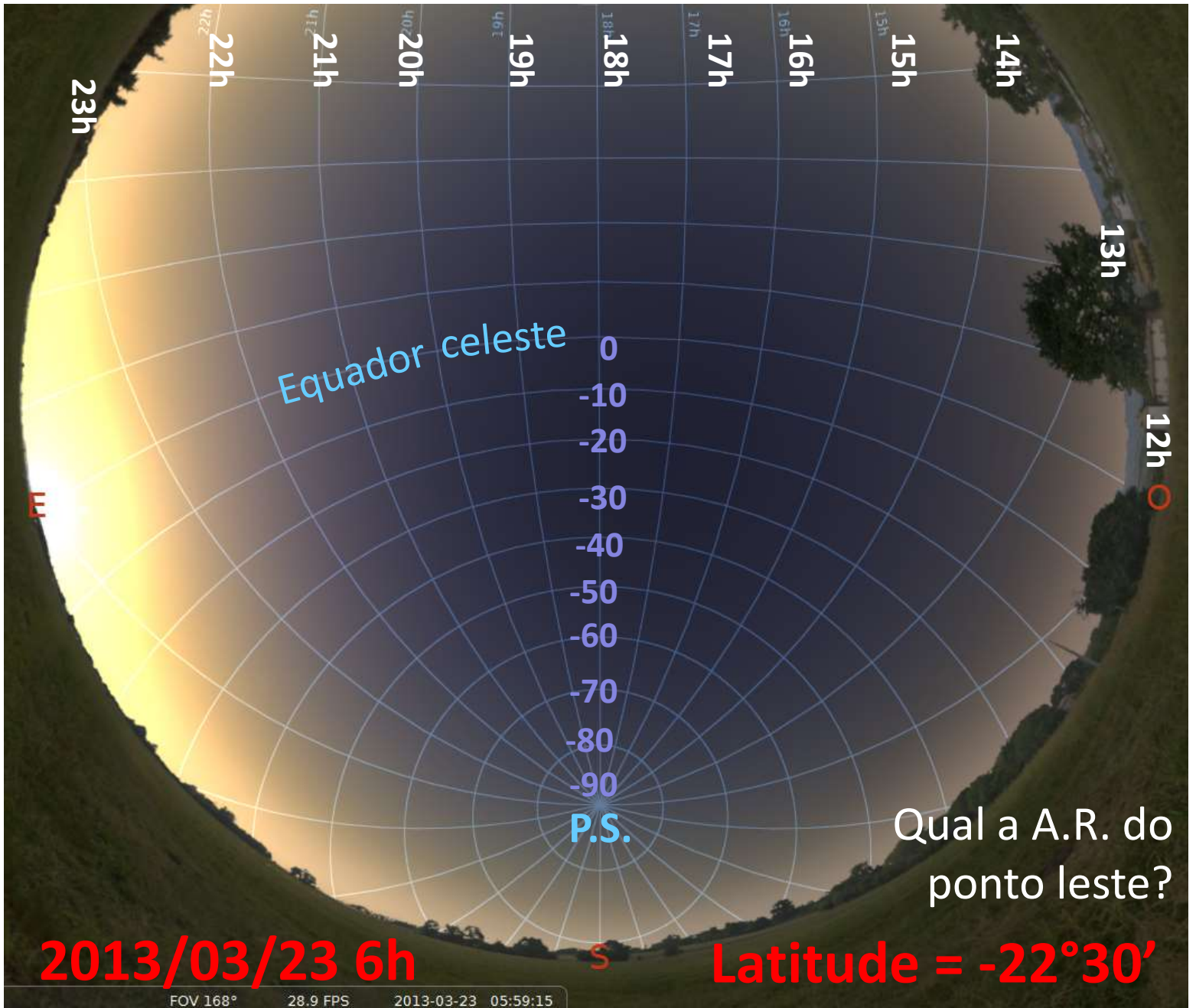


Qual será o ângulo horario (H) de Acturus às 5h da madrugada?

2013/03/23 4h

Latitude = -22°30’

Céu desde o OPD: equatorial



Campos dos Goytacazes, RJ

http://www.twanight.org

http://apod.nasa.gov/apod/ap090509.html

Imagine o sistema equatorial no céu!

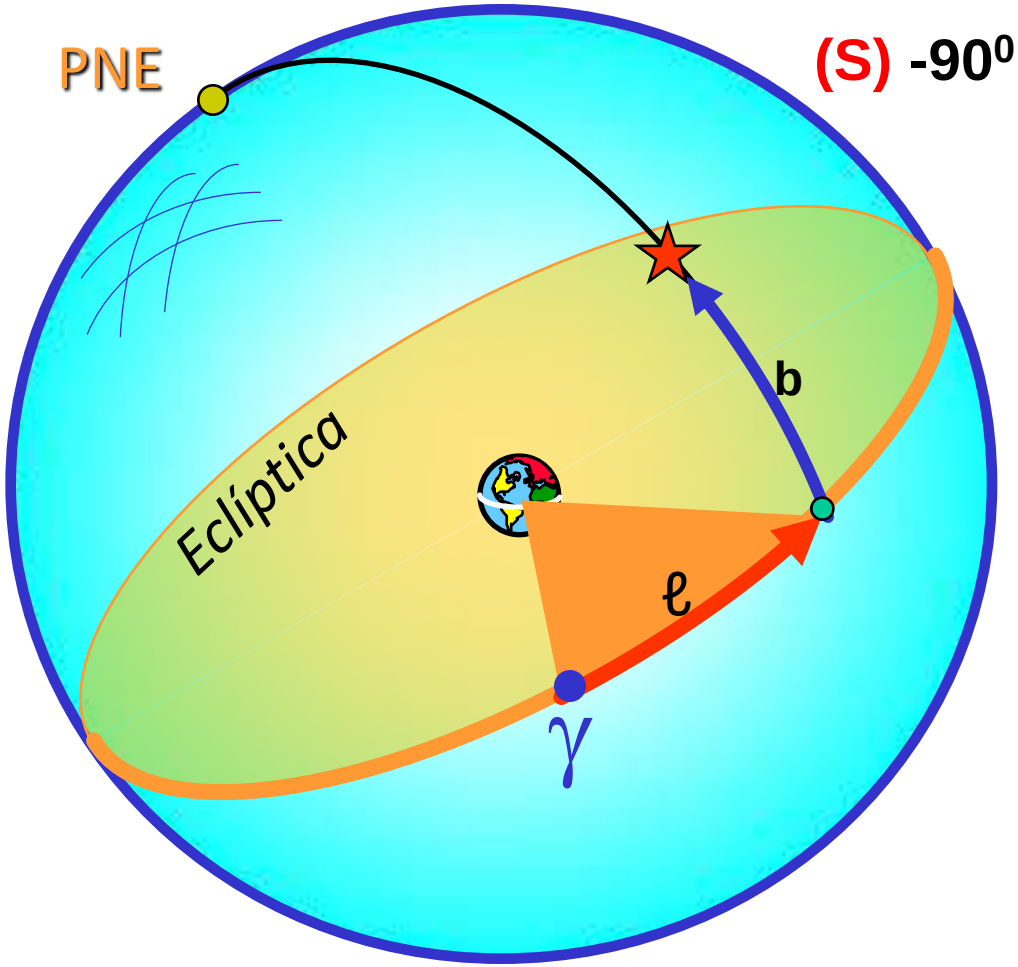
Sistema Eclíptico

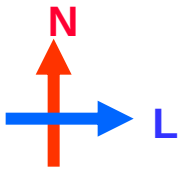
ℓ : longitude eclíptica
b : latitude eclíptica

★ **(ℓ , b)**

$0^0 \leq \ell < 360^0$

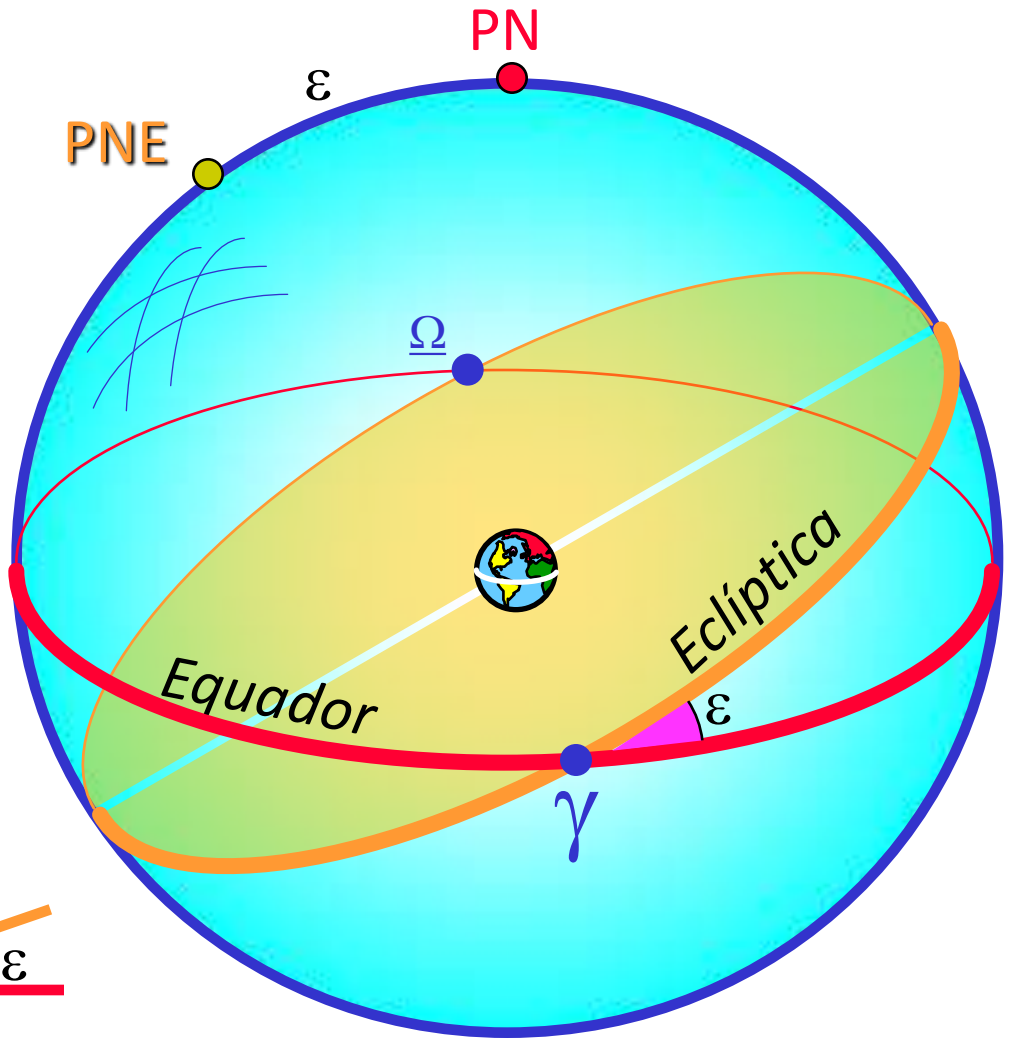
(S) $-90^0 \leq b \leq +90^0$ **(N)**

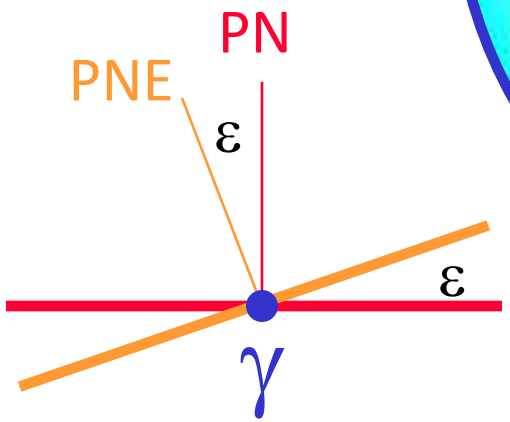


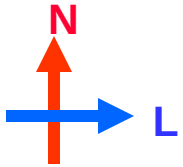


Slide adapted from Prof. Boczko

Sistemas Equatorial e Eclíptico







Slide adapted from Prof. Boczko

Galactic system (ℓ , b)

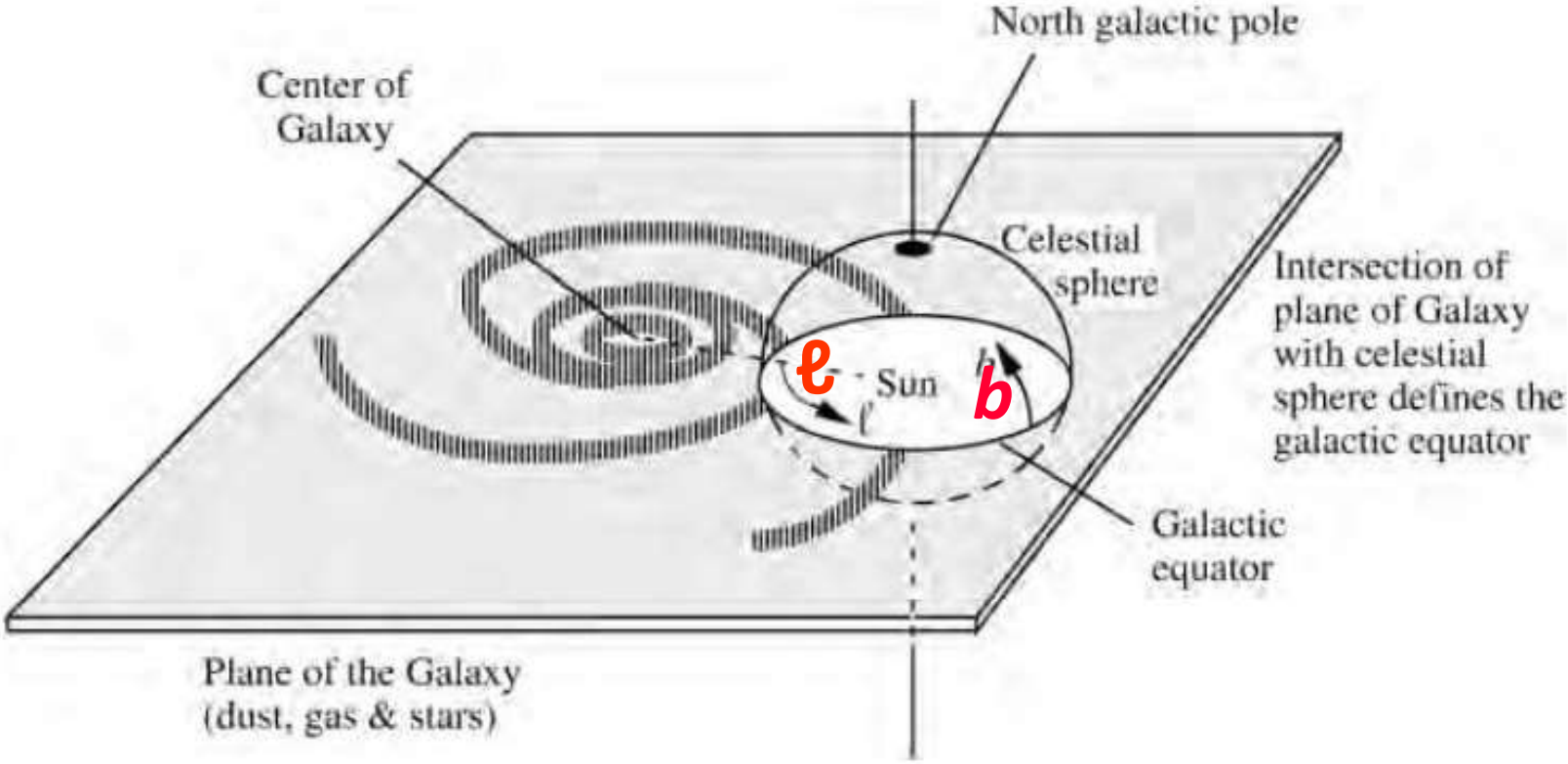
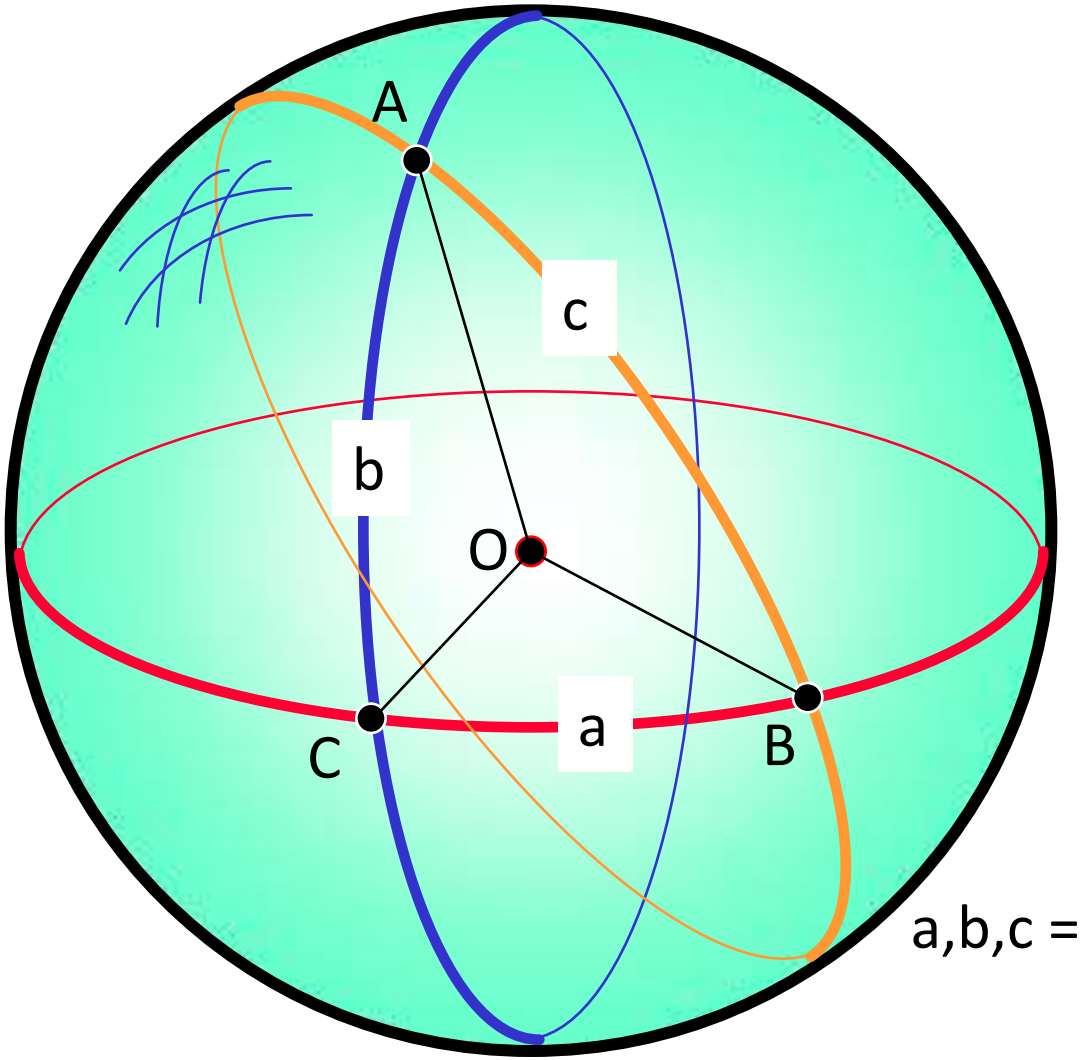


Figure 3.4. Galactic coordinates. The plane of the Galaxy defines the galactic equator on the celestial sphere. The angles that specify the location of a celestial body are measured from the sun. Galactic longitude, ℓ, is measured approximately eastward from the direction of the galactic center in units of degrees (0° to 359.9°) as shown. Galactic latitude, b, is measured in degrees (0° to ±90°) from the galactic equator, similar to latitude on the earth's surface. The north galactic pole (dark circle) is shown. The celestial sphere is quite small in this figure; in fact, its radius is infinite. The earth observer is located close to the sun.

Triângulo Esférico

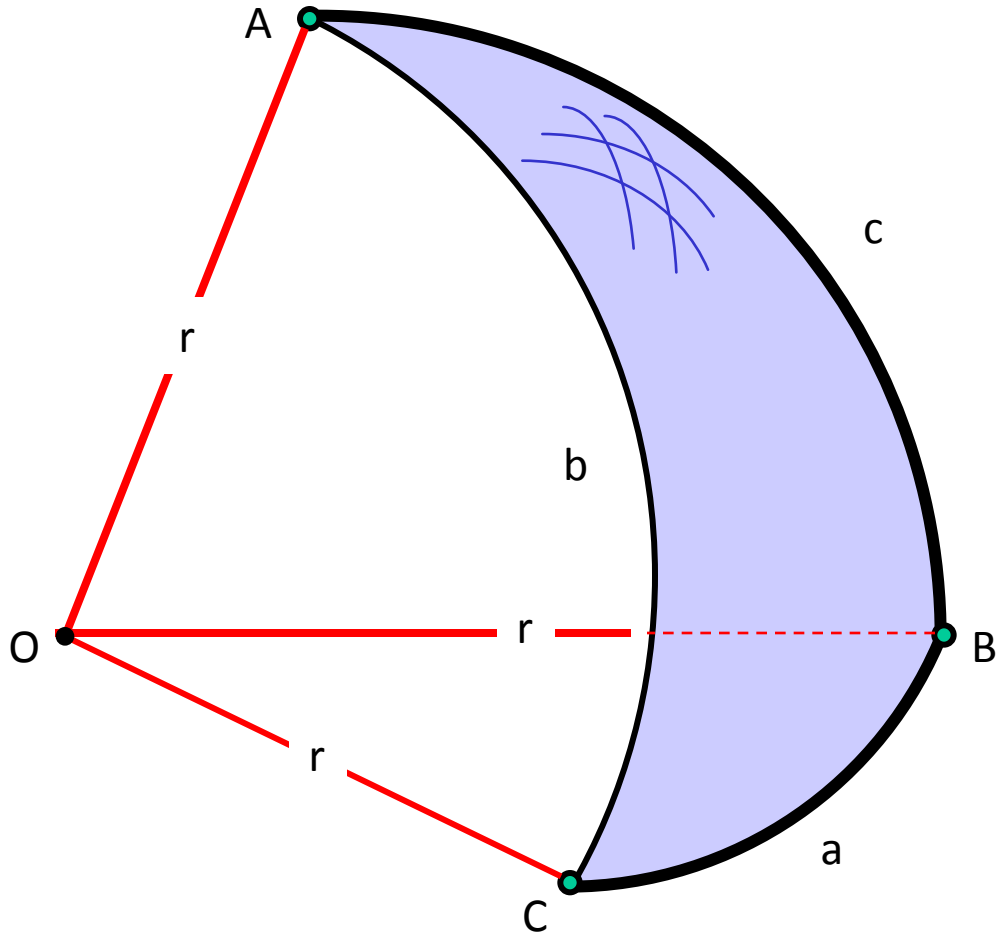
Triângulo esférico é a região da esfera delimitada pela intersecção, dois a dois, de 3 planos passantes pelo centro da esfera



A, B, C = vértices

a,b,c = lados

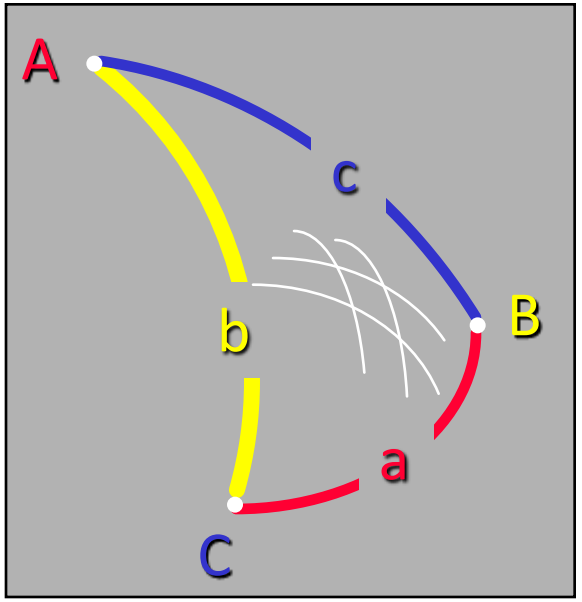
Triângulo esférico



a , b , c : lados do triângulo esférico = medidas dos ângulos centrais

Fórmula do seno & co-seno num triângulo esférico

Resumo das Fórmulas de Trigonometria Esférica



Co-seno

$$\cos a = \cos b \cdot \cos c + \operatorname{sen} b \cdot \operatorname{sen} c \cdot \cos A$$

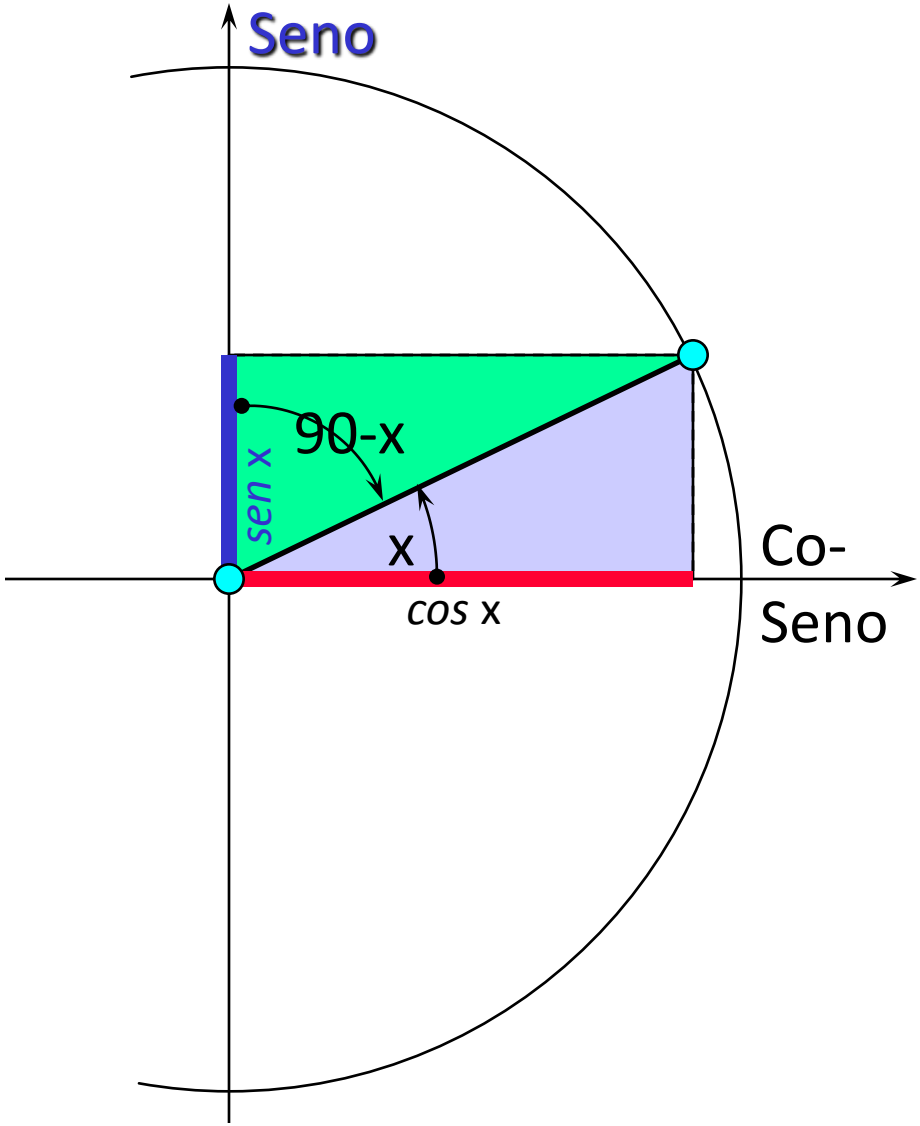
Seno

$$\frac{\operatorname{sen} a}{\operatorname{sen} A} = \frac{\operatorname{sen} b}{\operatorname{sen} B} = \frac{\operatorname{sen} c}{\operatorname{sen} C}$$

Seno & Co-seno

$$\operatorname{sen} a \cdot \cos B = \cos b \cdot \operatorname{sen} c - \operatorname{sen} b \cdot \cos c \cdot \cos A$$

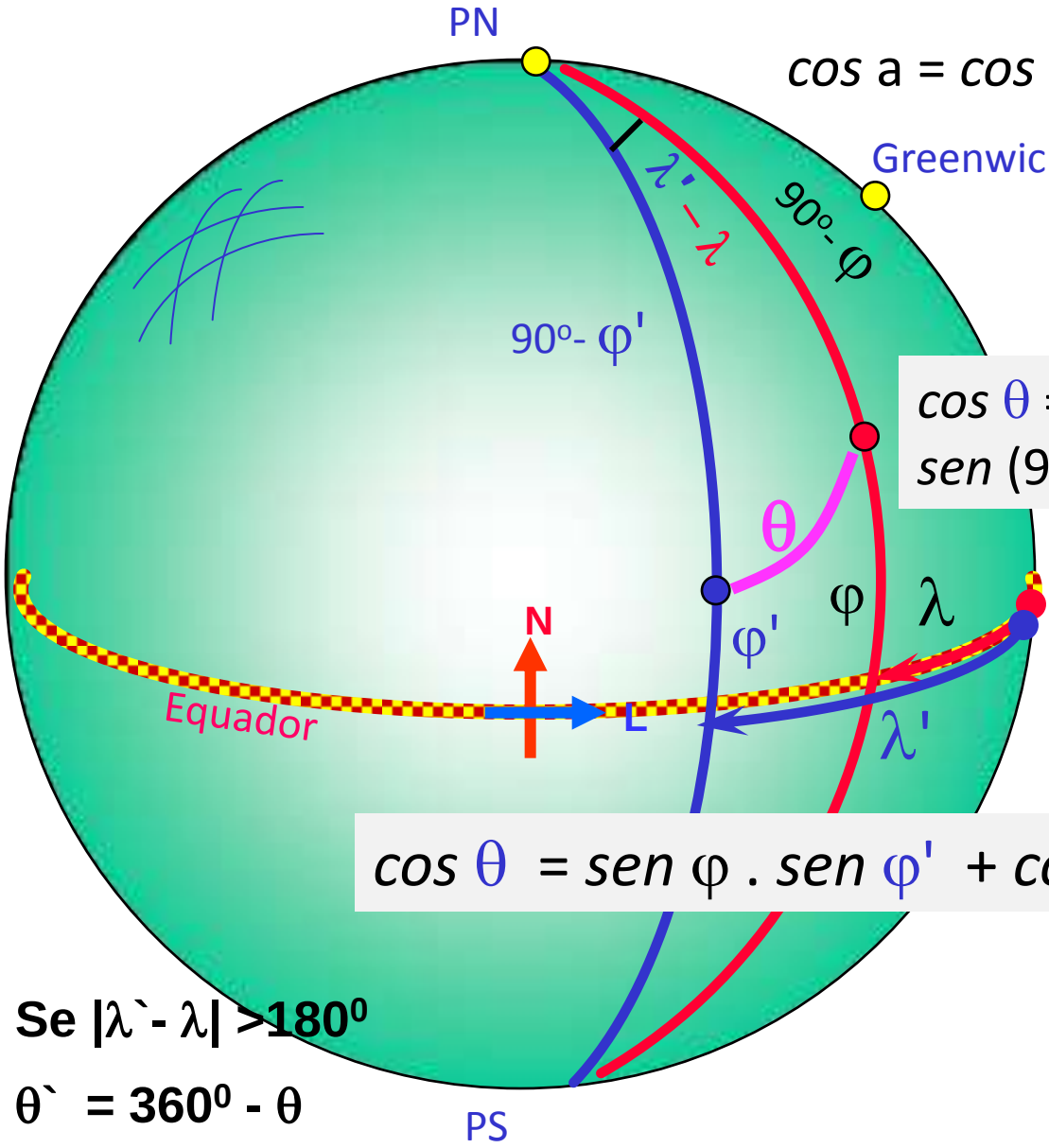
Seno & Co-seno de (90^0- x)



sen (90^0-x) = *cos* x

cos (90^0-x) = *sen* x

Ângulo entre duas cidades



cos a = *cos* b . *cos* c + *sen* b . *sen* c . *cos* A

Co-seno

cos θ = *cos* (90- φ) . *cos* (90- φ') +
sen (90- φ) . *sen* (90- φ') . *cos* (λ' - λ)

cos θ = *sen* φ . *sen* φ' + *cos* φ . *cos* φ' . *cos* (λ' - λ)

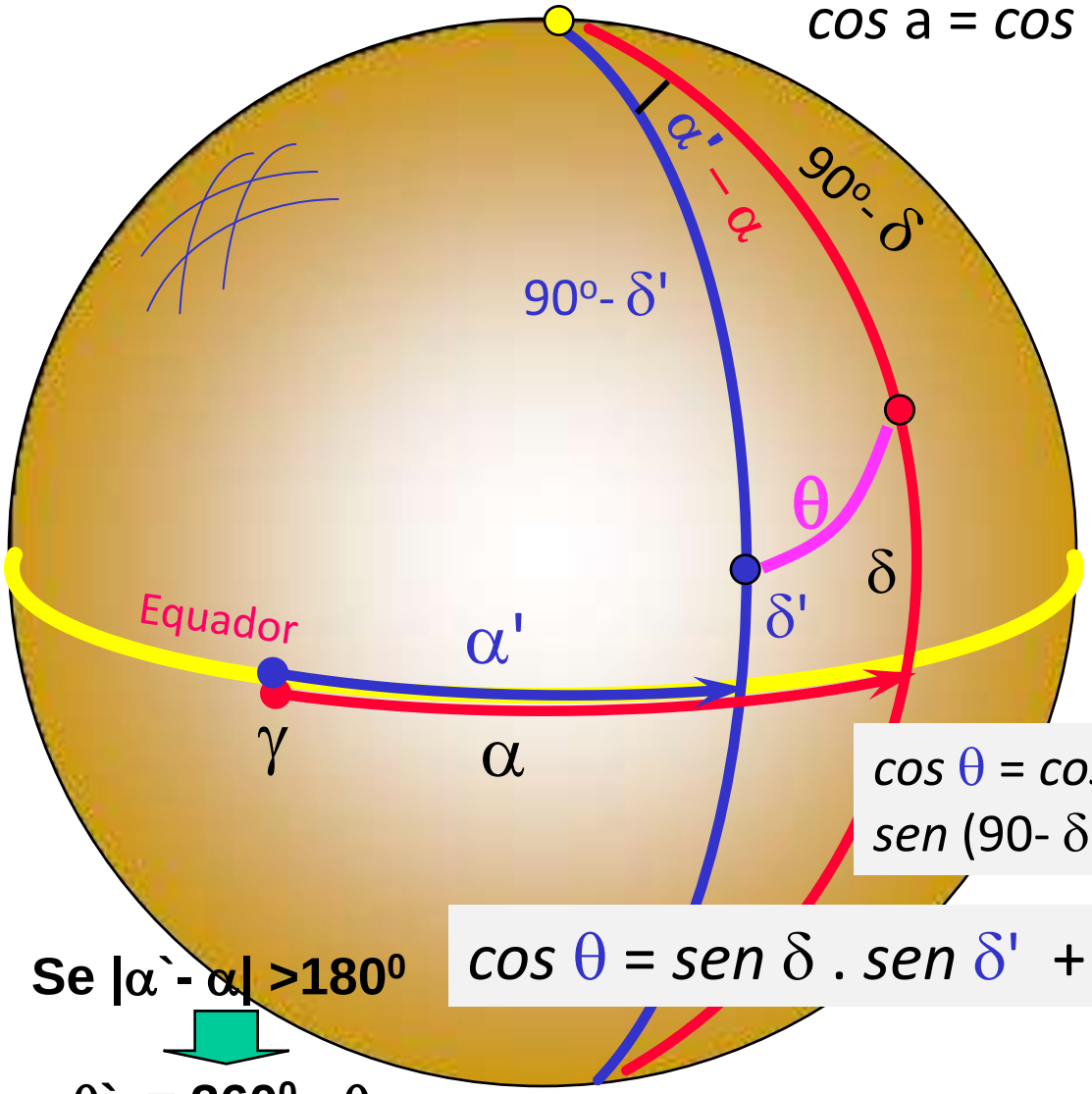
Se |λ`- λ| >180⁰

θ` = 360⁰ - θ

Ângulo entre dois astros

cos a = *cos* b . *cos* c + *sen* b . *sen* c . *cos* A

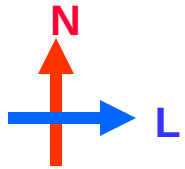
Co-seno



Dados:

α , δ

α' , δ'



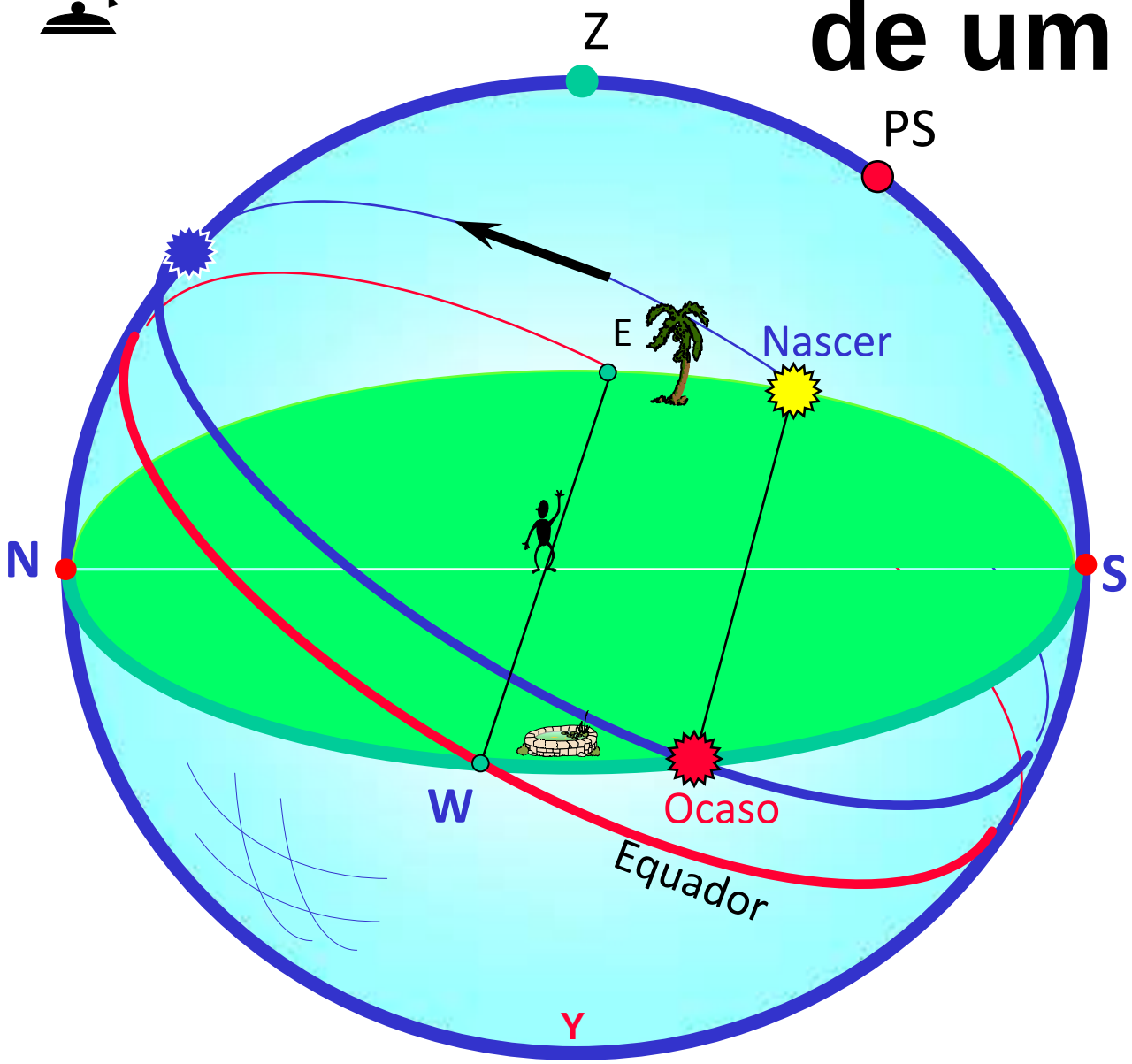
$\cos\theta = \cos(90-\delta) \cdot \cos(90-\delta') + \operatorname{sen}(90-\delta) \cdot \operatorname{sen}(90-\delta') \cdot \cos(\alpha' - \alpha)$

$\cos\theta = \operatorname{sen}\delta \cdot \operatorname{sen}\delta' + \cos\delta \cdot \cos\delta' \cdot \cos(\alpha' - \alpha)$

Se $|\alpha` - \alpha| > 180^0$

$\theta` = 360^0 - \theta$

Nascer e Ocaso de um astro (HS)



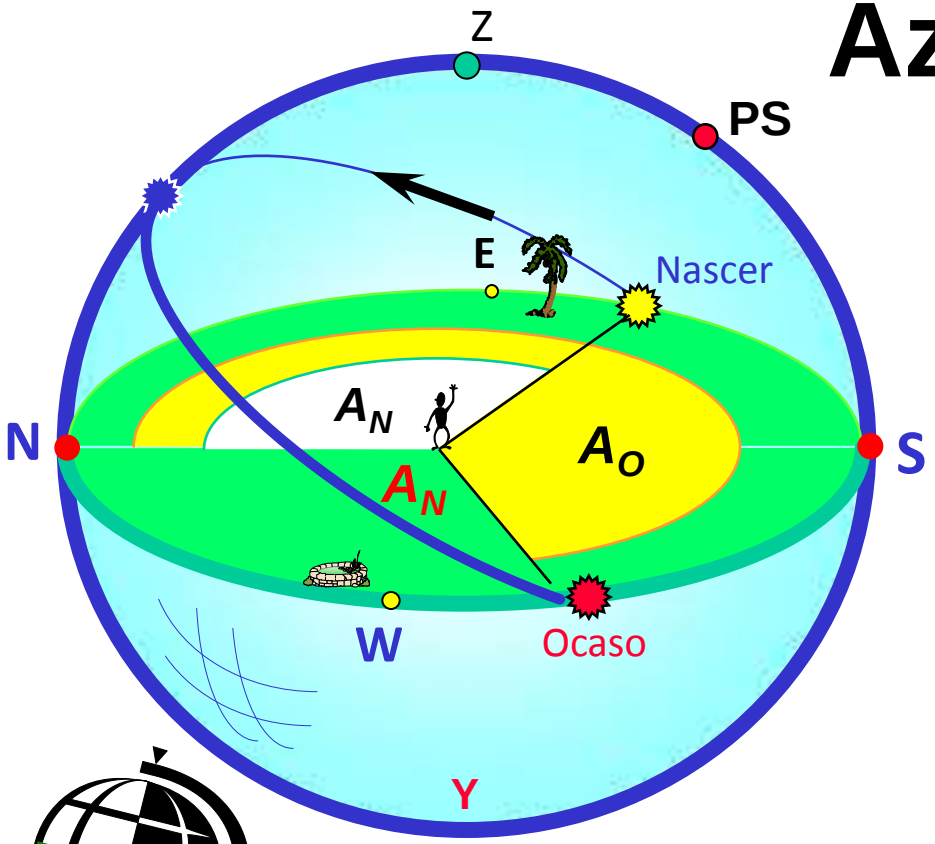
Condição de nascer e de ocaso:

h = 0

ou

z = 90º

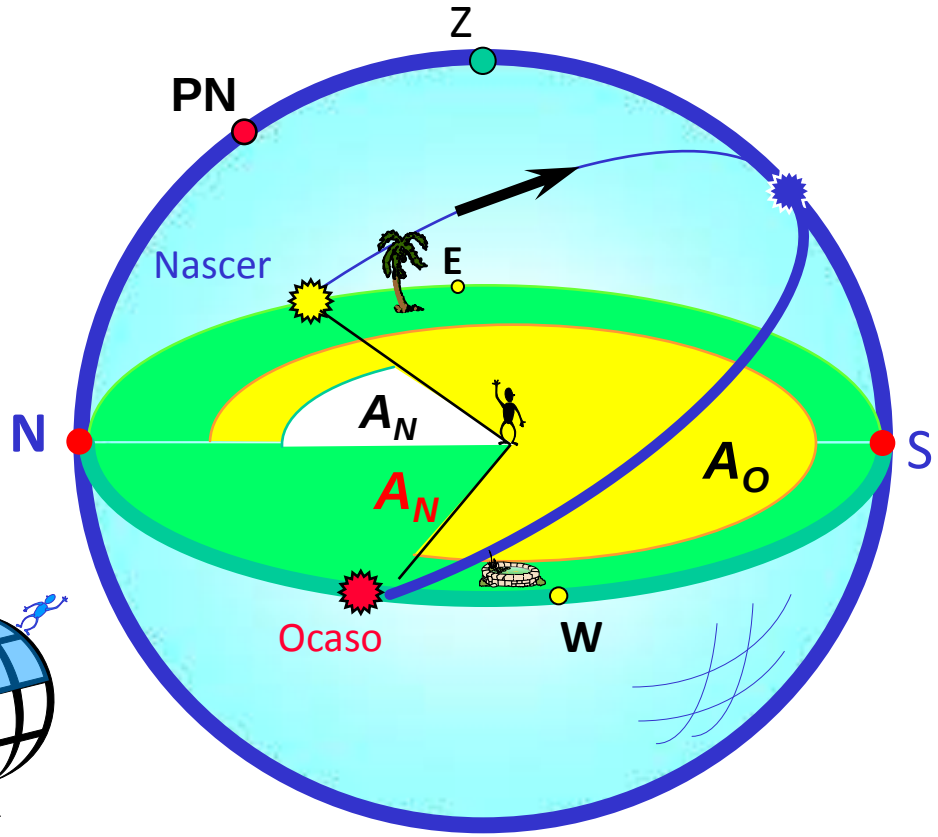
Azimutes do nascer e do ocaso nos diferentes hemisférios



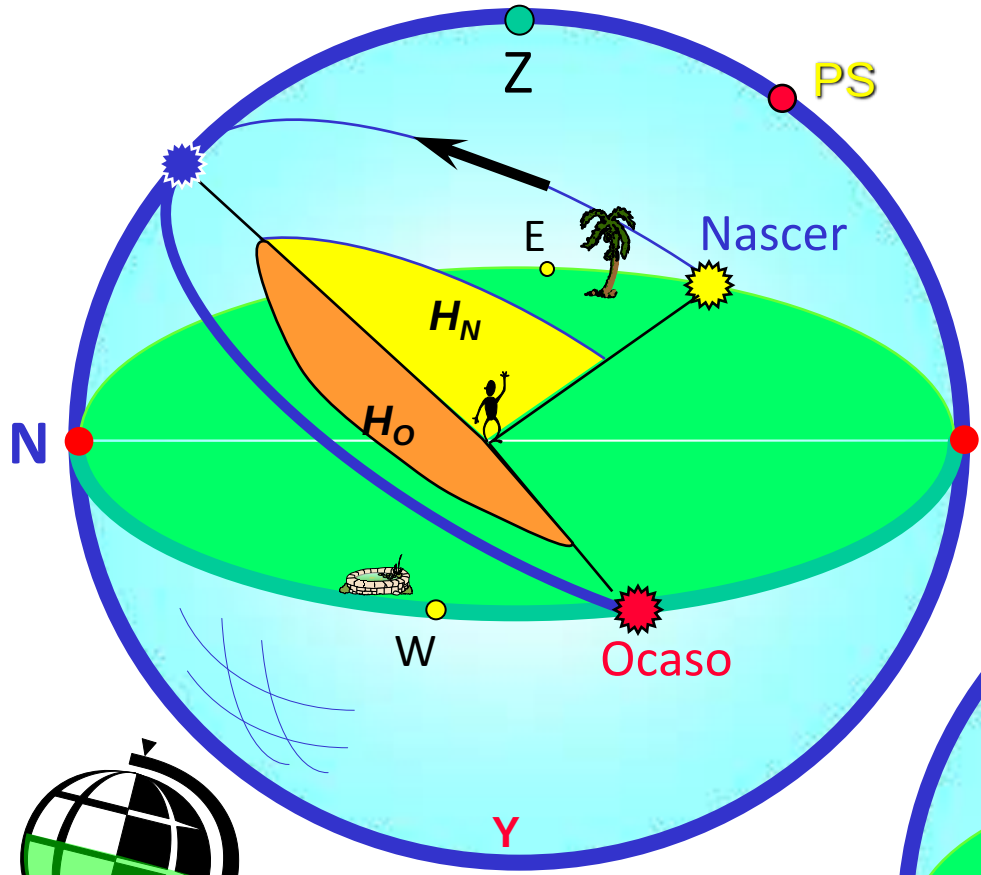
A_N: Azimute Nascer

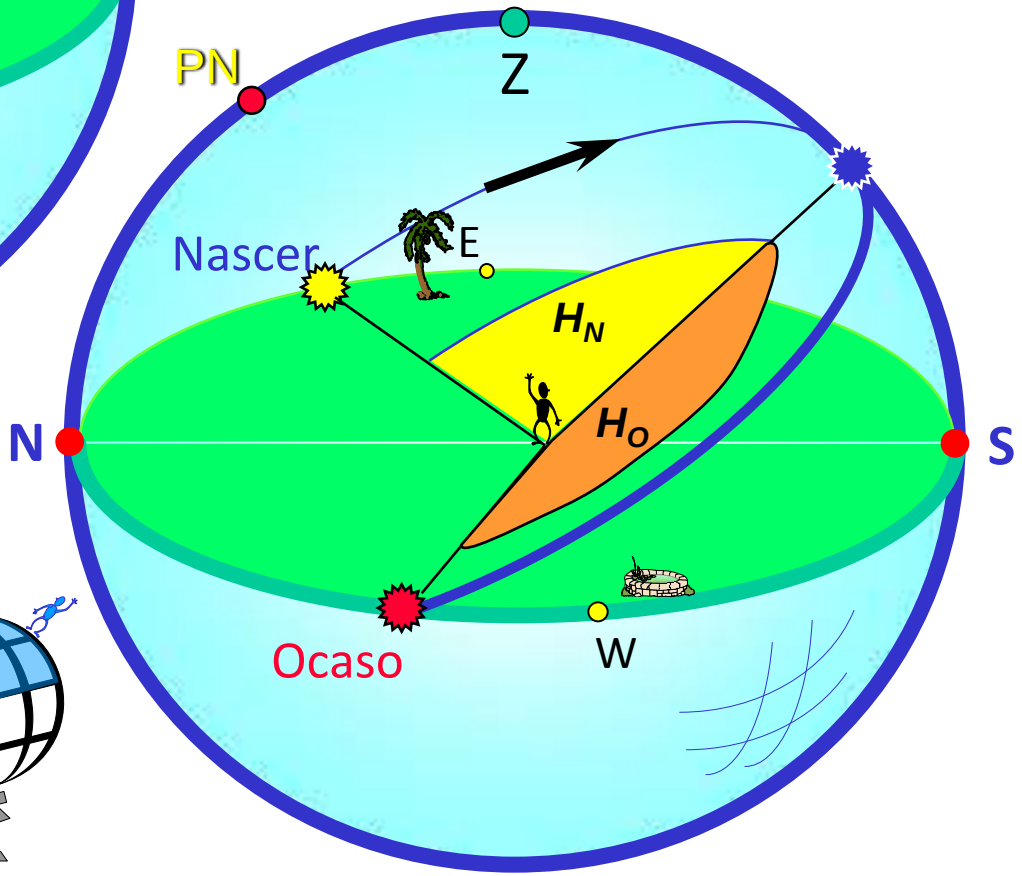
A_O : Azimute Ocaso

$$A_{Ocaso} = 360^o - A_{Nascer}$$



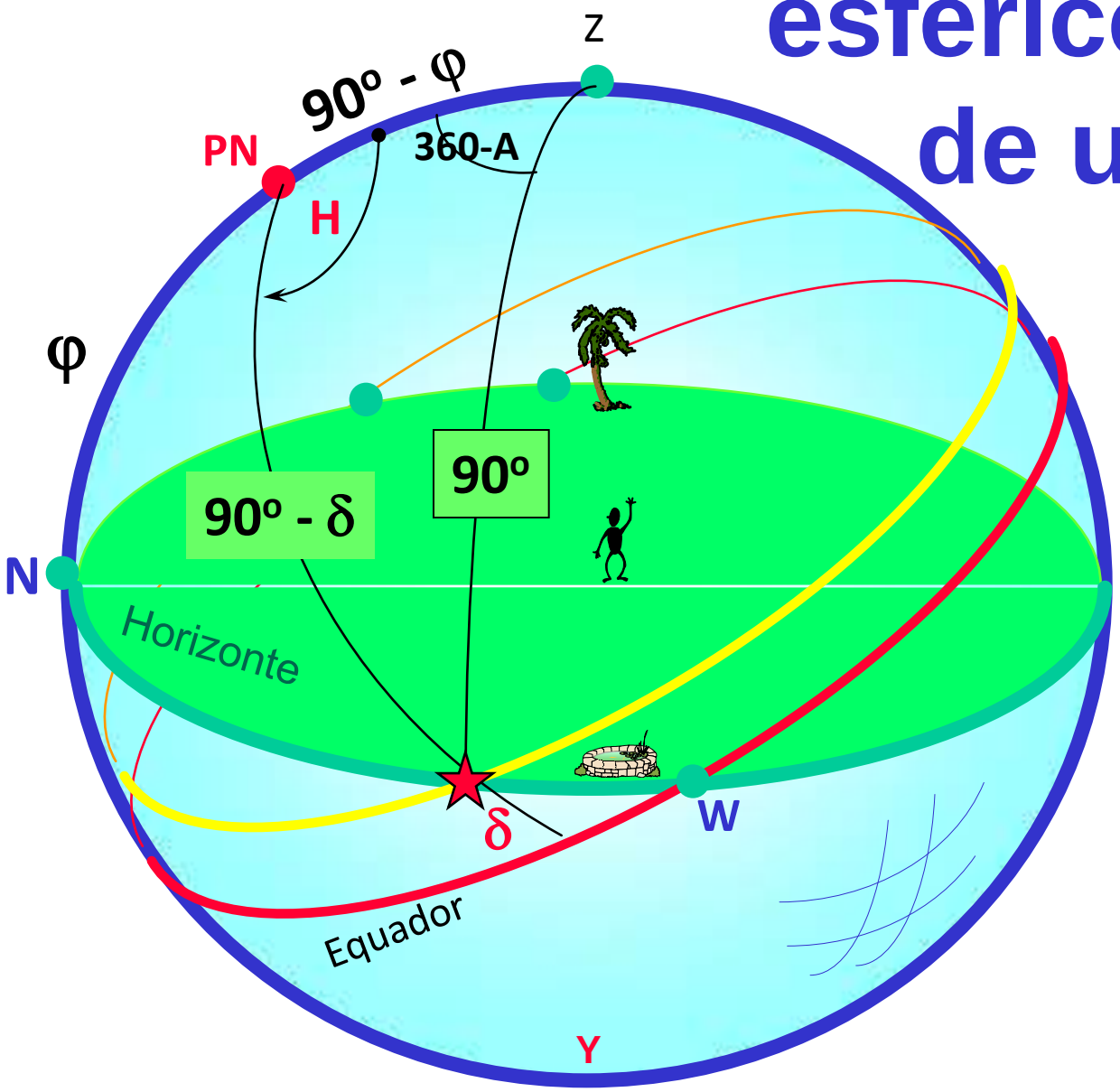
Simetria do nascer e do ocaso com relação ao meridiano local

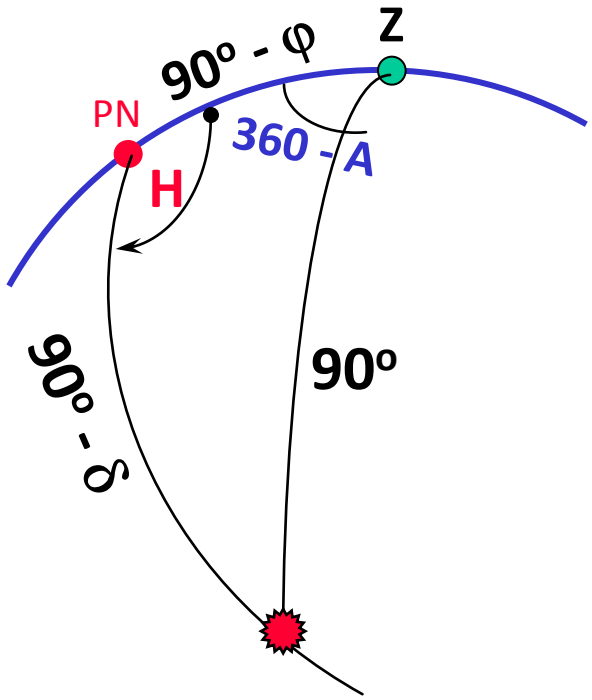




Azimute e Hora do nascer e do ocaso de um astro

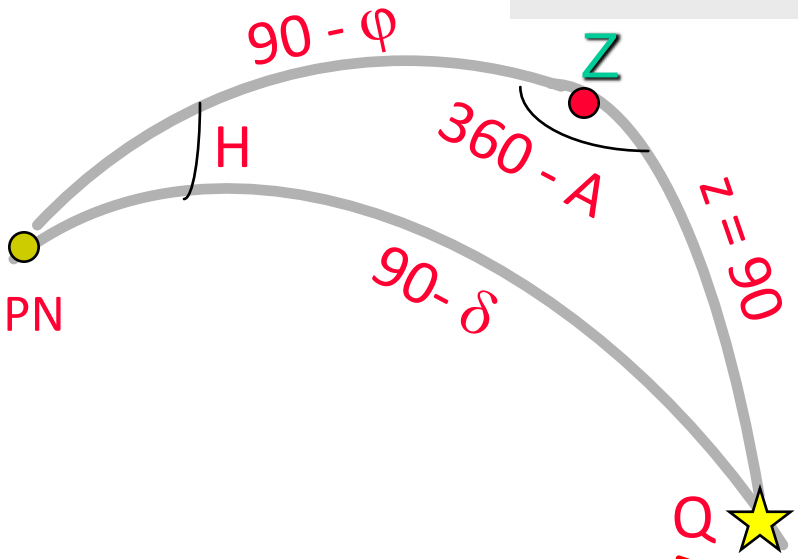
Triângulo esférico no ocaso de um astro





Azimute do Nascer e do Ocaso

$\cos a = \cos b \cdot \cos c + \sin b \cdot \sin c \cdot \cos A$



a = 90 – δ
b = z = 90 (distância zenital)
c = 90 – φ
A = 360 – A

$\cos(90-\delta) = \cos z \cdot \cos(90-\varphi) + \sin(90-\varphi) \cdot \sin z \cdot \cos(360-A)$ (= 1.0)

$\cos(90-\delta) = \sin(90-\varphi) \cdot \cos(360-A)$

$\sin\delta = \cos\varphi \cdot \cos A$

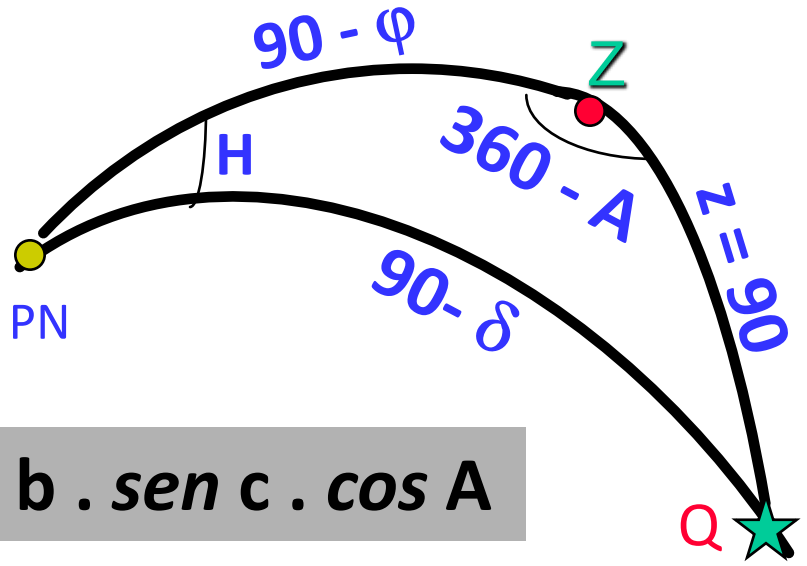
$$\cos A = \sin\delta / \cos\varphi$$

$\Rightarrow 0 \leq \underline{A} \leq 180^o$

No Nascer: A = $\underline{A}$

No Ocaso: A = $360^o - \underline{A}$

Ângulo horário no nascer e no ocaso



$$\cos a = \cos b \cdot \cos c + \operatorname{sen} b \cdot \operatorname{sen} c \cdot \cos A$$

$$\cos z = \cos(90-\varphi) \cdot \cos(90-\delta) + \operatorname{sen}(90-\varphi) \cdot \operatorname{sen}(90-\delta) \cdot \cos H$$

$$0 = \operatorname{sen}\varphi \cdot \operatorname{sen}\delta + \cos\varphi \cdot \cos\delta \cdot \cos H$$

$$\cos H = -\operatorname{sen}\varphi \cdot \operatorname{sen}\delta \,/\, \cos\varphi \cdot \cos\delta$$

$$\cos H = -\tan\varphi \cdot \tan\delta$$

$$\Rightarrow 0 \leq \underline{H} \leq 180^0$$

No Ocaso: $H_o = \underline{H}$

No Nascer: $H_n = -\underline{H}$

Distância zenital de um astro extenso no Nascer e no Ocaso

$$z = 90^0 + s$$