R. Boczko

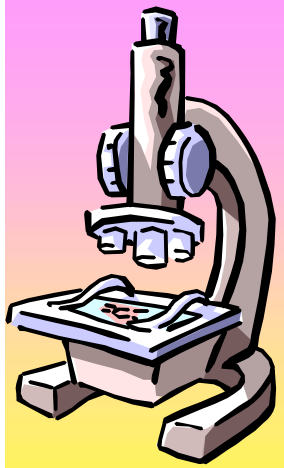
IAG - USP

Escalas de Distância e de Tempo usadas em Astronomia

R. Boczko
IAG-USP

11
01
04

Abrangência da Astronomia



Metro
10^0

0

-35 -30 -25 -20 -15 -10 -5 5 10 15 20 25 26

Micro mundo (tempo)

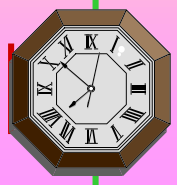
Macro mundo (tempo)

10^0 = 1 s

0

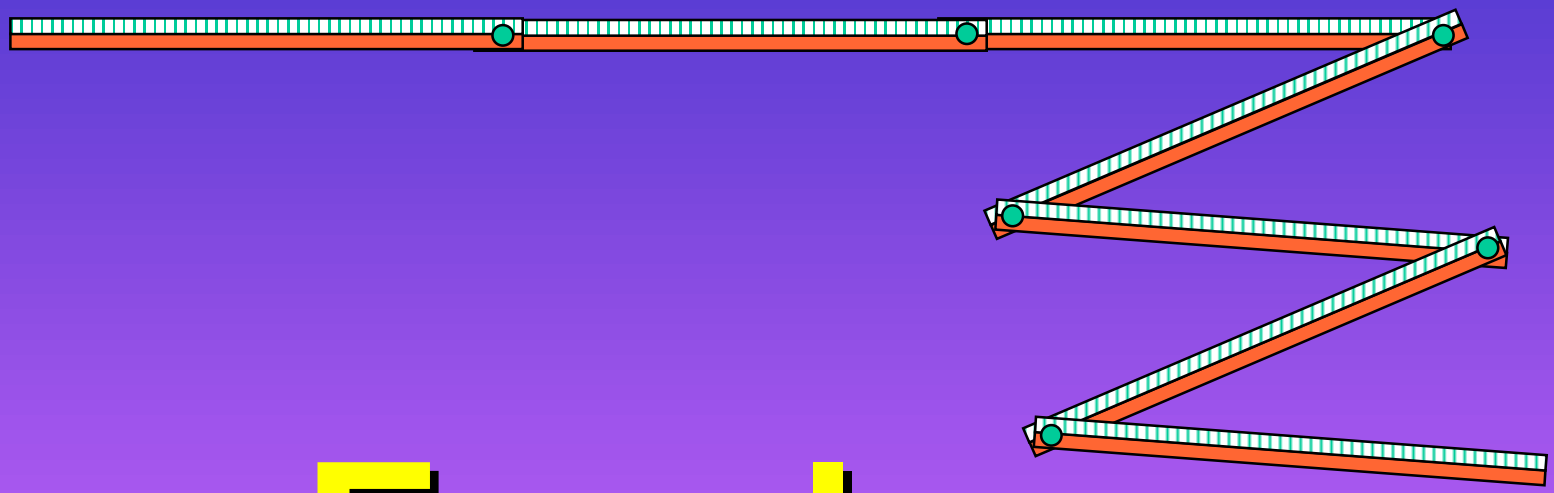
-40 -35 -30 -25 -20 -15 -10 -5 5 10 15 18

-44



Big-bang

Hoje



Escalas de distância

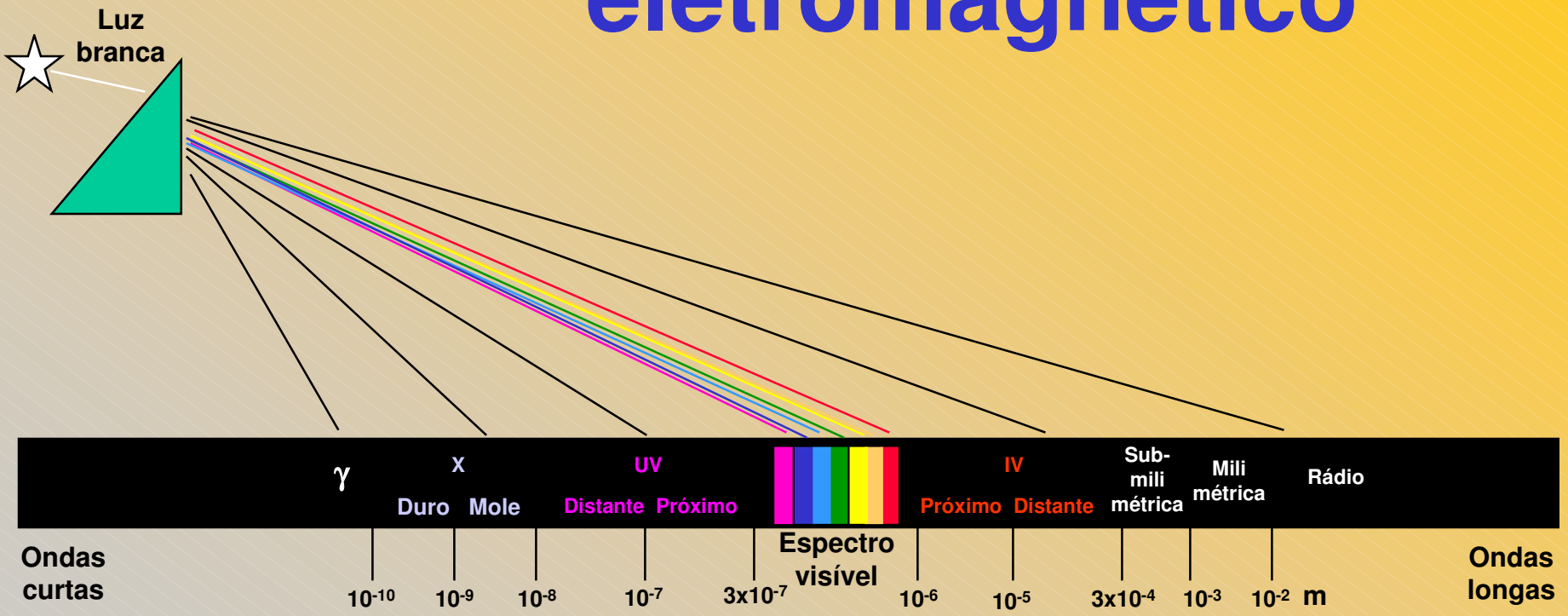
Definição Inicial do Metro

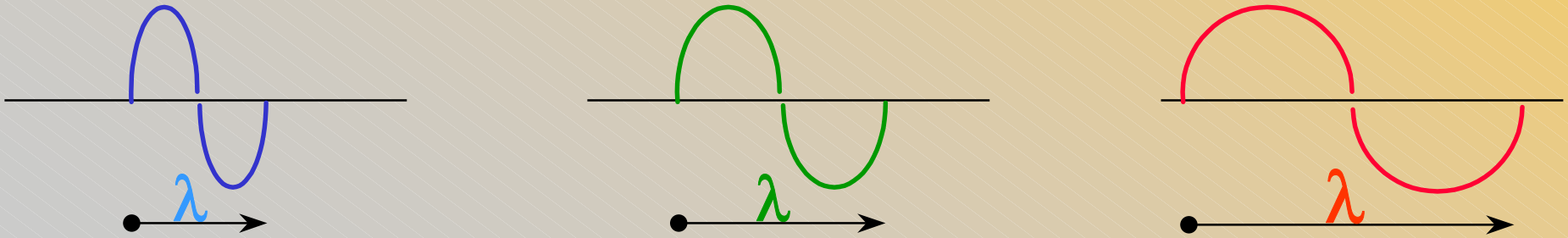
1/40.000.000 da circunferência de um meridiano Terrestre

1 metro

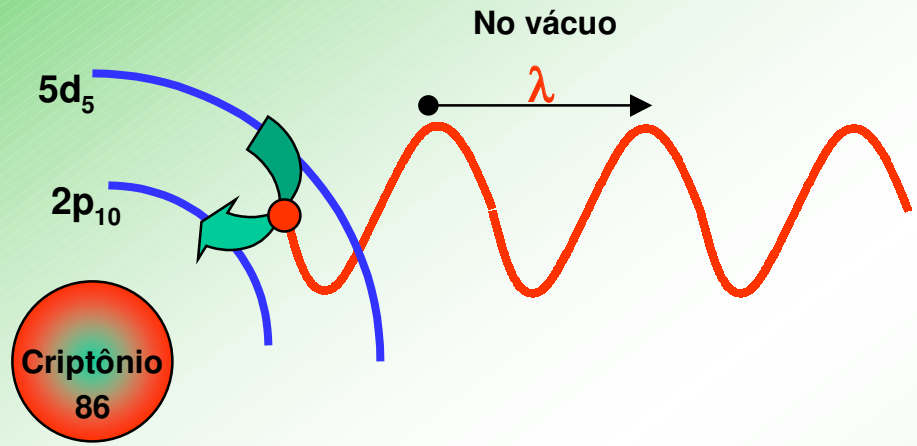
Padrão de platina no Museu de Sèvres

Espectro eletromagnético





Outra Definição do Metro



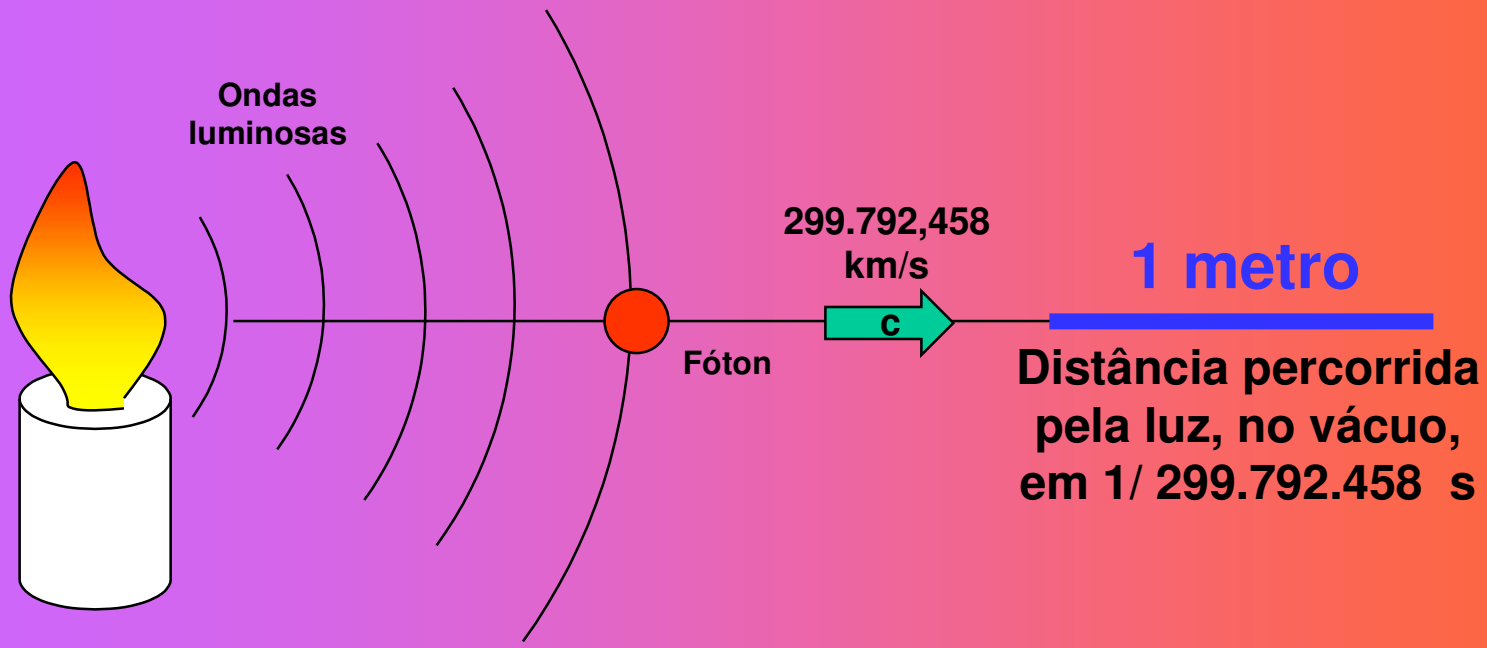
1/40.000.000 da circunferência do equador Terrestre

1 metro padrão de platina no Museu de Sèvres

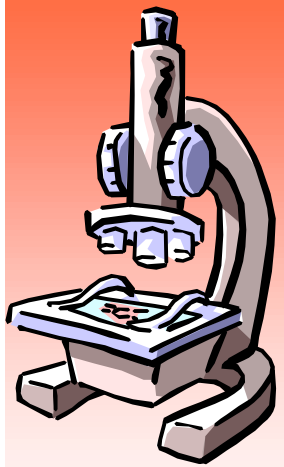
1.650.763,73 λ

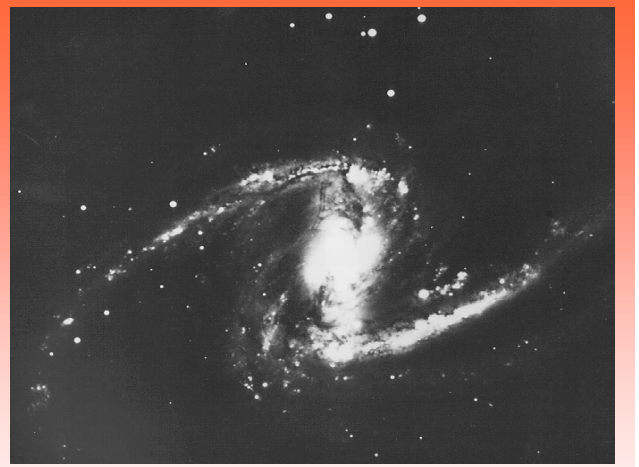
1 metro

Definição atual do metro



Do micro ao macro





Metro
10^0

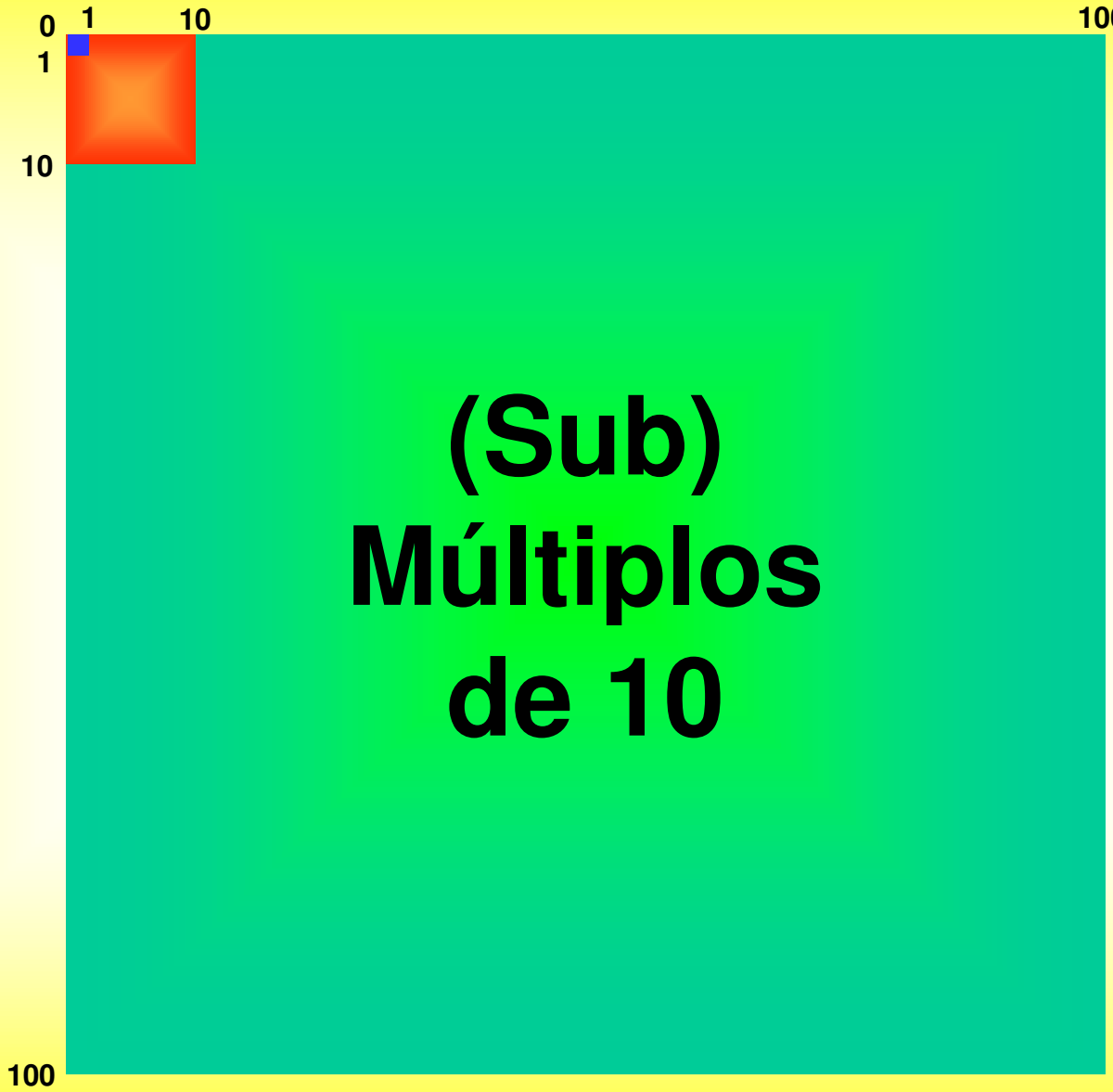
-35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 26

Micro mundo

Macro mundo

Cada traço à esquerda significa o traço da direita dividido por 10

Cada traço à direita significa o traço da esquerda multiplicado por 10

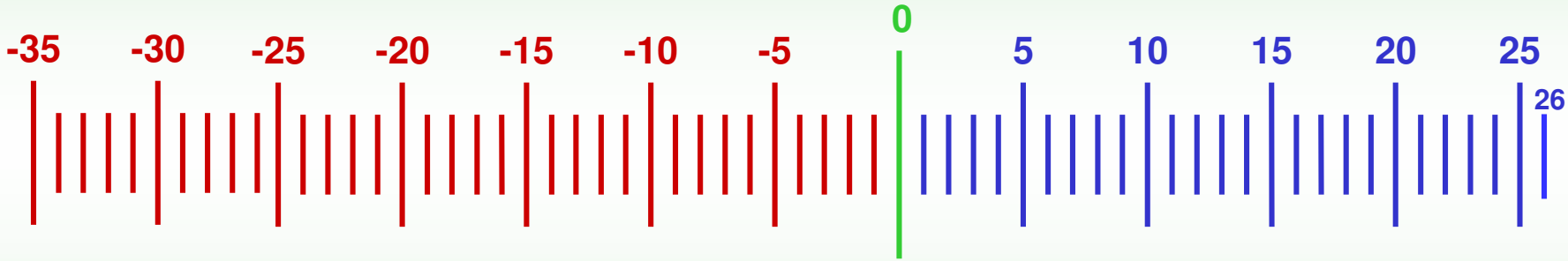


(Sub) Múltiplos de 10

10^{12} = T = Tera
10^{9} = G = Giga
10^{6} = M = Mega
10^{3} = k = kilo
10^{2} = h = hecto
10^{1} = da= deca
10^{0} = base

10^{-00} = base
10^{-01} = d = deci
10^{-02} = c = centi
10^{-03} = m = mili
10^{-06} = μ = micro
10^{-09} = n = nano
10^{-12} = p = pico
10^{-15} = f = femto
10^{-18} = a = atto

Para o micromundo



÷ 10

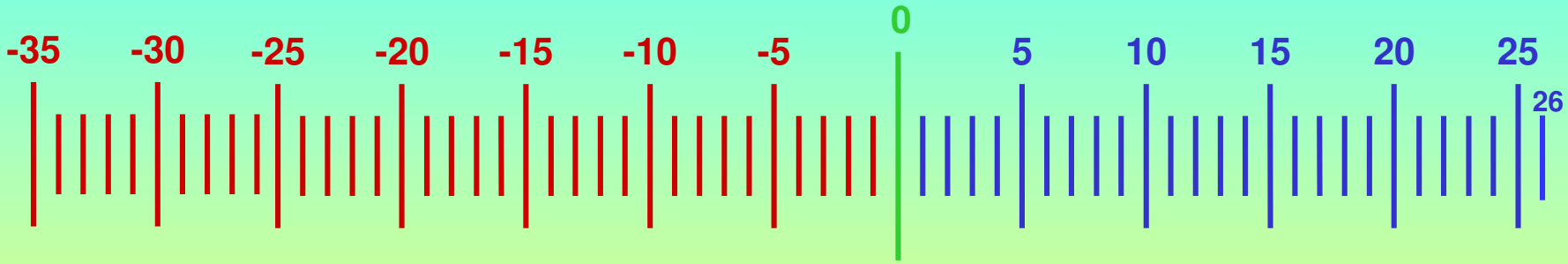
Micromundo

Cada traço à esquerda significa o traço da direita dividido por 10

Metro: unidade fundamental

$f = 10^0$

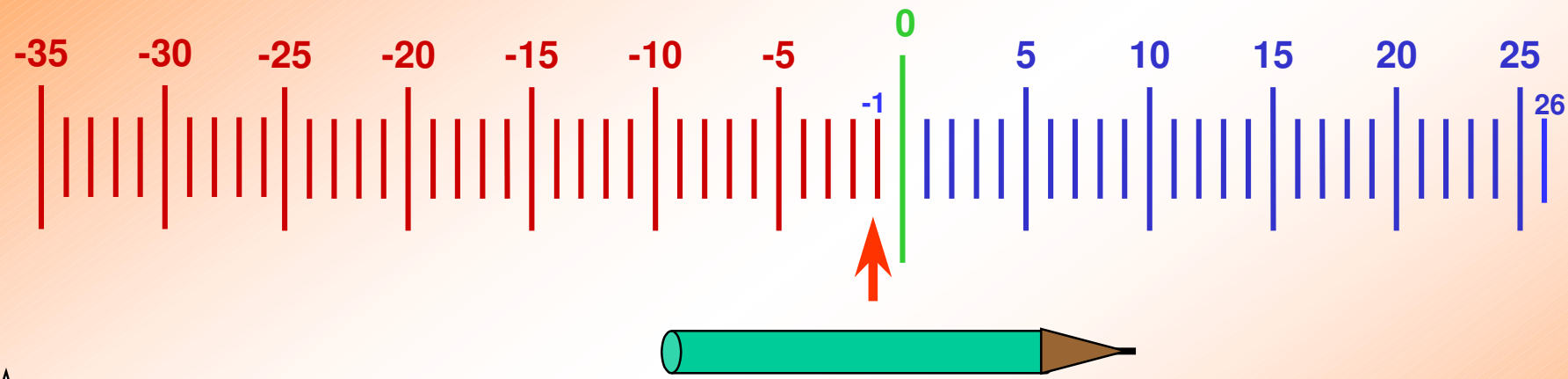
10^0 m = 1 m

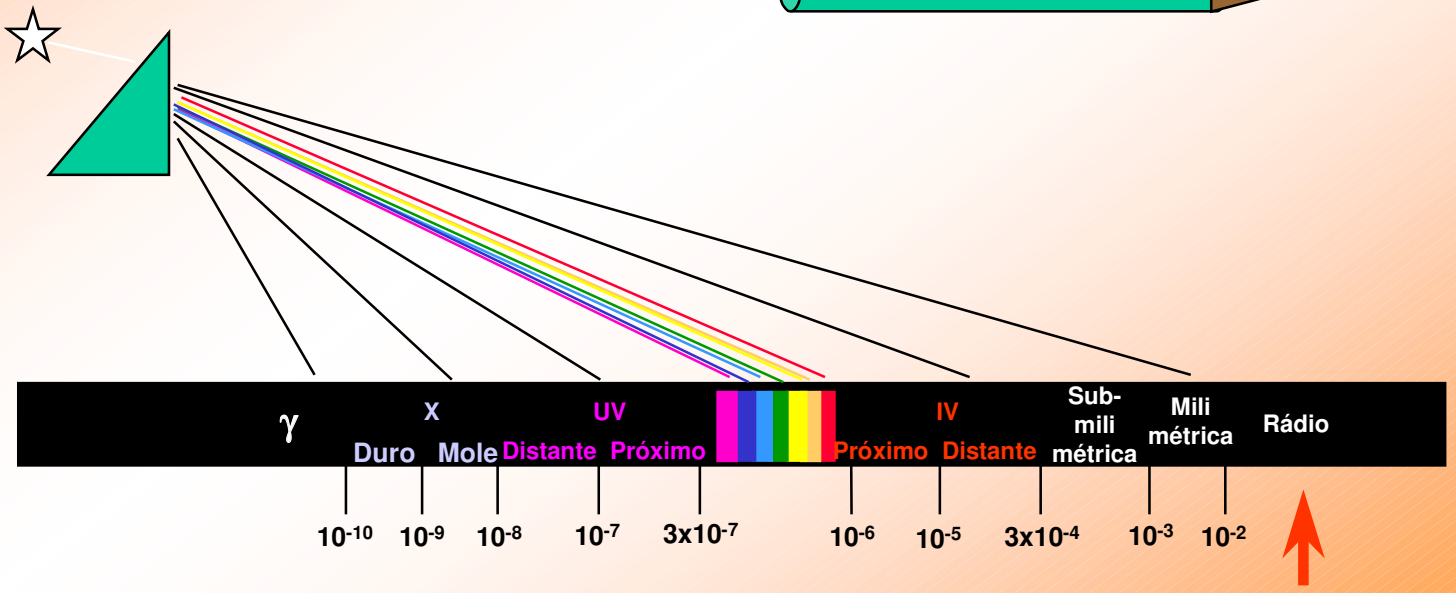


Elemento representativo da escala

Decímetro f = 10^{-1}

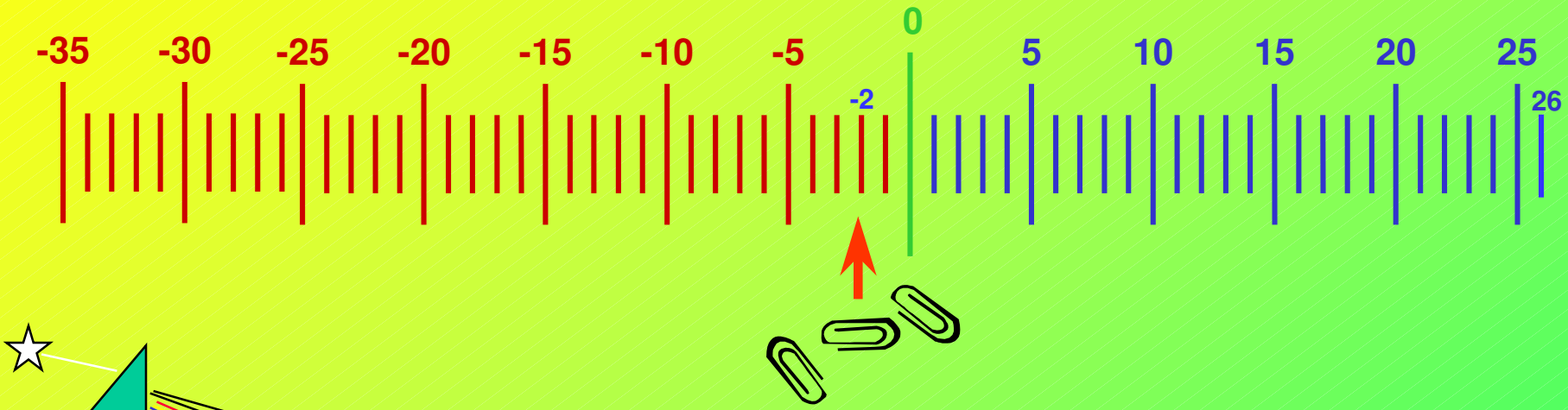
10^{-1} m = 0,1 m

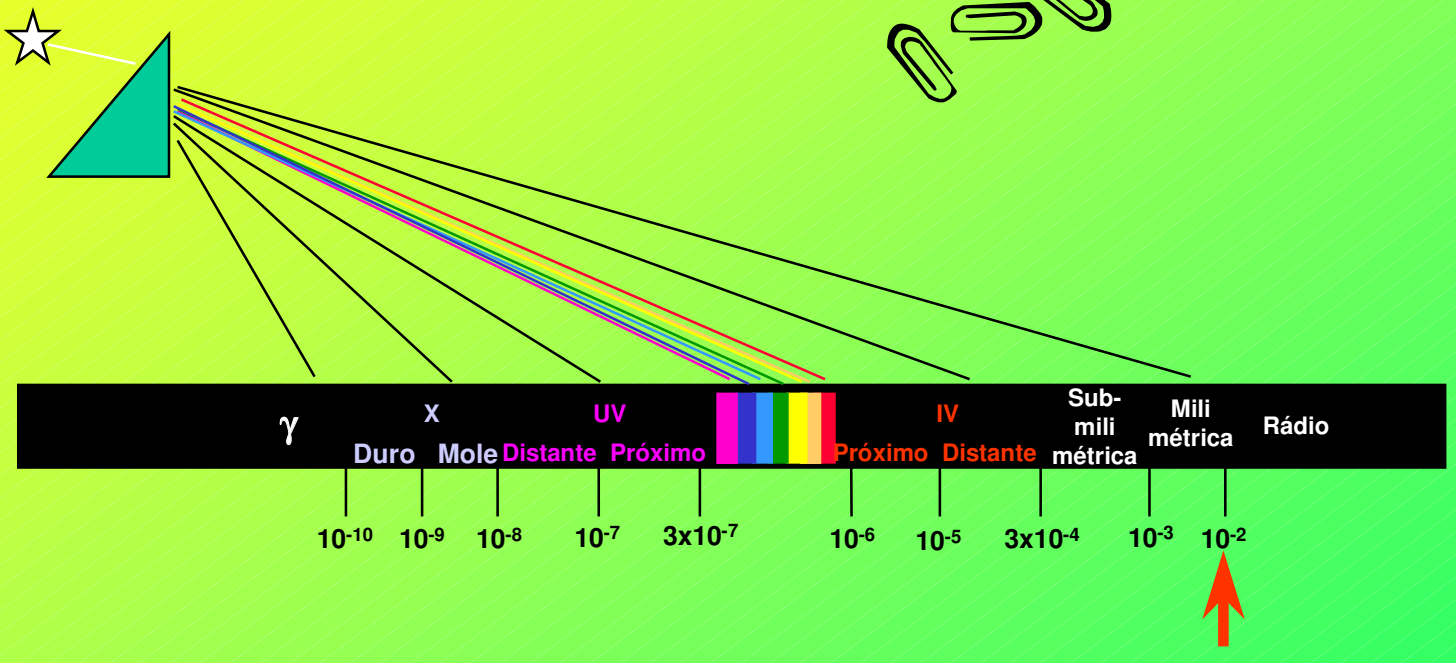




Centímetro f = 10^{-2}

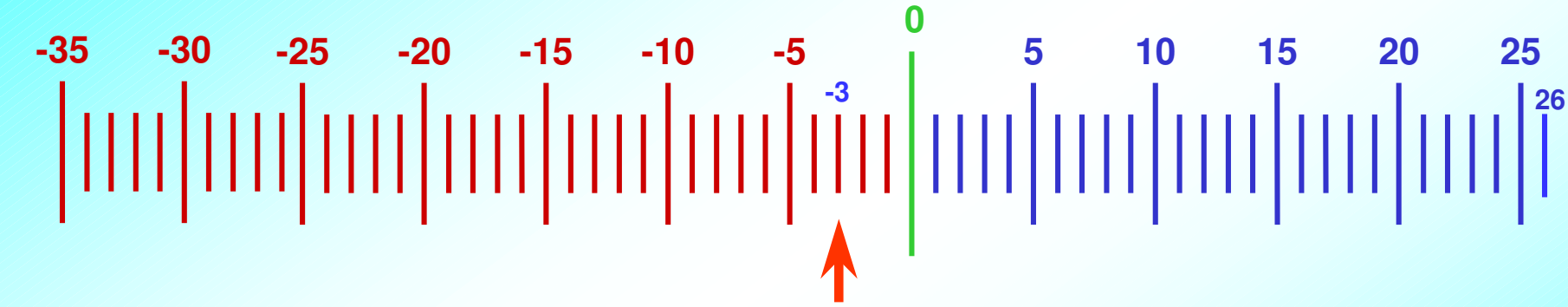
10^{-2} m = 0,01 m



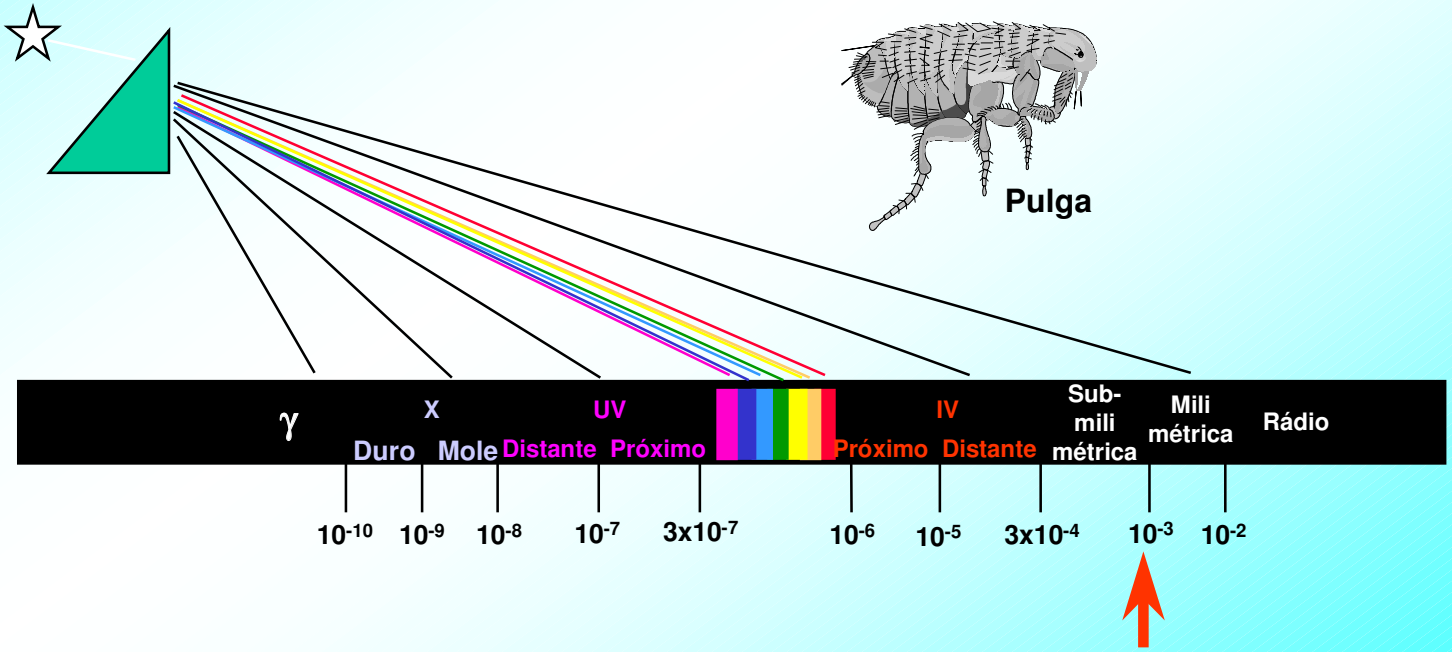


Milímetro f = 10^{-3}

10^{-3} m = 0,001 m

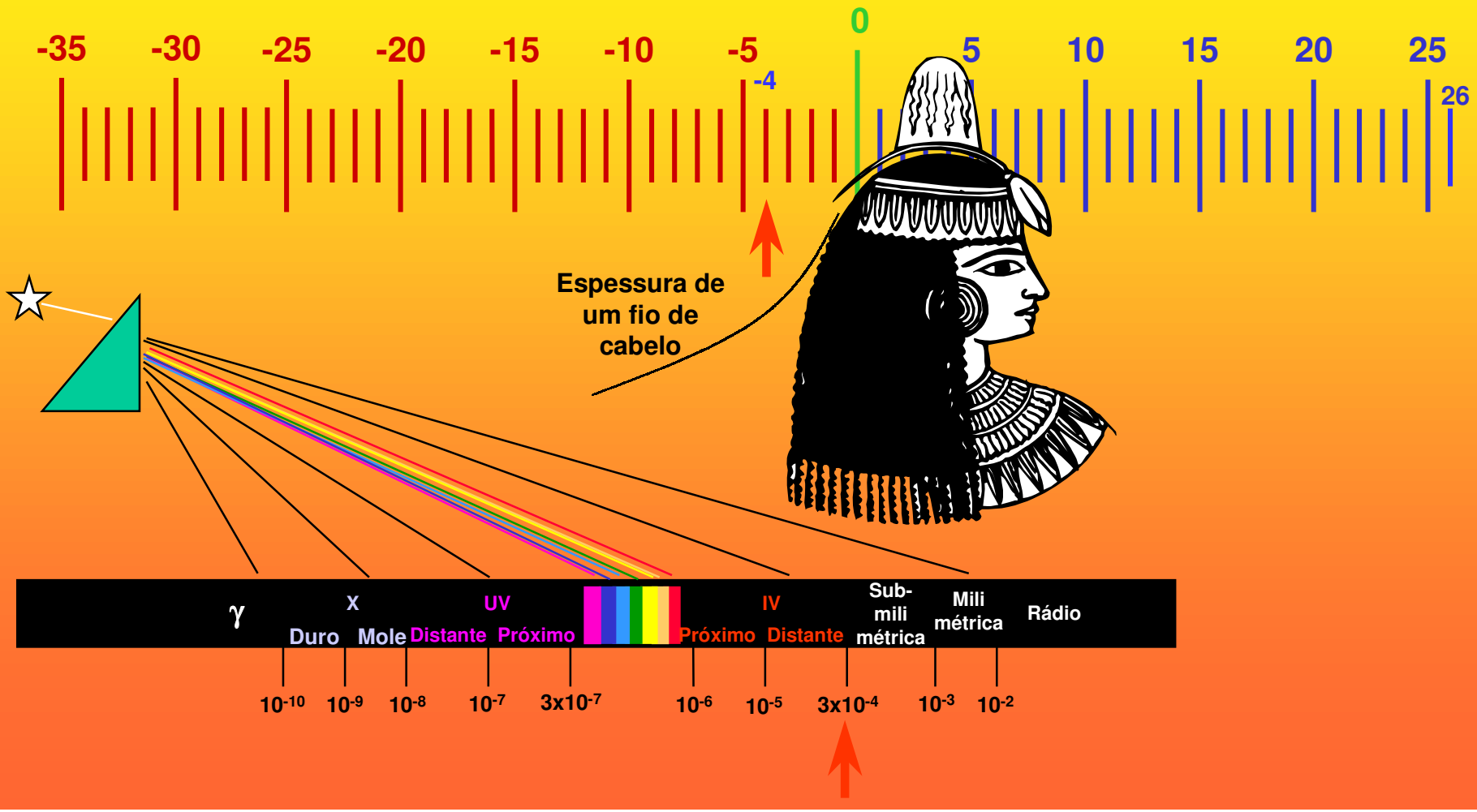


Pulga



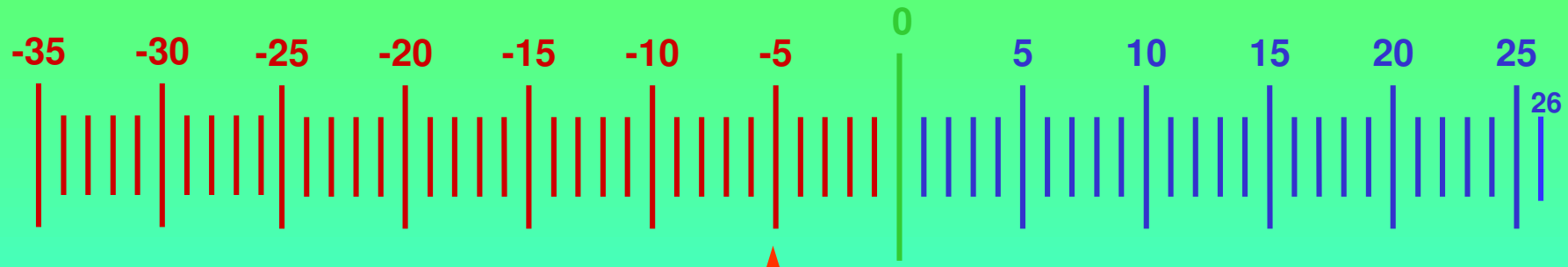
$f = 10^{-4}$

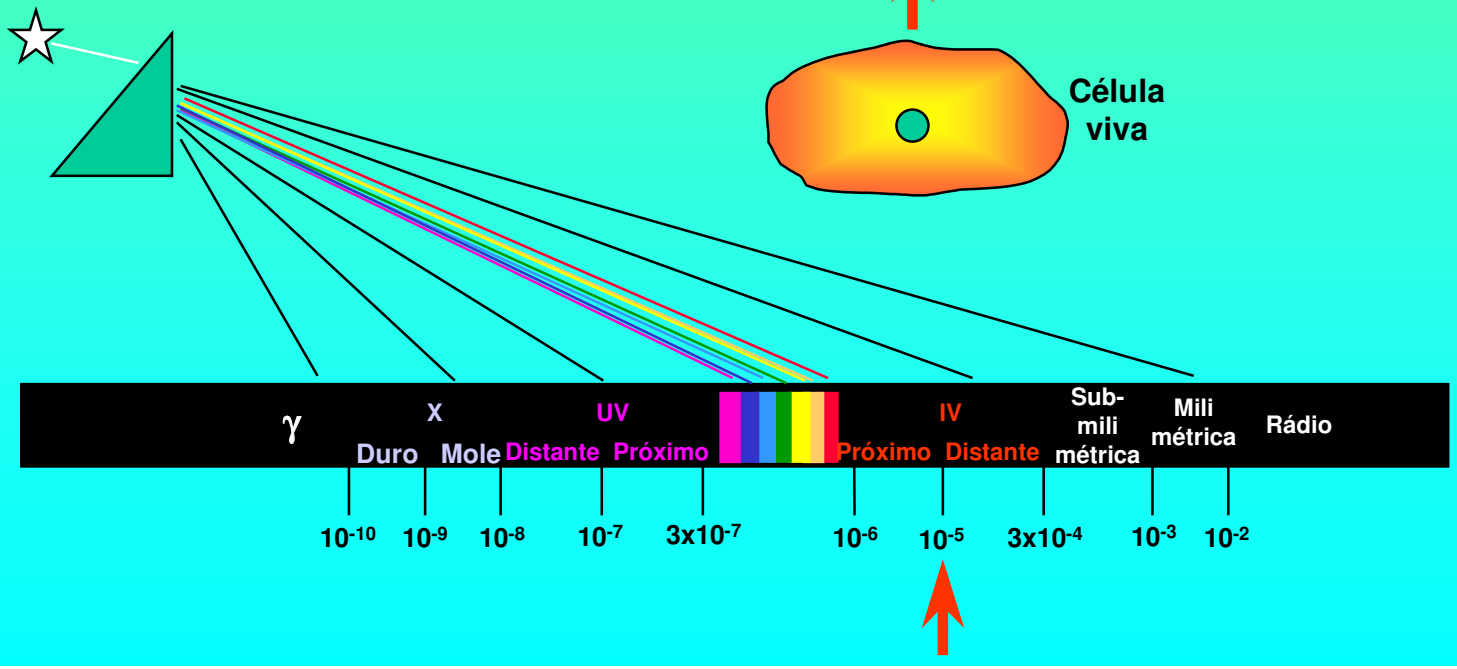
10^{-4} m = 0,000.1 m



$f = 10^{-5}$

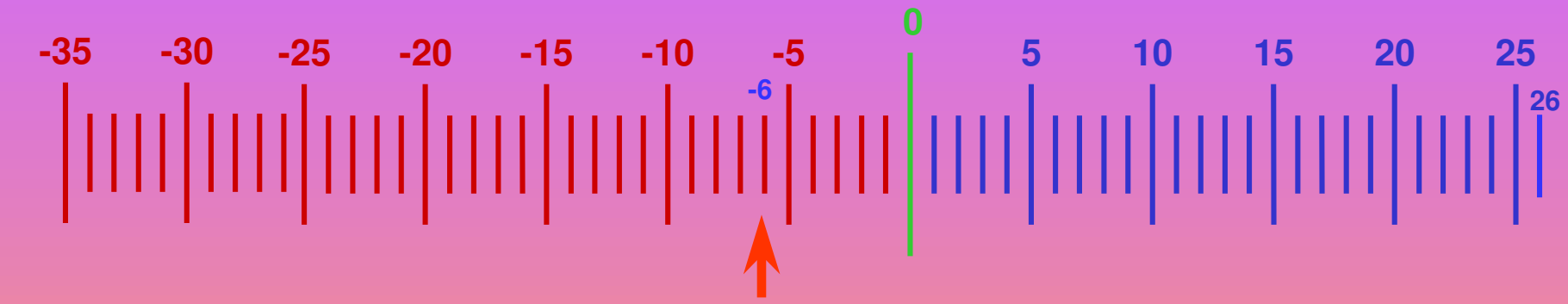
10^{-5} m = 0,000.01 m

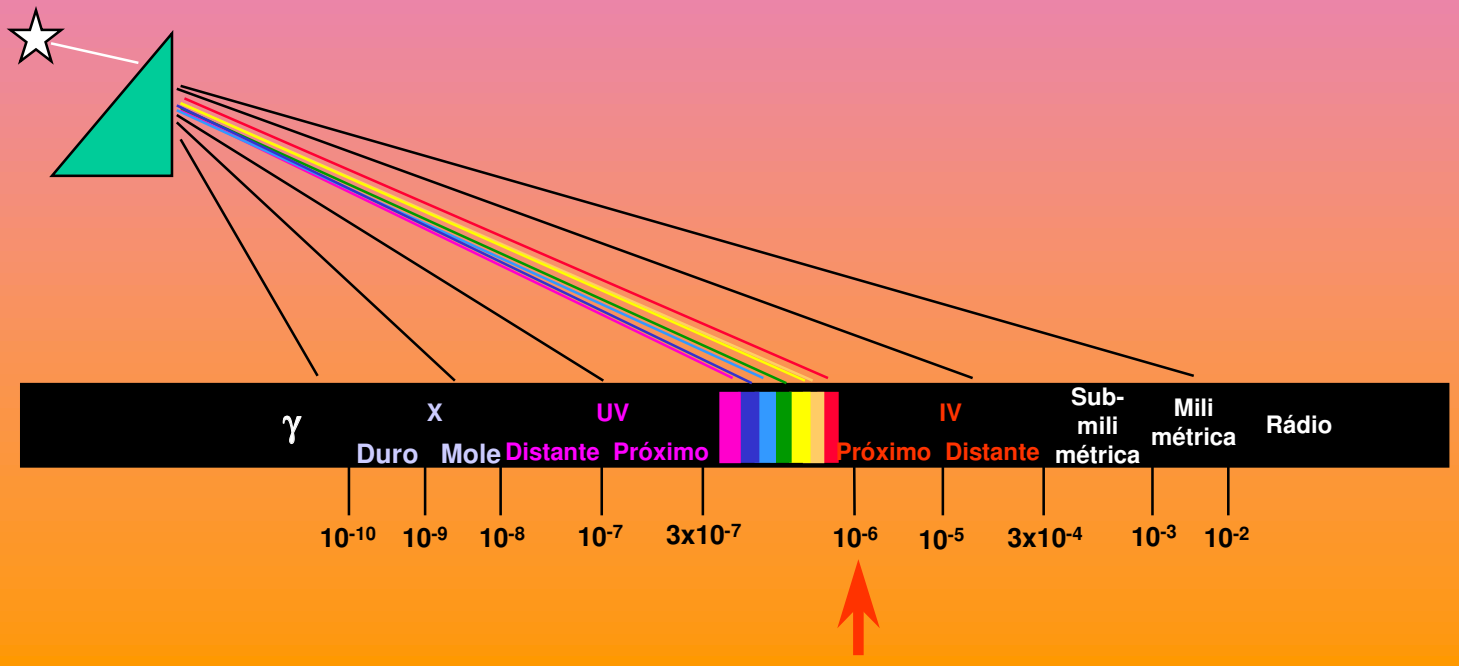




Micro f = 10^{-6}

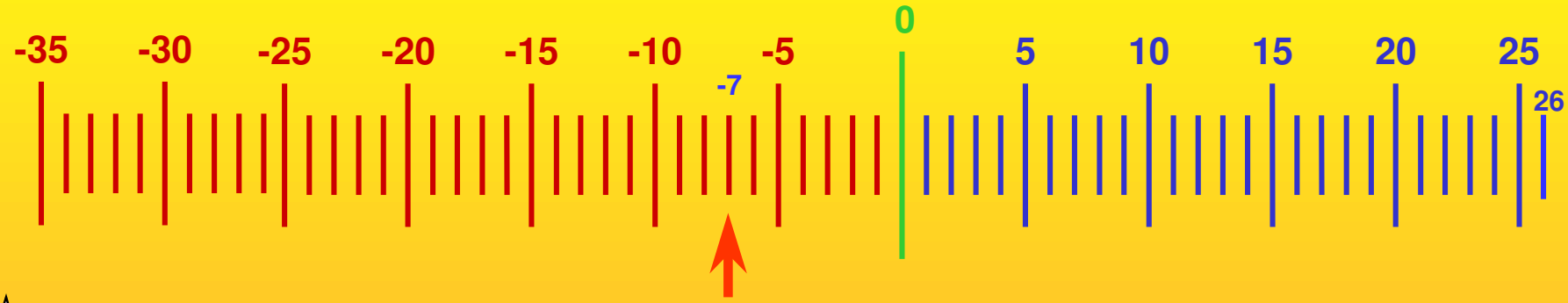
10^{-6} m = 0,000.001 m

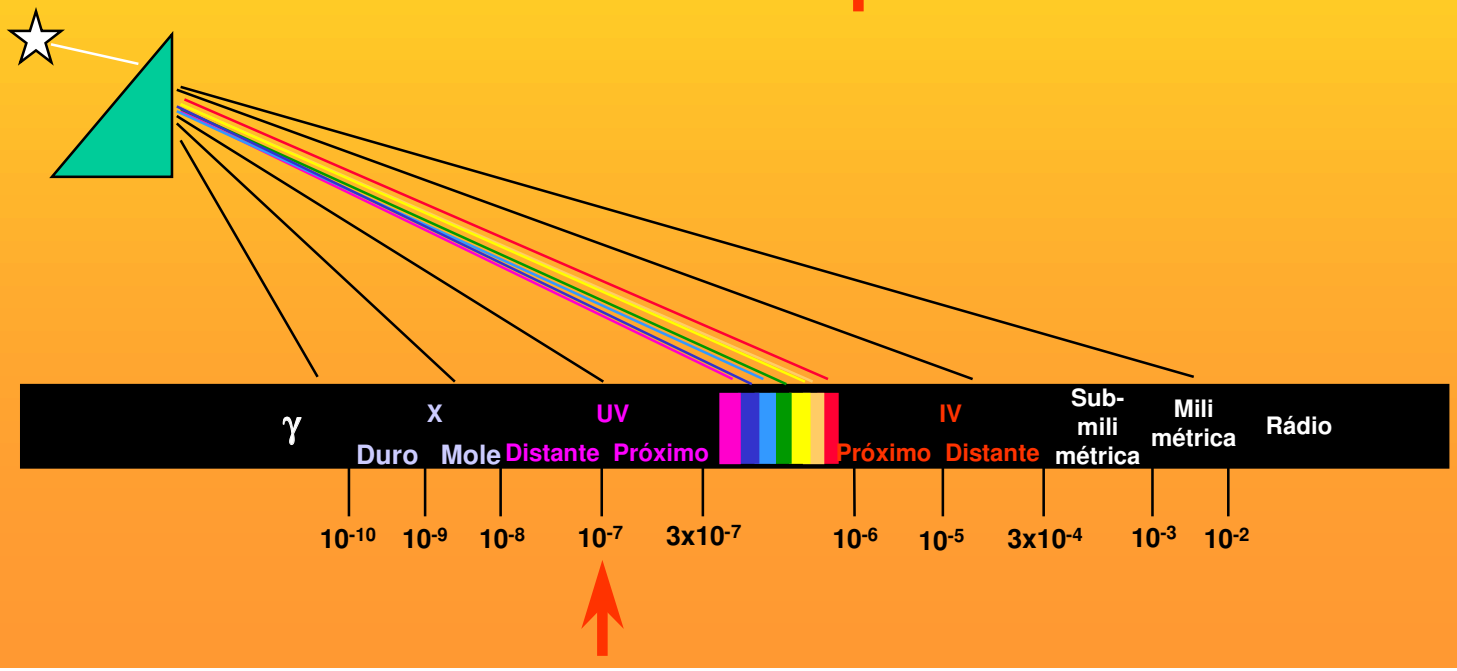




$f = 10^{-7}$

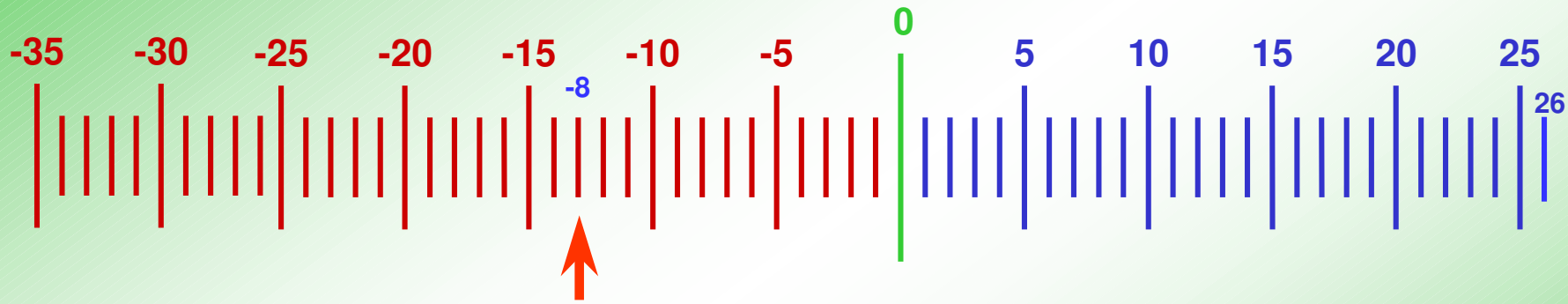
10^{-7} m = 0,000.000.1 m

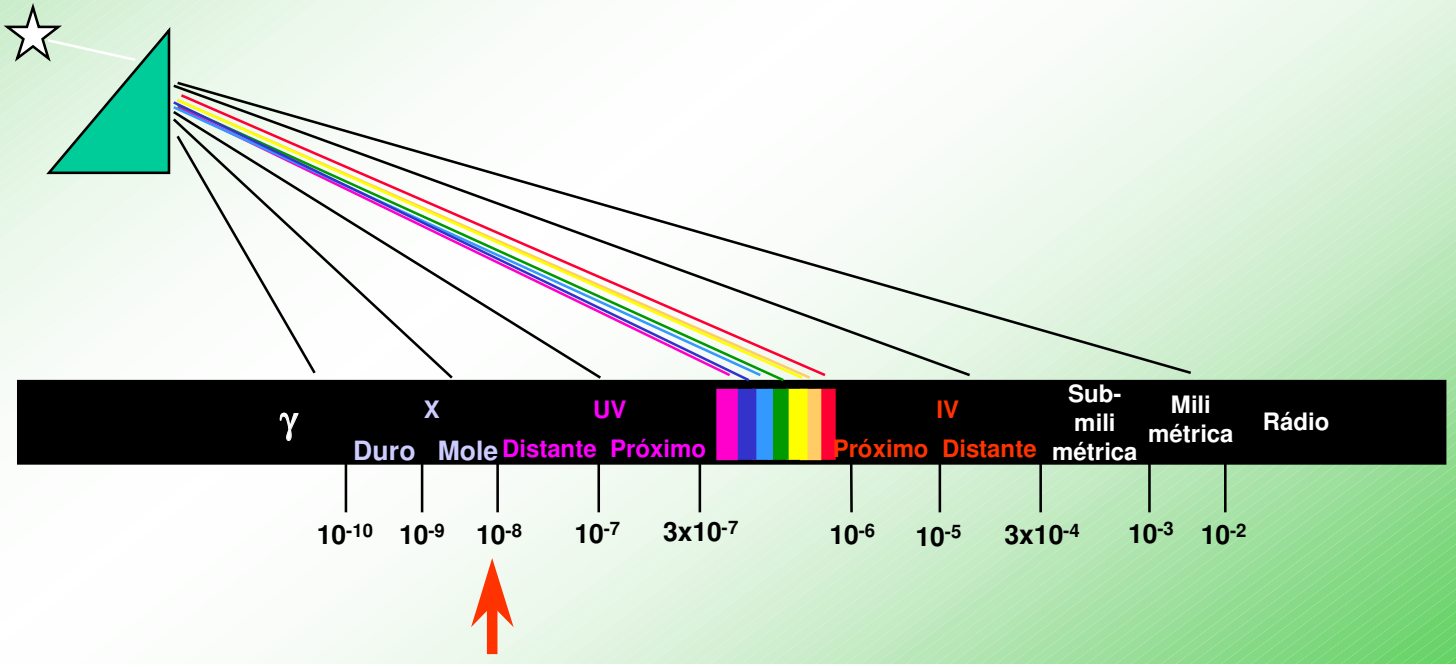




$f = 10^{-8}$

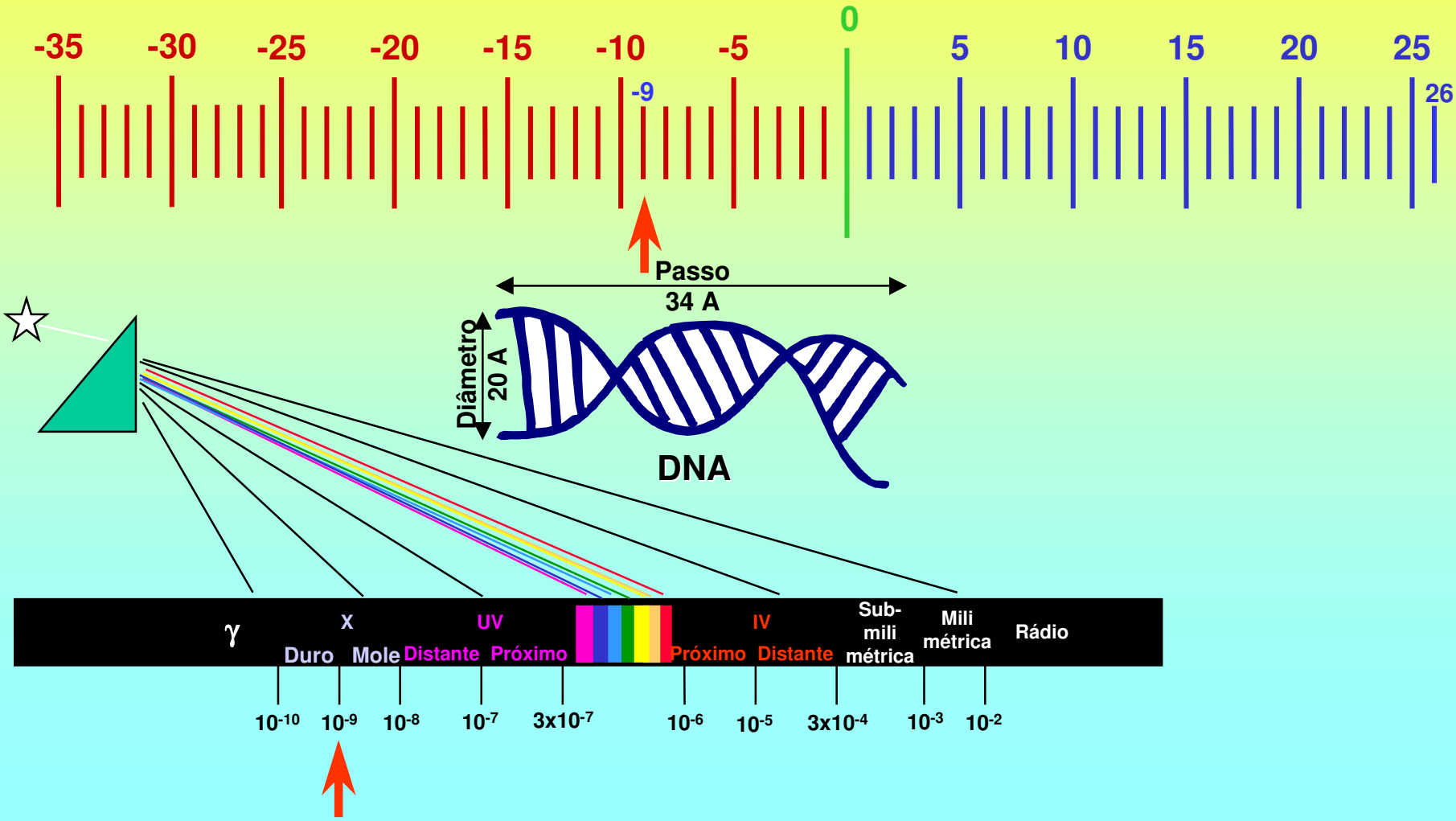
10^{-8} m = 0,000.000.01 m





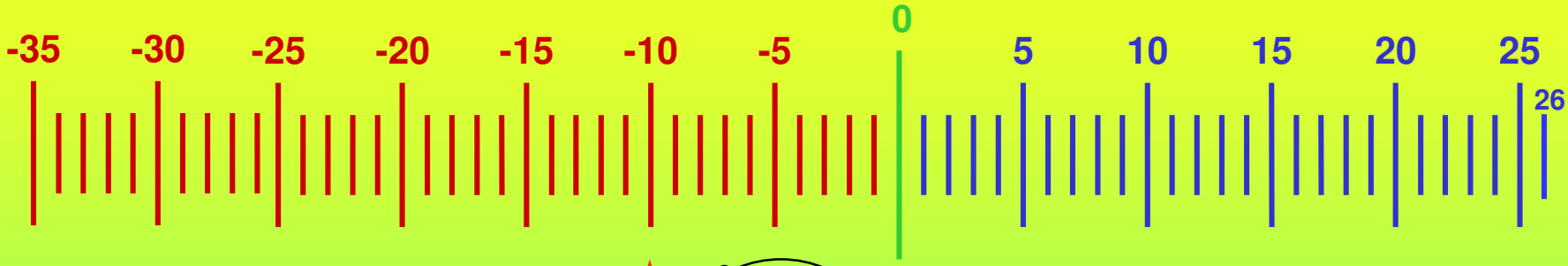
Nano f = 10^{-9}

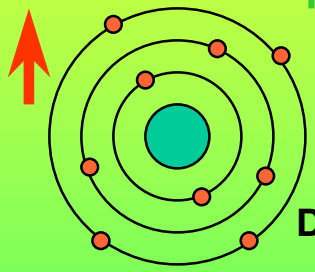
10^{-9} m = 0,000.000.001 m



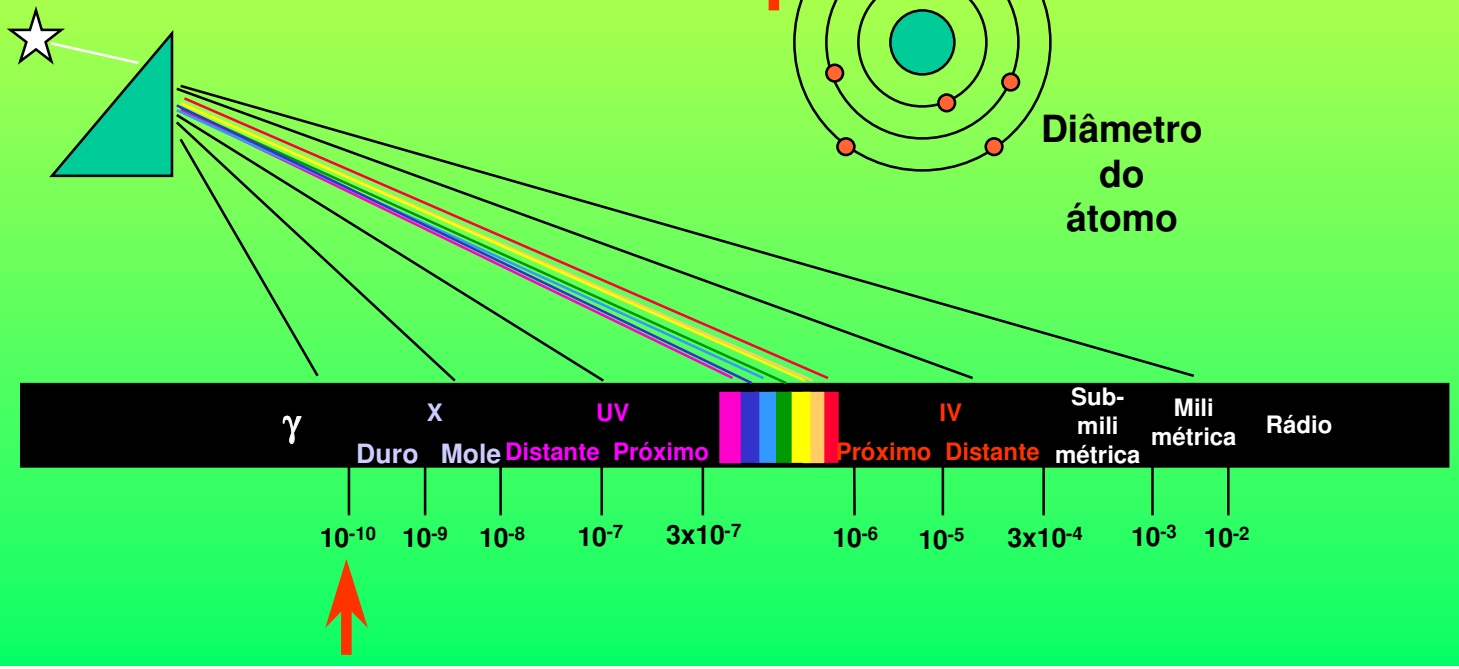
Angstrom f = 10^{-10}

10^{-10} m = 0,000.000.000.1 m



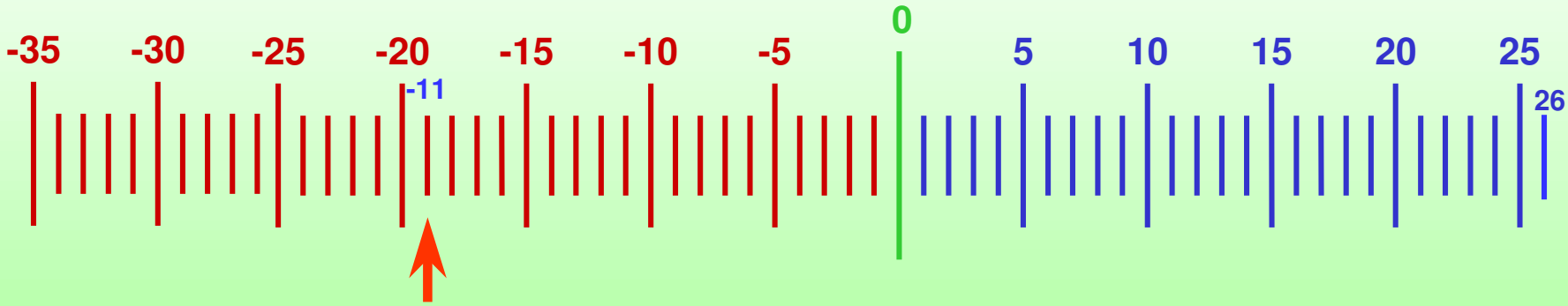


Diâmetro do átomo



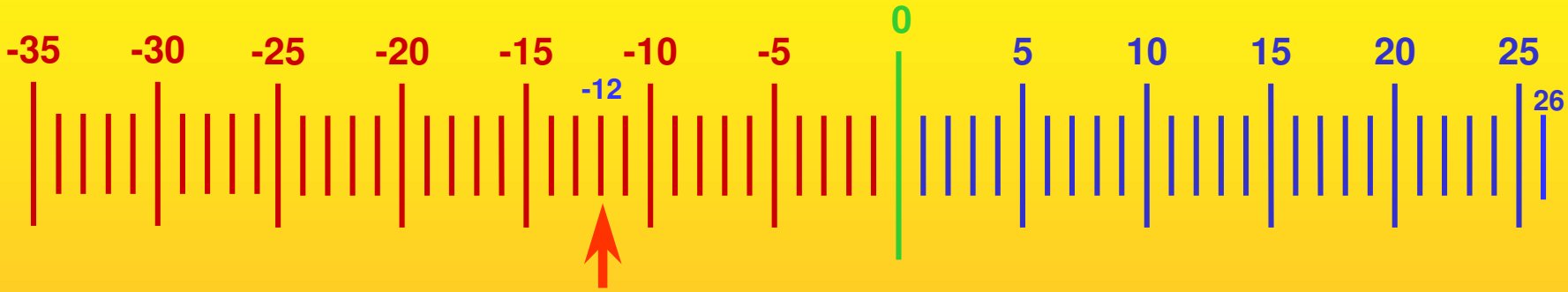
$f = 10^{-11}$

10^{-11} m = 0,000.000.000.01 m



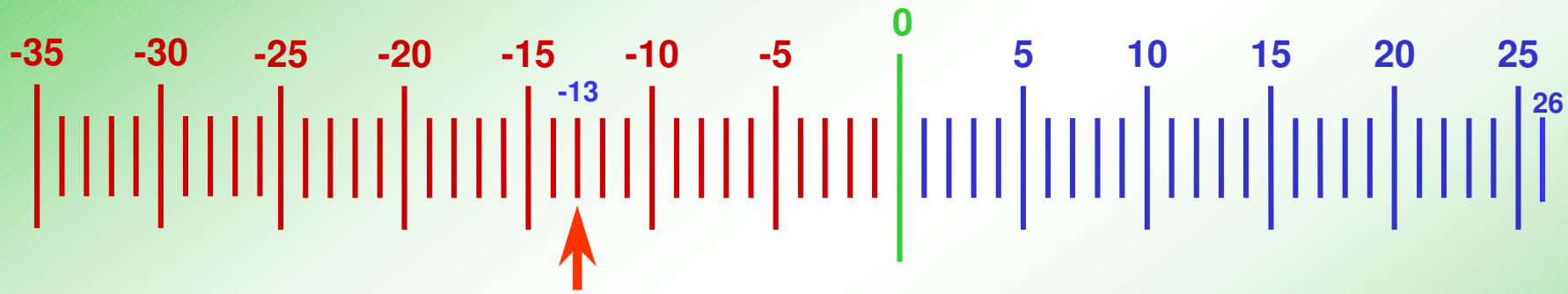
Pico f = 10^{-12}

10^{-12} m = 0,000.000.000.001 m



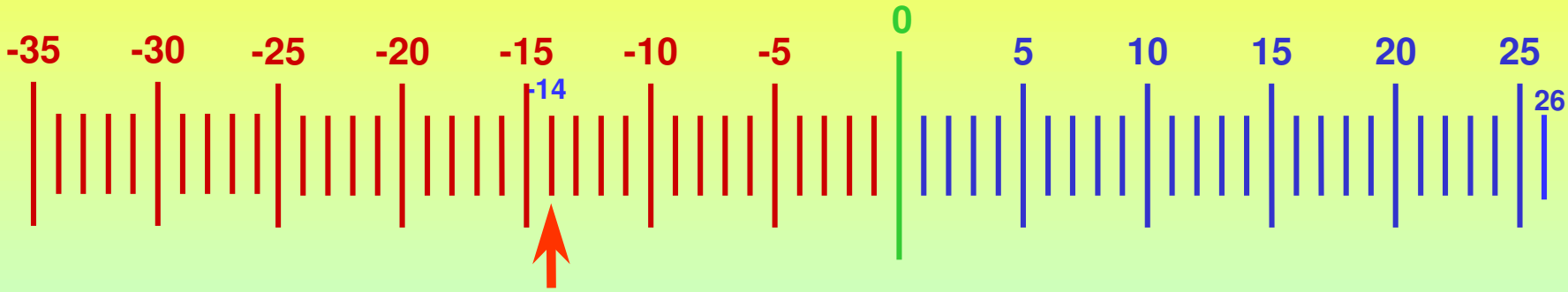
$f = 10^{-13}$

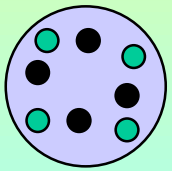
10^{-13} m = 0,000.000.000.000.1 m



$f = 10^{-14}$

10^{-14} m = 0,000.000.000.000.01 m

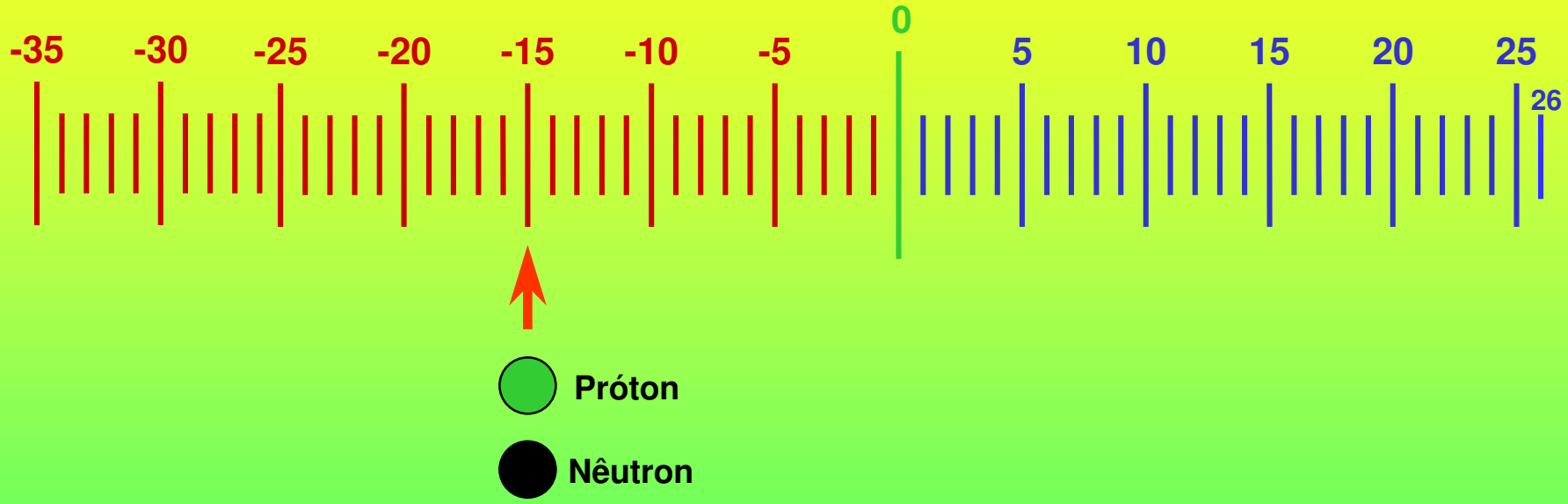




Diâmetro do
núcleo de
átomos pesados

Femto f = 10^{-15}

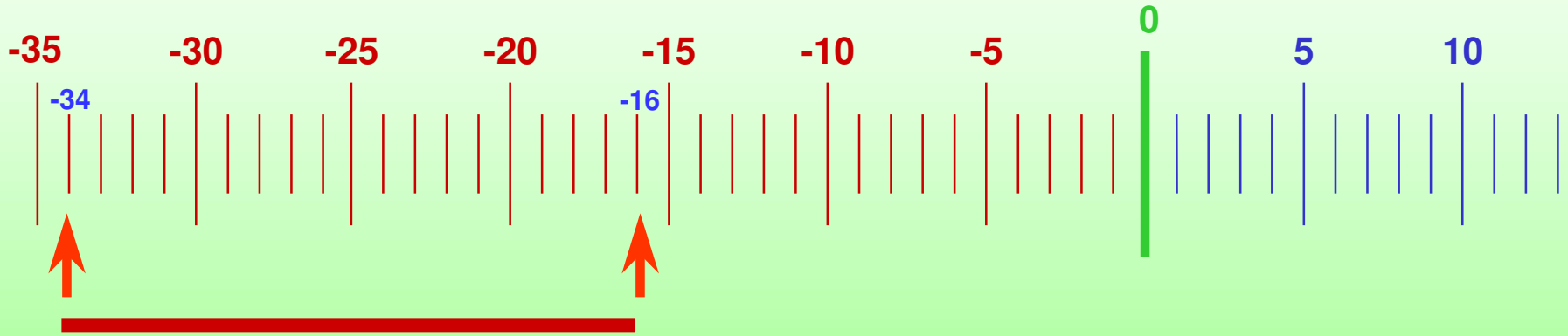
10^{-15} m = 0,000.000.000.000.001 m



$f = 10^{-16}$ a 10^{-34}

10^{-16} m = 0,000.000.000.000.000.1 m

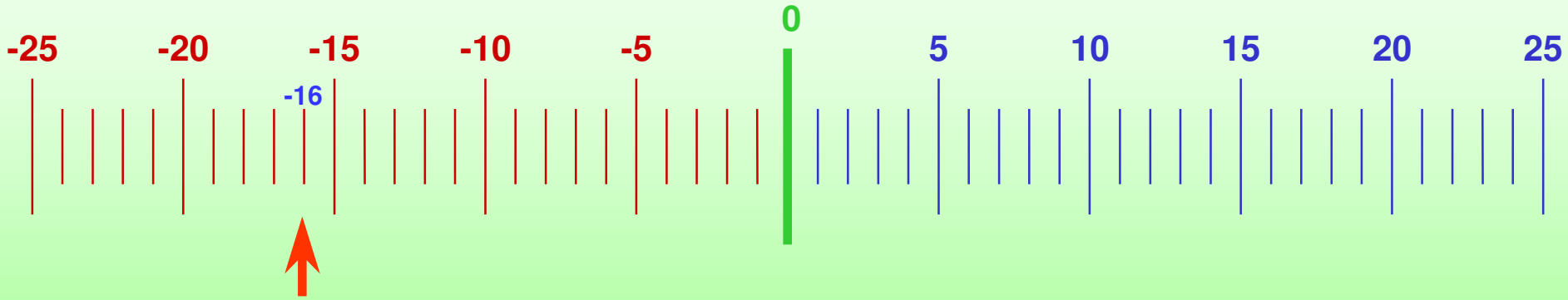
10^{-34} m = 0,000.000.000.000.000.000.000.000.000.000.1 m



Pular!

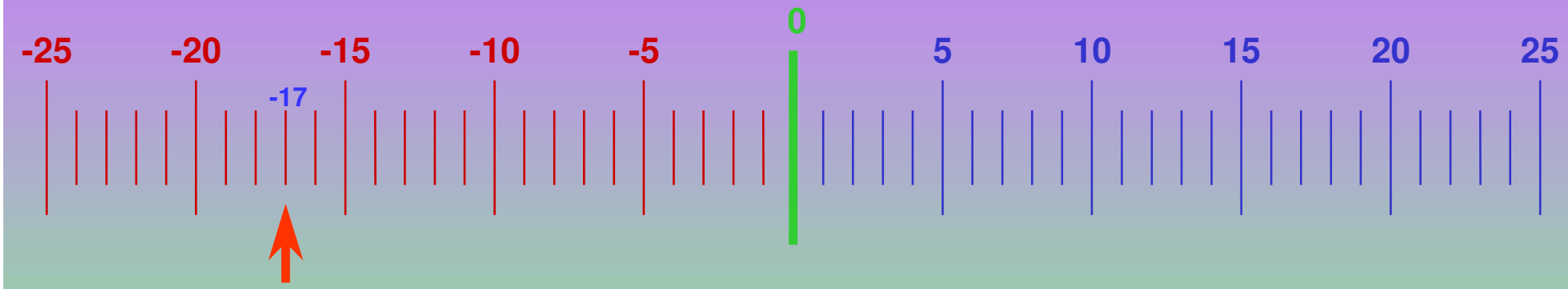
$f = 10^{-16}$

10^{-16} m = 0,000.000.000.000.000.1 m



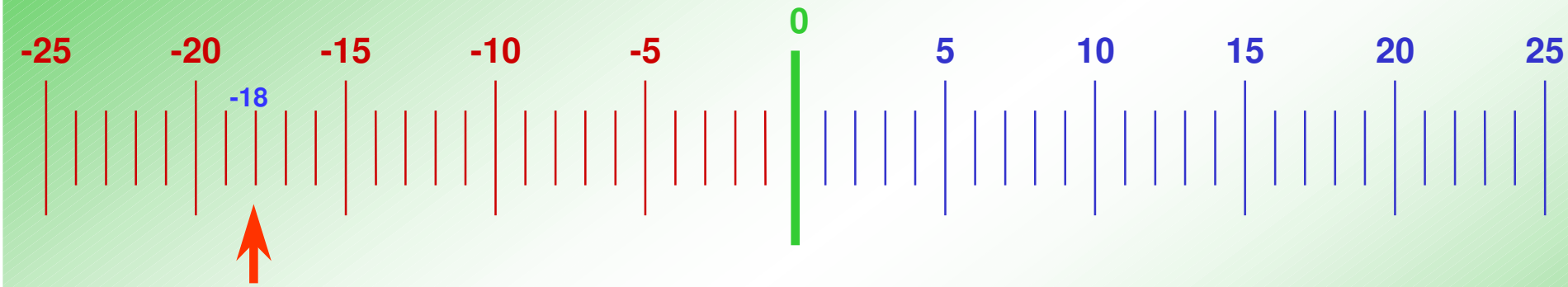
$f = 10^{-17}$

10^{-17} m = 0,000.000.000.000.000.01 m



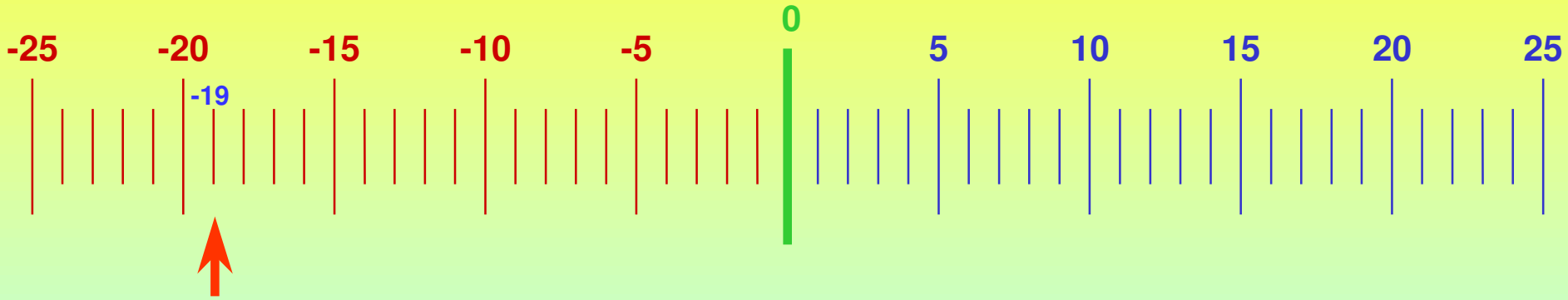
Atto f = 10^{-18}

10^{-18} m = 0,000.000.000.000.000.001 m



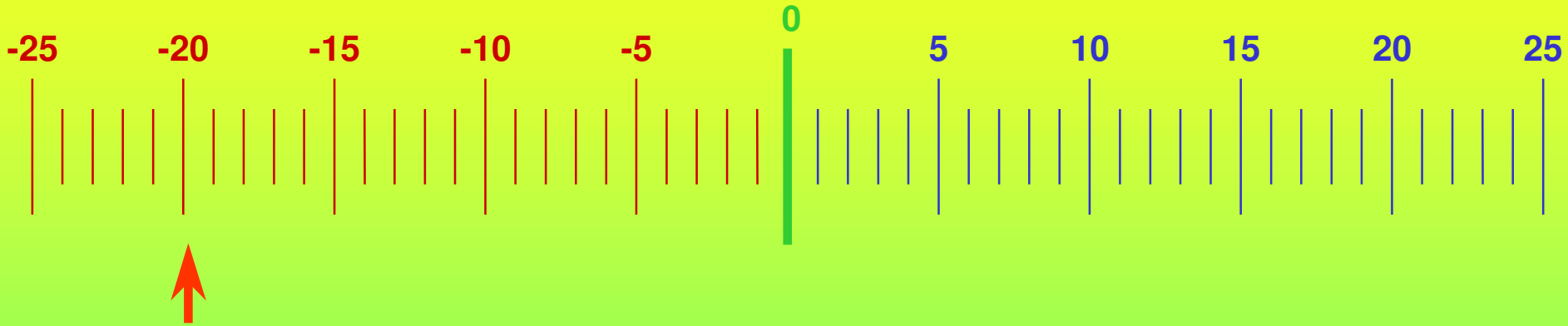
$f = 10^{-19}$

10^{-19} m = 0,000.000.000.000.000.000.1 m



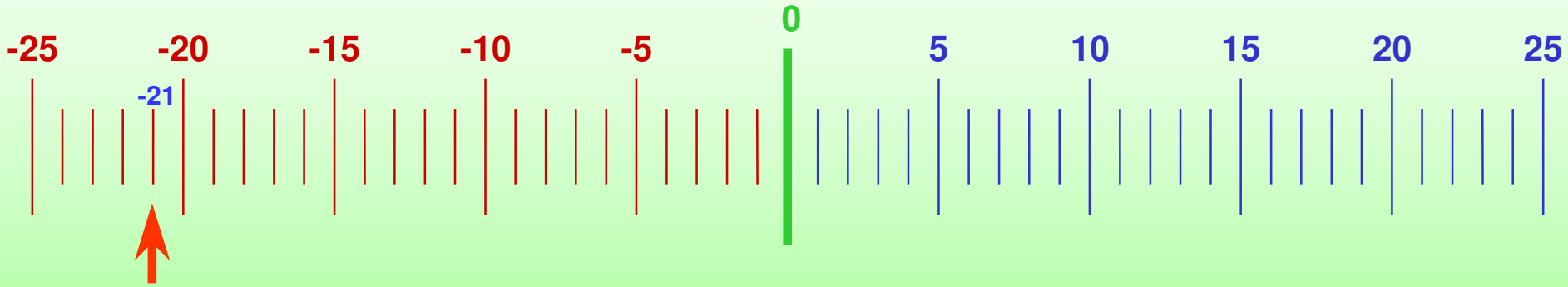
$f = 10^{-20}$

10^{-20} m = 0,000.000.000.000.000.000.01 m



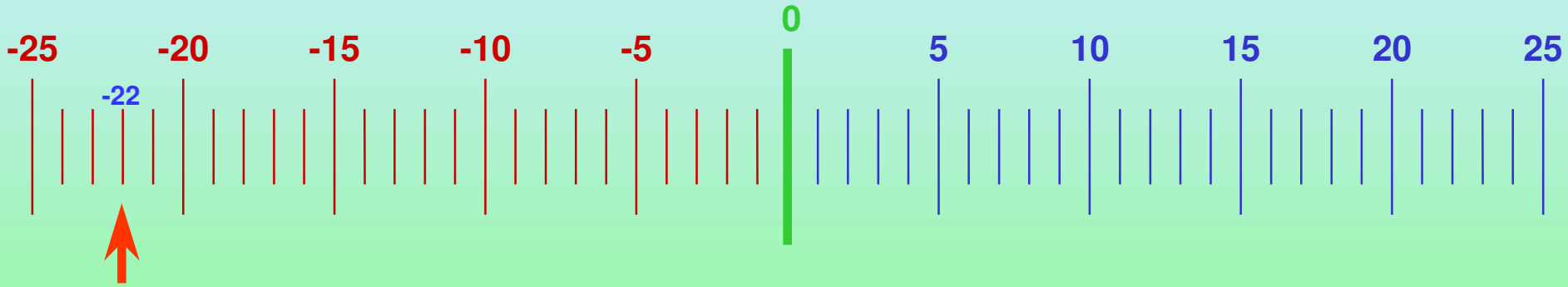
$f = 10^{-21}$

10^{-21} m = 0,000.000.000.000.000.000.001 m



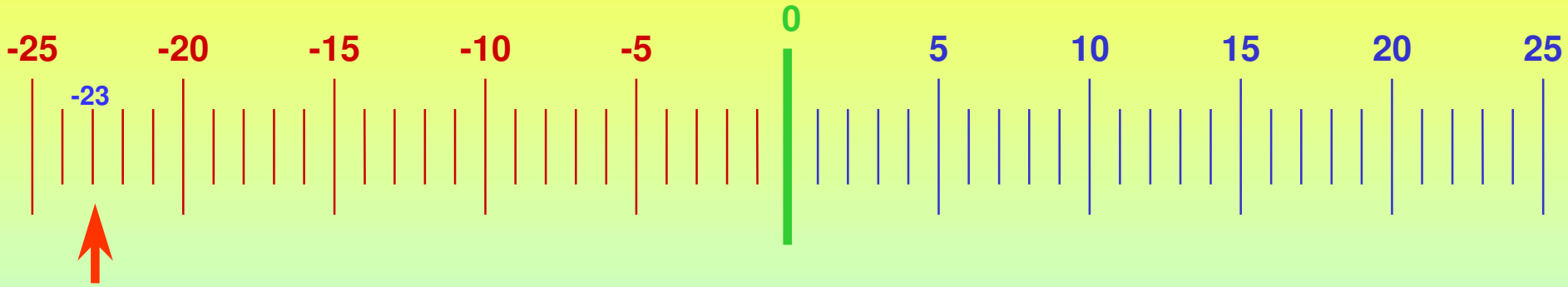
$f = 10^{-22}$

10^{-22} m = 0,000.000.000.000.000.000.000.1 m



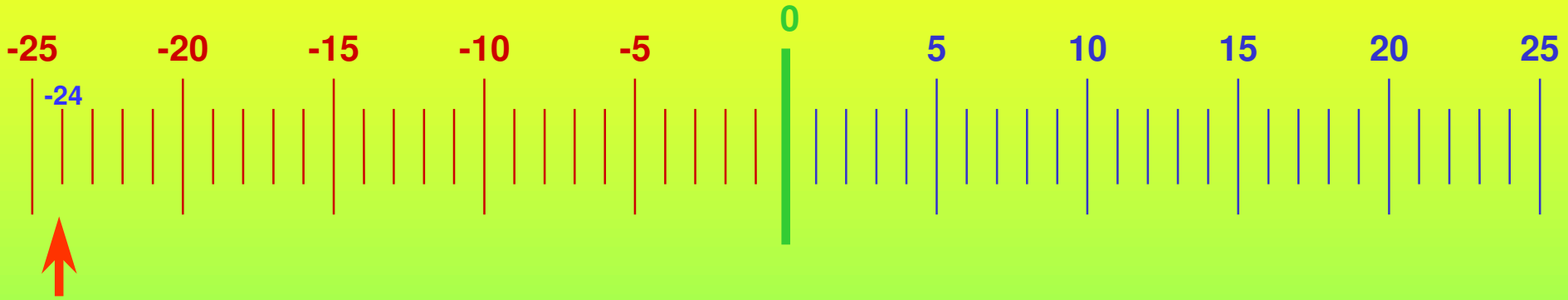
$f = 10^{-23}$

10^{-23} m = 0,000.000.000.000.000.000.000.01 m



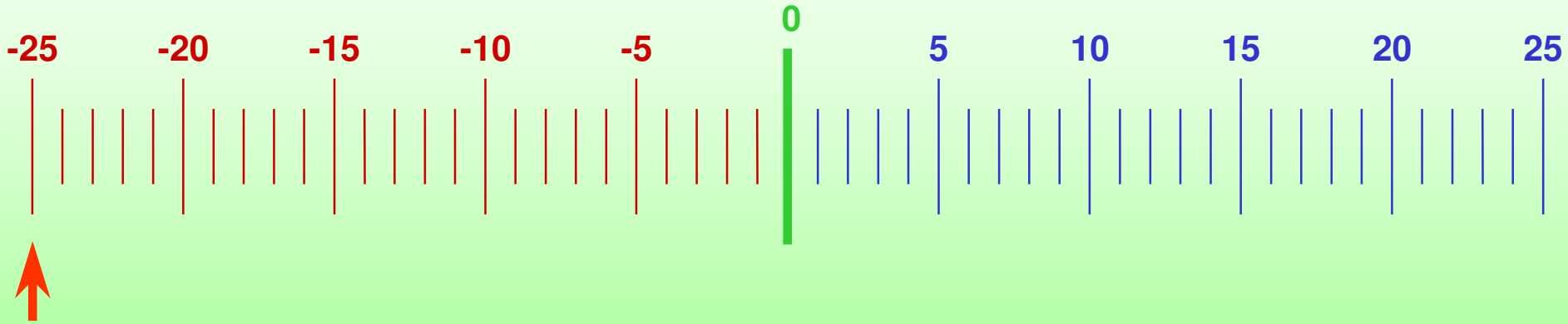
$f = 10^{-24}$

10^{-24} m = 0,000.000.000.000.000.000.000.001 m



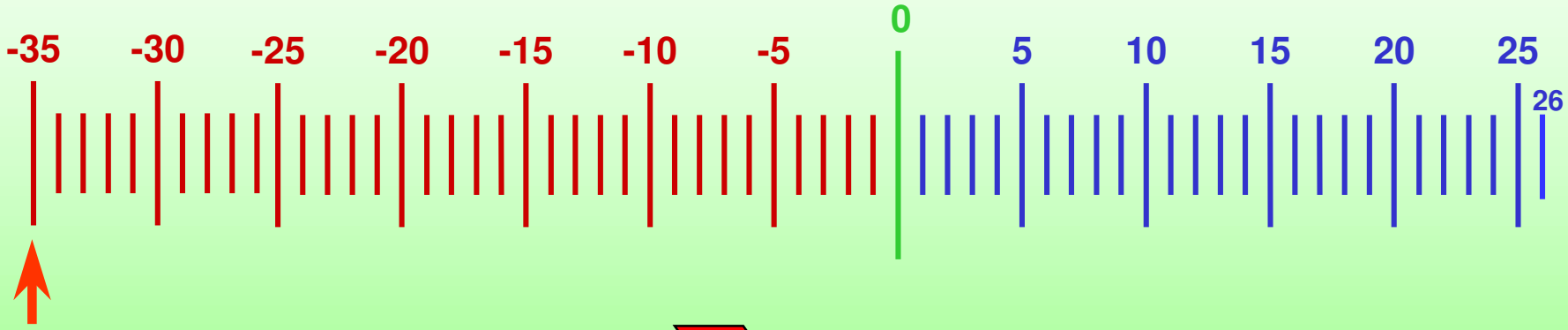
$f = 10^{-25}$

10^{-25} m = 0,000.000.000.000.000.000.000.000.1 m



$f = 10^{-35}$

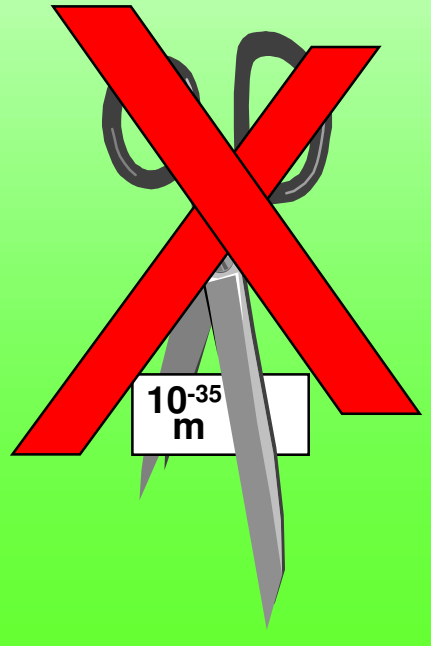
10^{-35} m = 0,000.000.000.000.000.000.000.000.000.000.000.01 m



Tamanho Planck

Quantum de espaço

Menor tamanho de um espaço



Para o macromundo

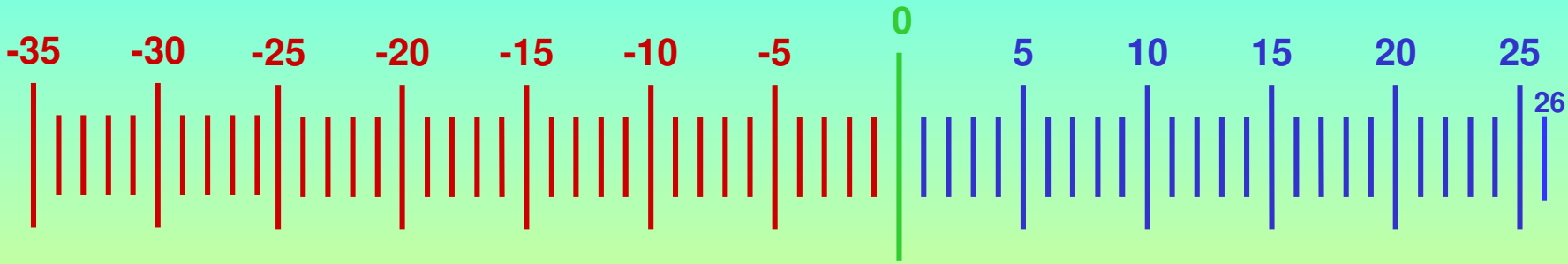
x 10

Macromundo

Cada traço à direita significa o traço da esquerda multiplicado por 10

Metro f = 10^0

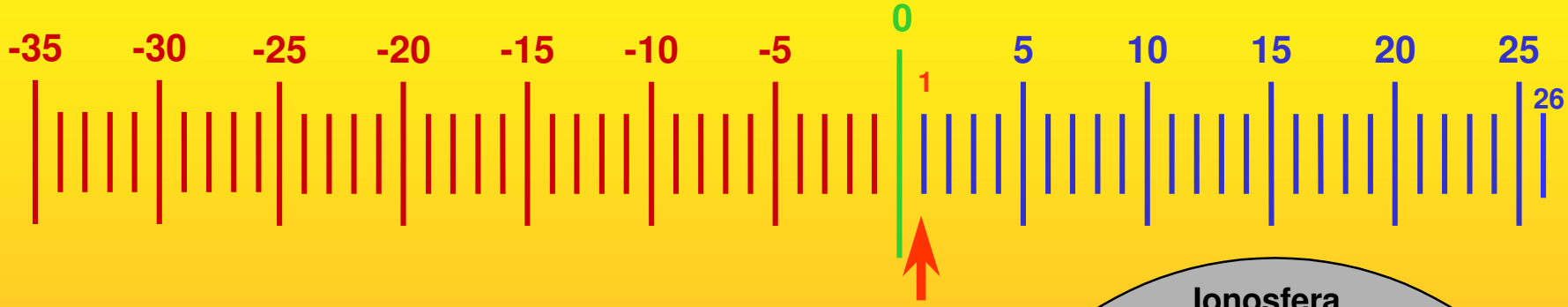
10^0 m = 1 m

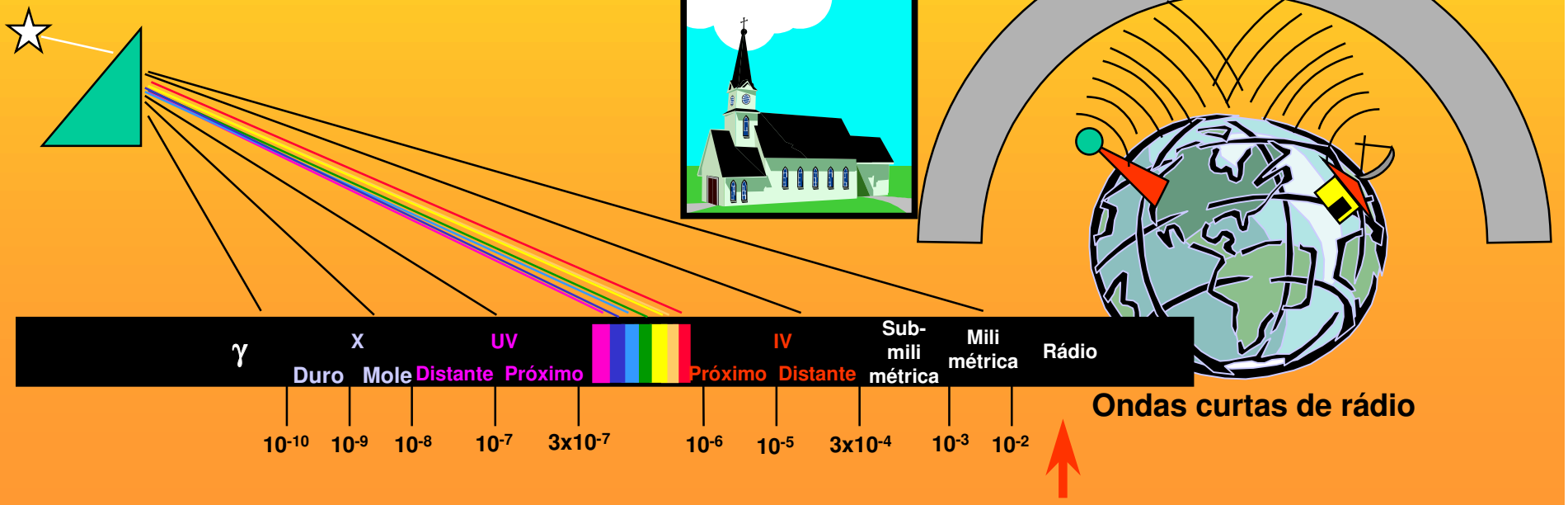


Elemento representativo da escala

Decametro f = 10^1

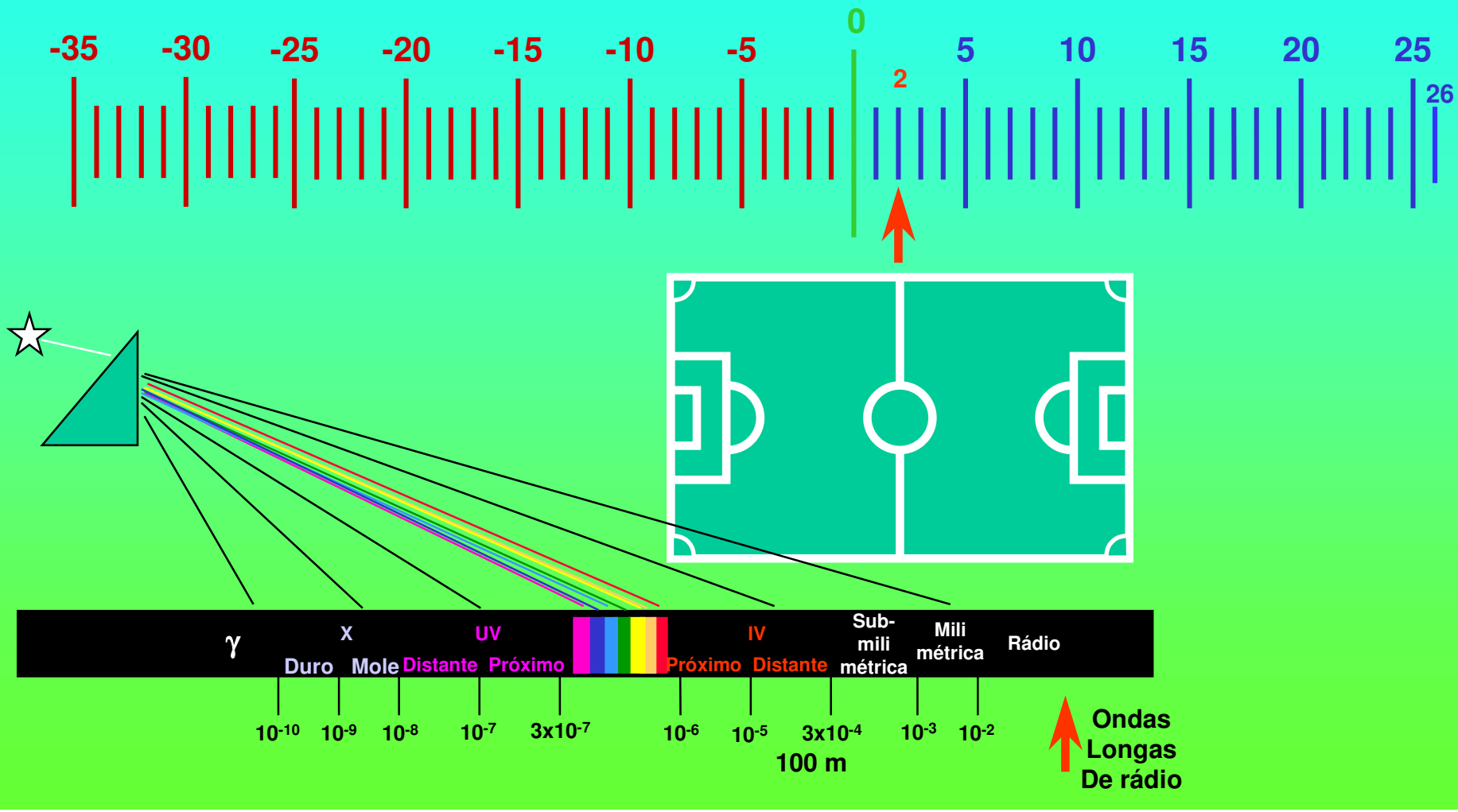
10^1 m = 10 m





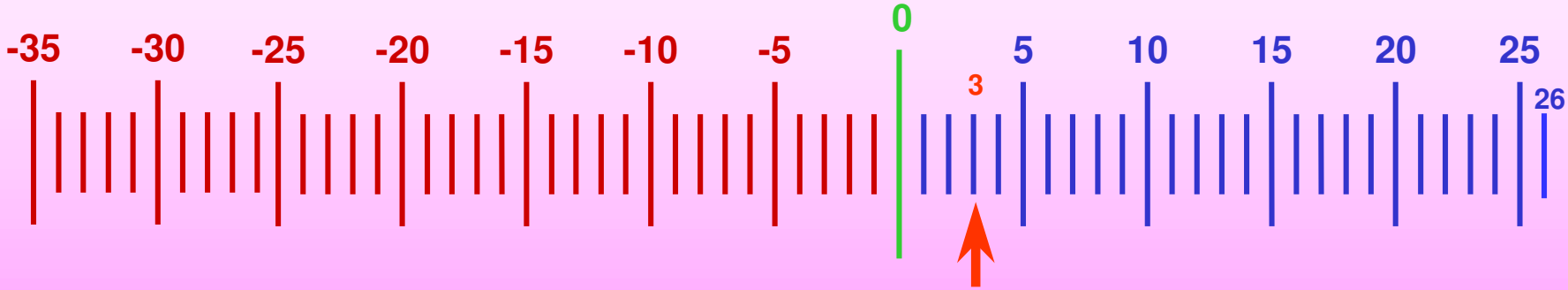
Hectometro f = 10^2

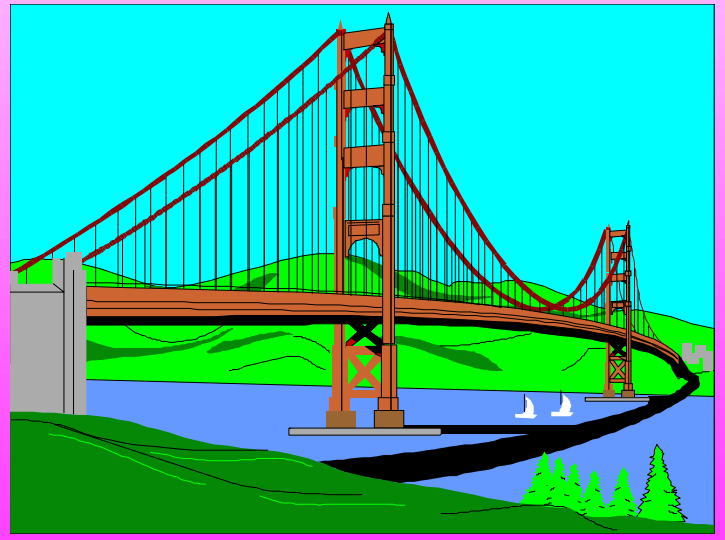
10^2 m = 100 m



Kilômetro f = 10^3

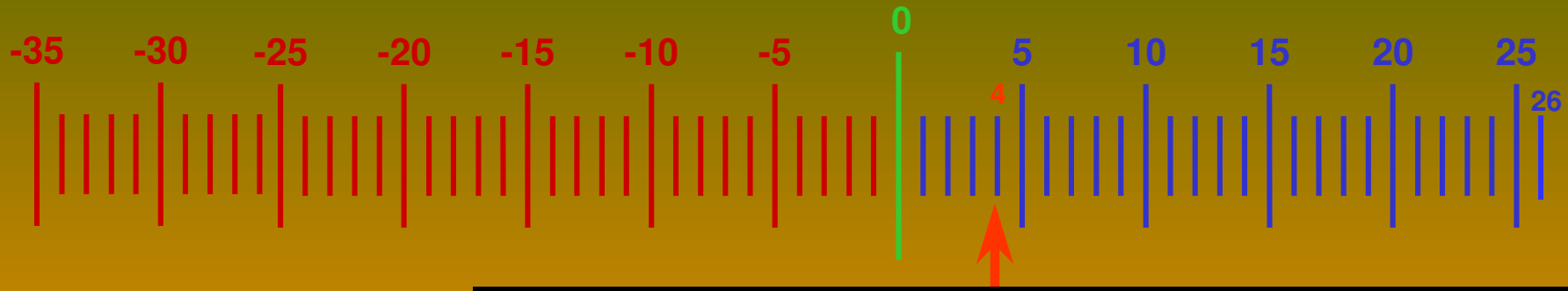
10^3 m = 1.000 m

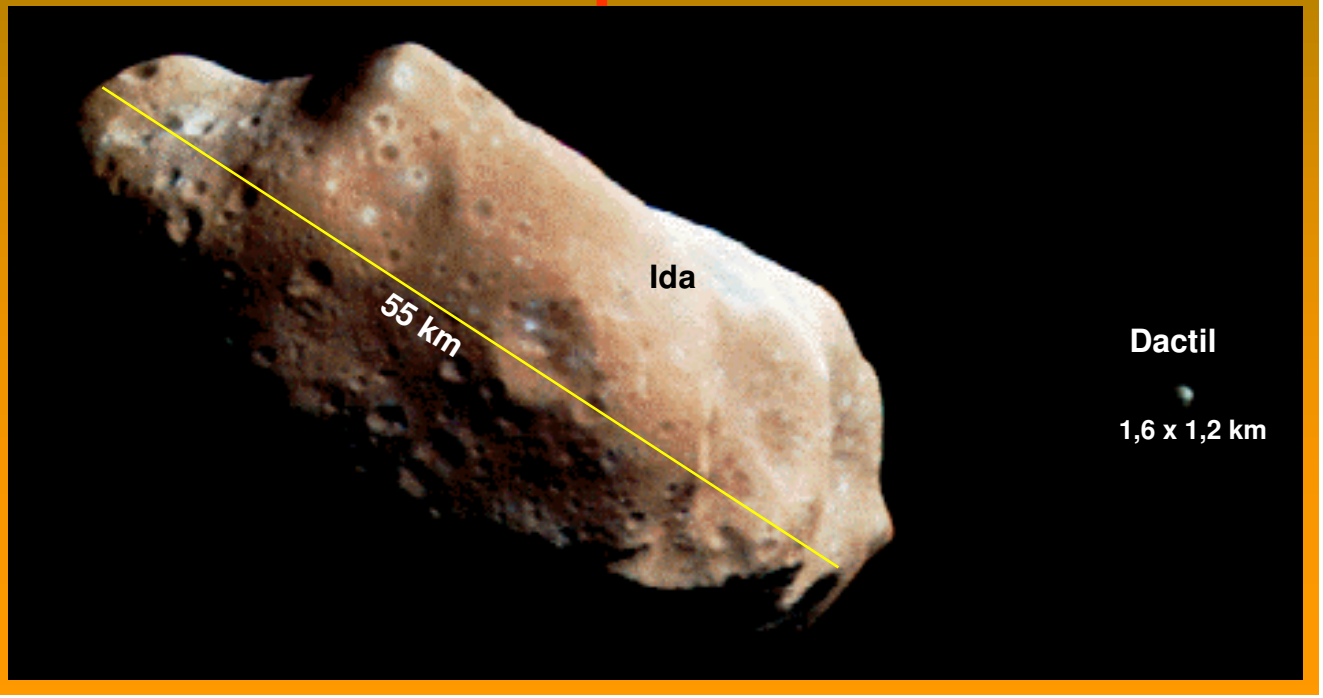




$f = 10^4$

10^4 m = 10.000 m

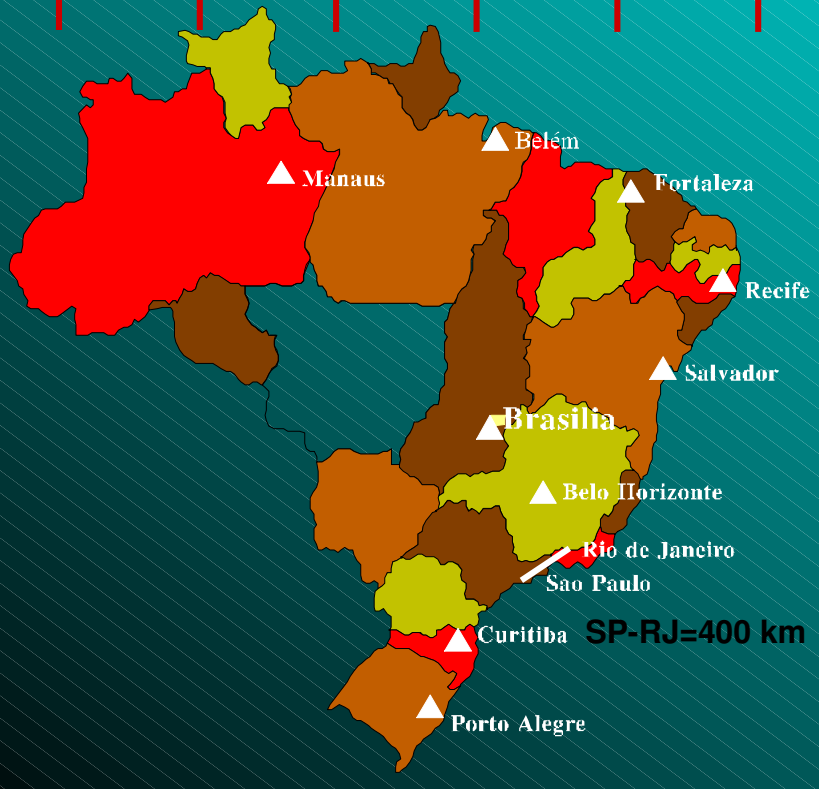


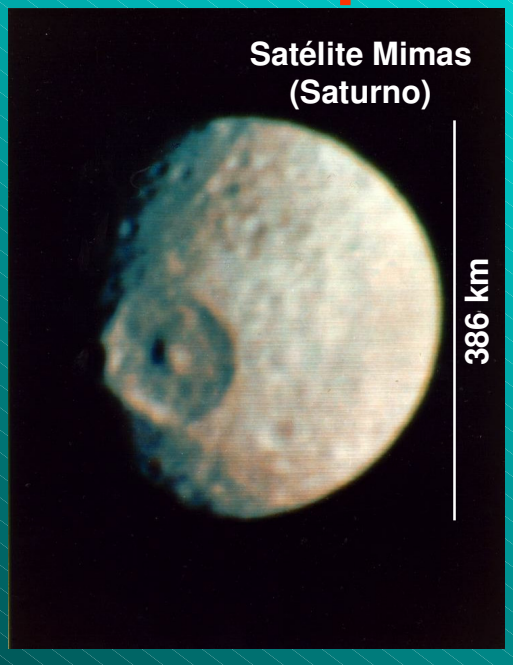


$f = 10^5$

10^5 m = 100.000 m

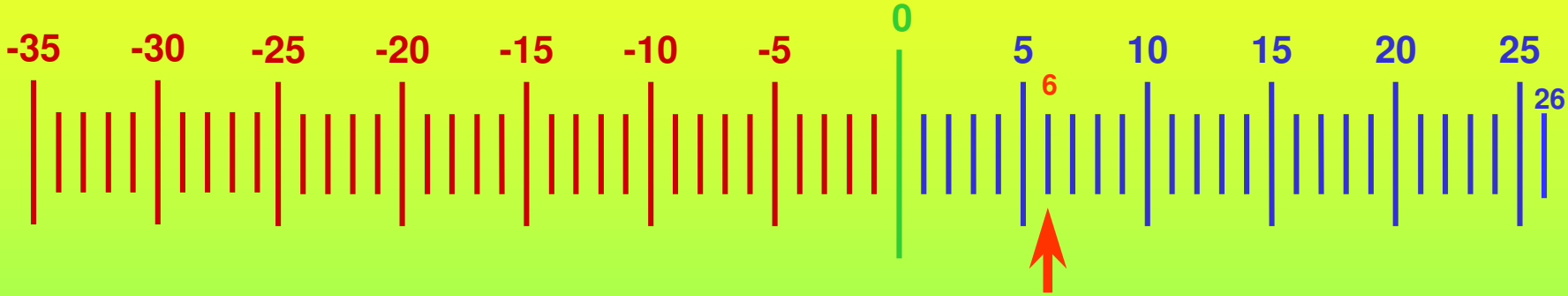
-35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 26





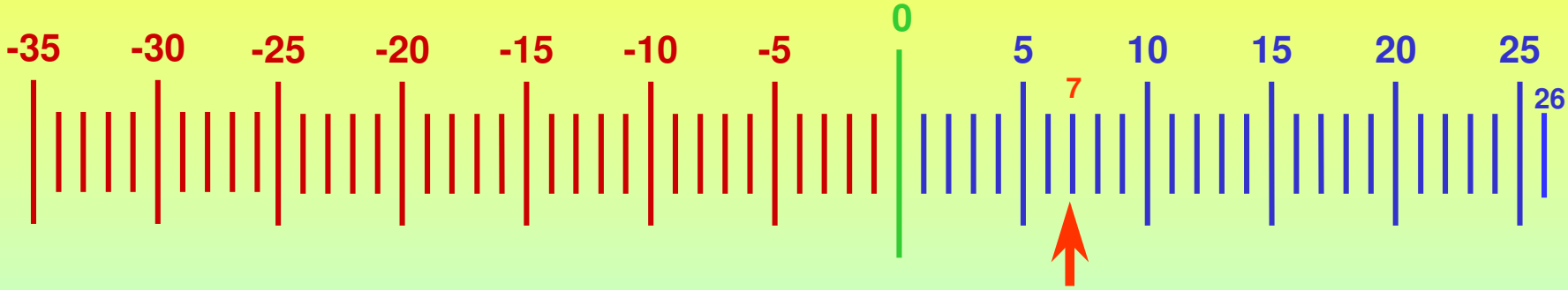
Mega f = 10^6

10^6 m = 1.000.000 m



Terra f = 10^7

10^7 m = 10.000.000 m

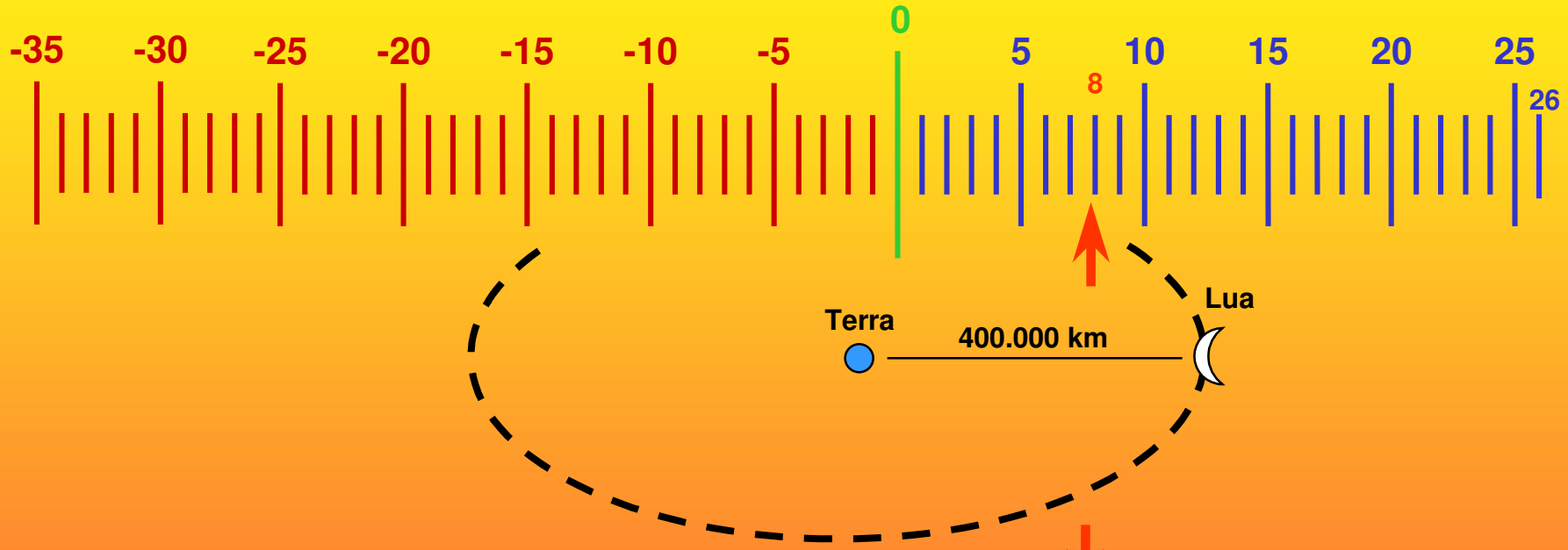


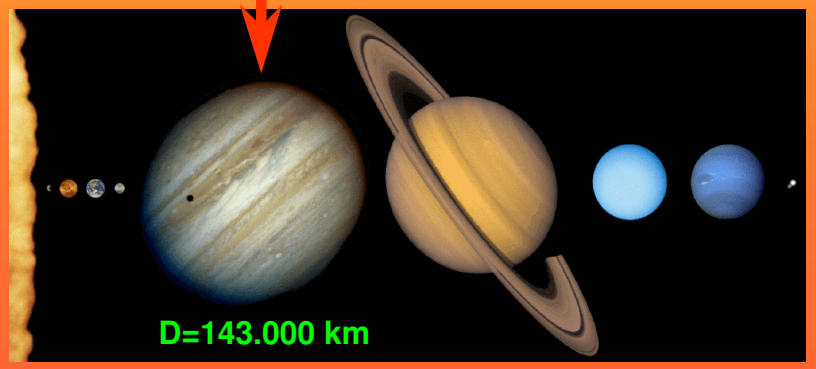
D = 20.000 km

D = 12.796 km

$f = 10^8$

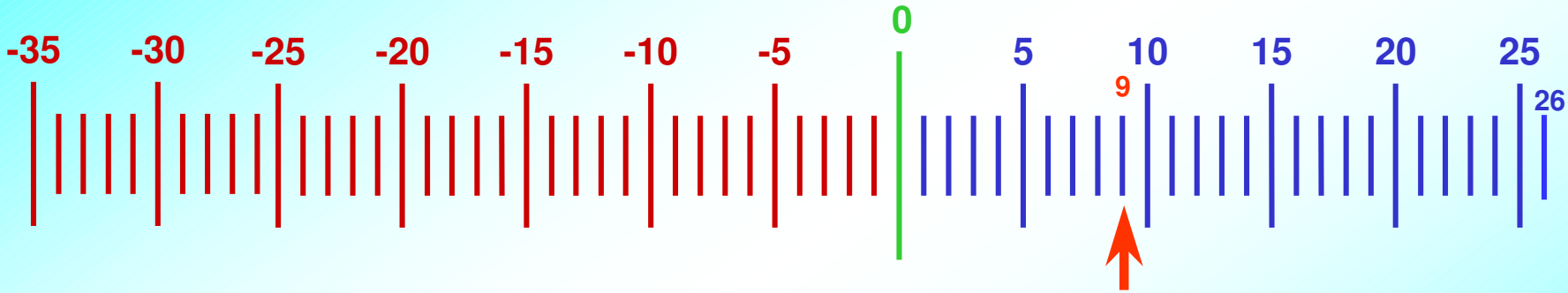
10^8 m = 100.000.000 m



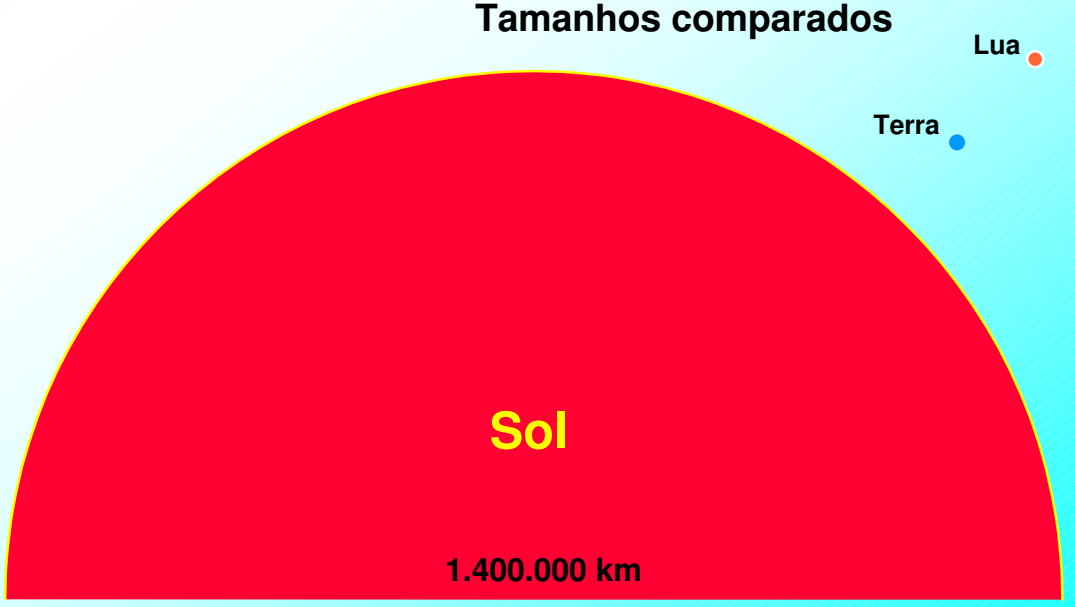


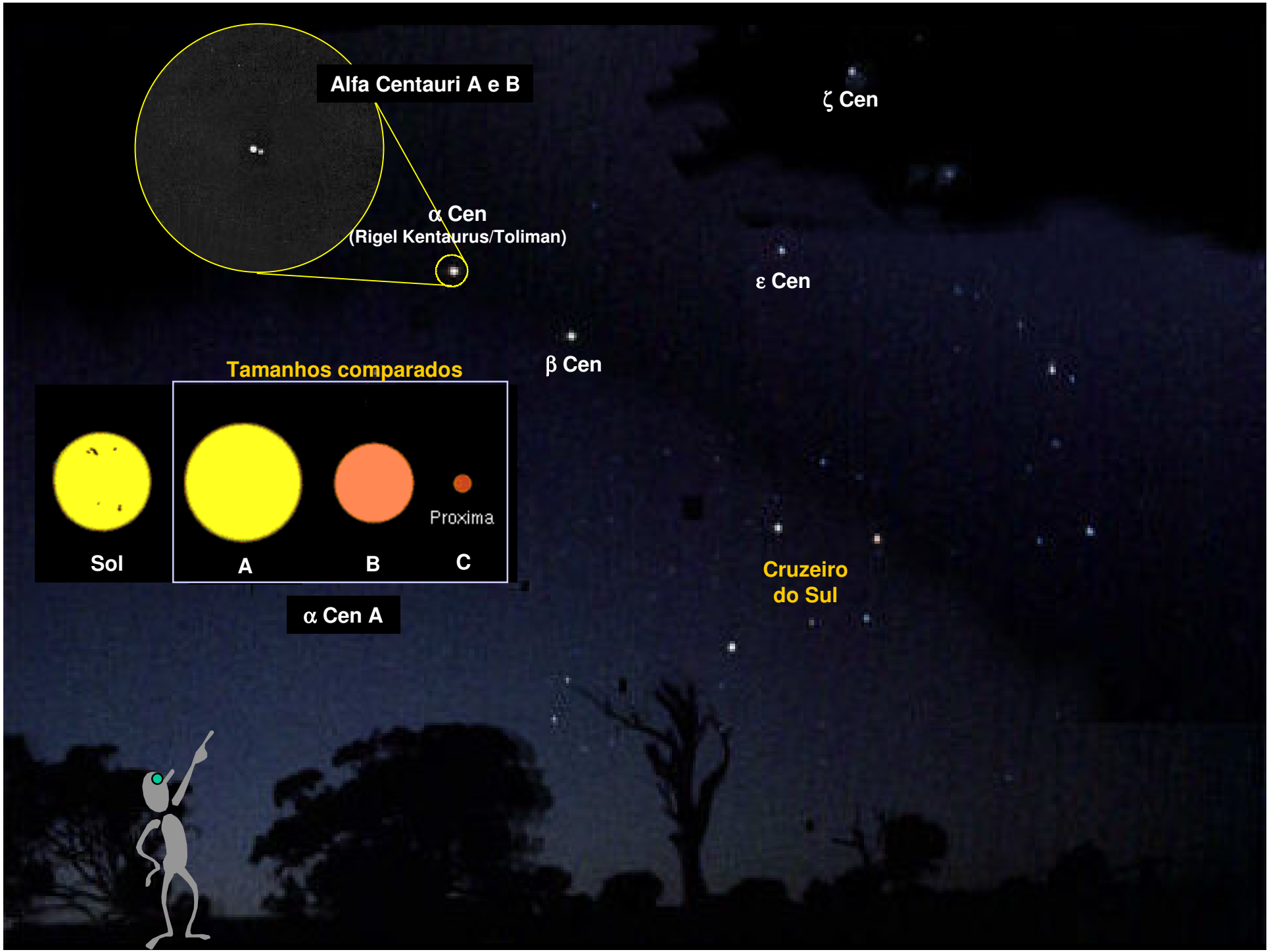
Giga f = 10^9

10^9 m = 1.000.000.000 m

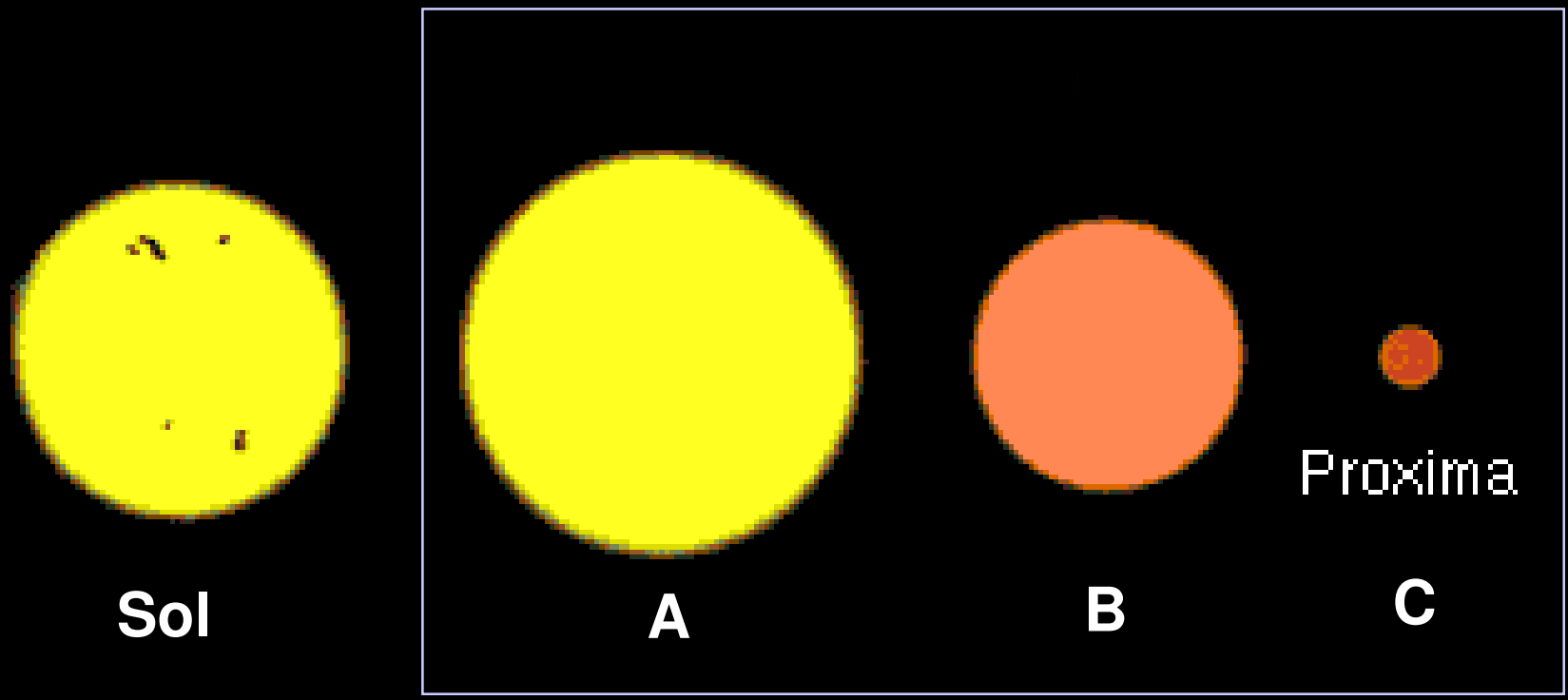


Tamanhos comparados



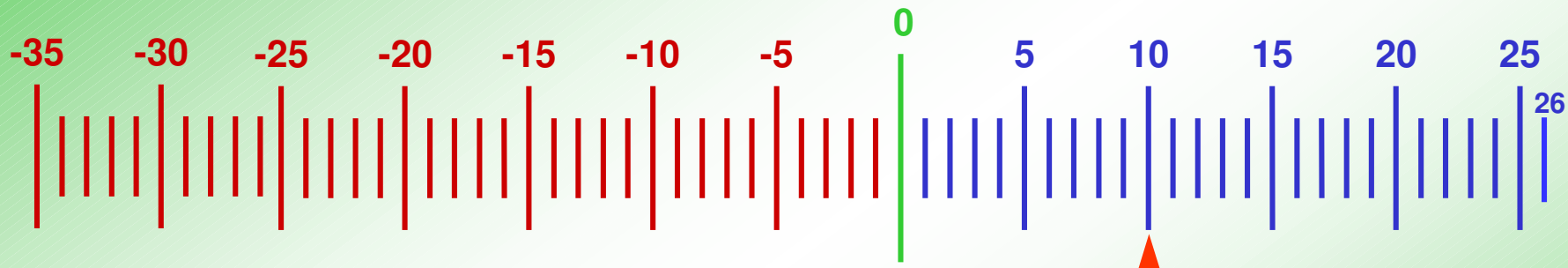

Alfa Centauri A e B
α Cen
(Rigel Kentaurus/Toliman)
ζ Cen
ε Cen
β Cen
Tamanhos comparados
Sol
A
B
Proxima
C
α Cen A
Cruzeiro
do Sul

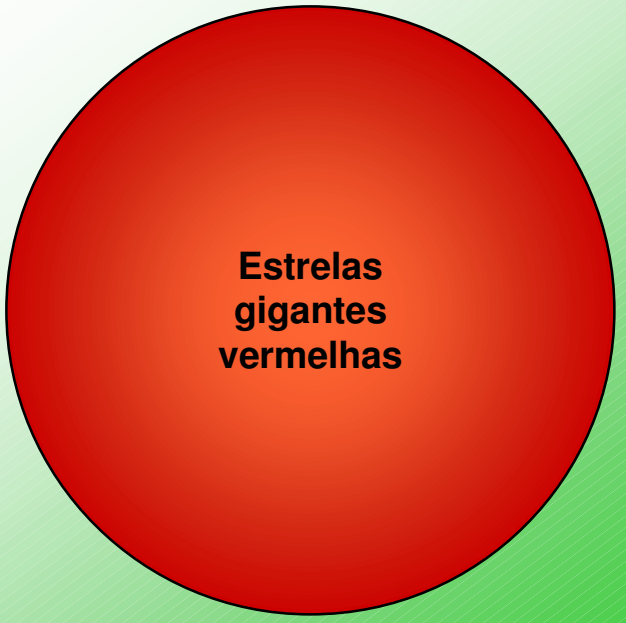
Tamanhos relativos do Sol e das estrelas de αCen



$f = 10^{10}$

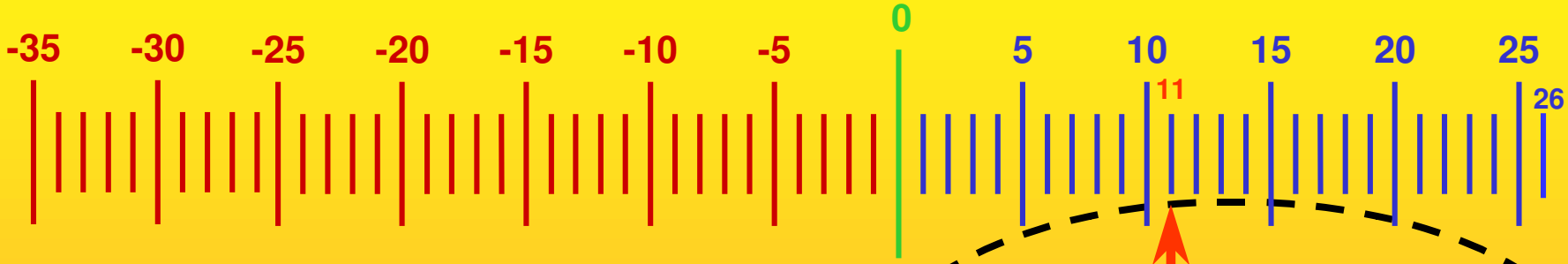
10^{10} m = 10.000.000.000 m

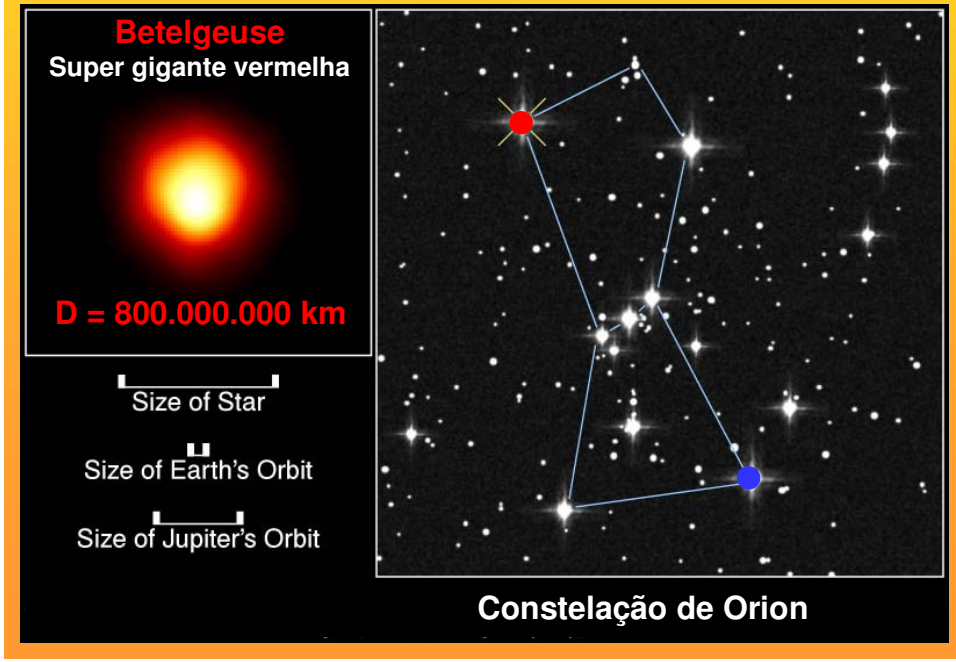




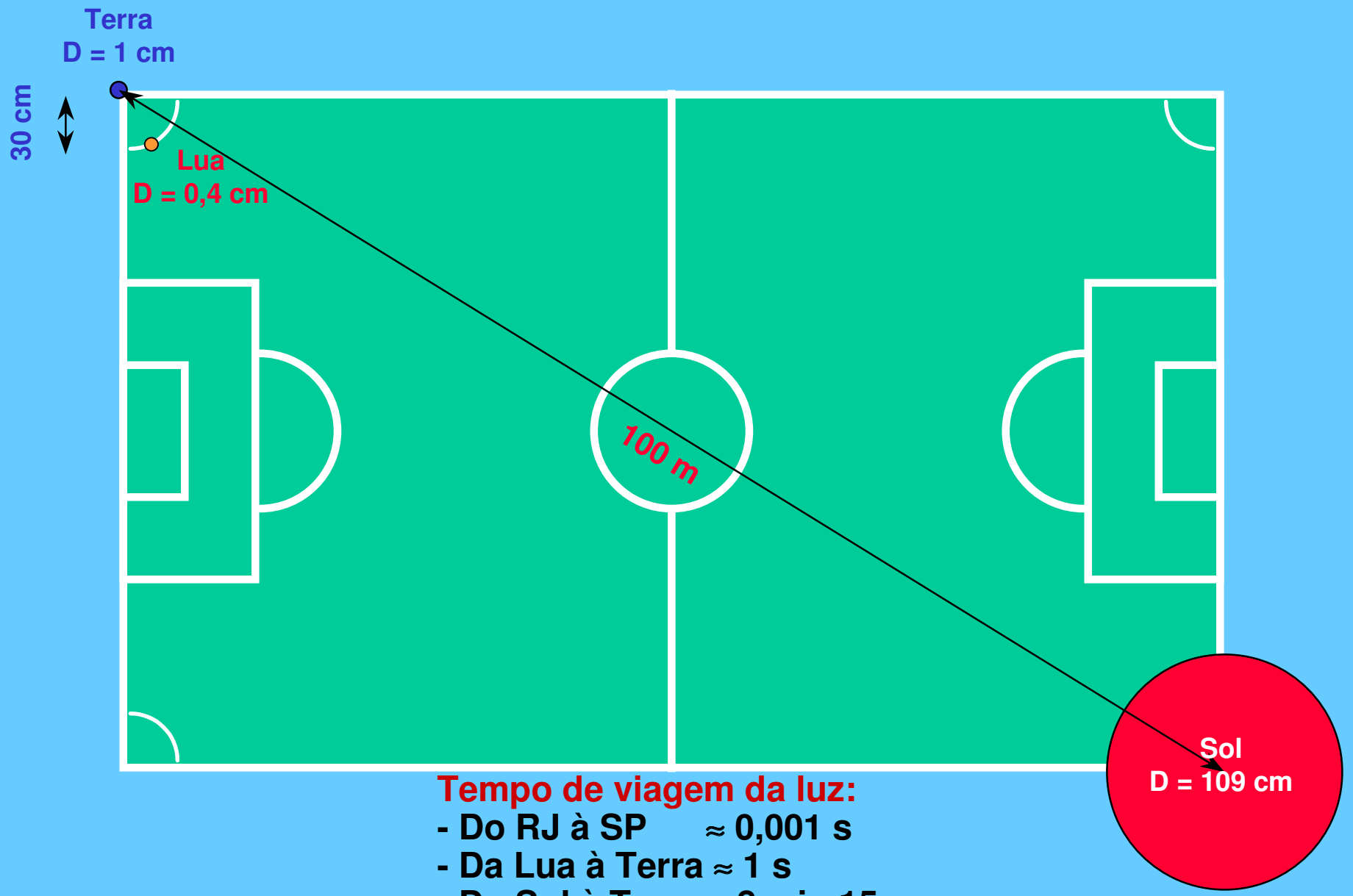
$f = 10^{11}$

10^{11} m = 100.000.000.000 m





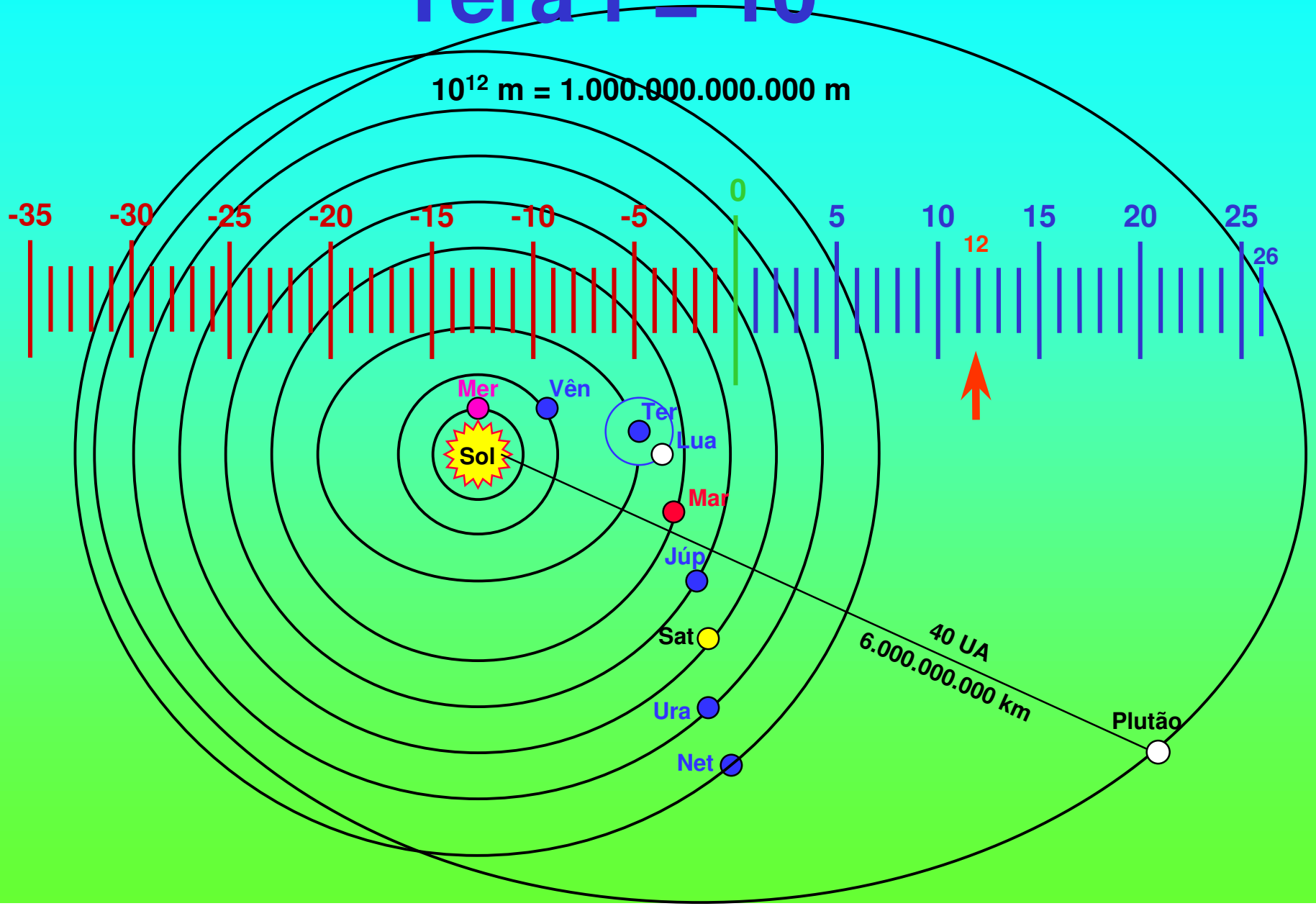
Distâncias e tamanhos comparados



Tempo de viagem da luz:

- Do RJ à SP ≈ 0,001 s
- Da Lua à Terra ≈ 1 s
- Do Sol à Terra ≈ 8 min 15 s

Tera f = 10^{12}


10^12 m = 1.000.000.000.000 m
-35
-30
-25
-20
-15
-10
-5
0
5
10
15
20
25
12
26
Mer
Vên
Ter
Lua
Sol
Mar
Júp
Sat
Ura
Net
40 UA
6.000.000.000 km
Plutão

Distâncias e tamanhos comparados no Sistema Solar

Se a Terra
D = 1 cm

Sol

4 km = 40 campos de futebol

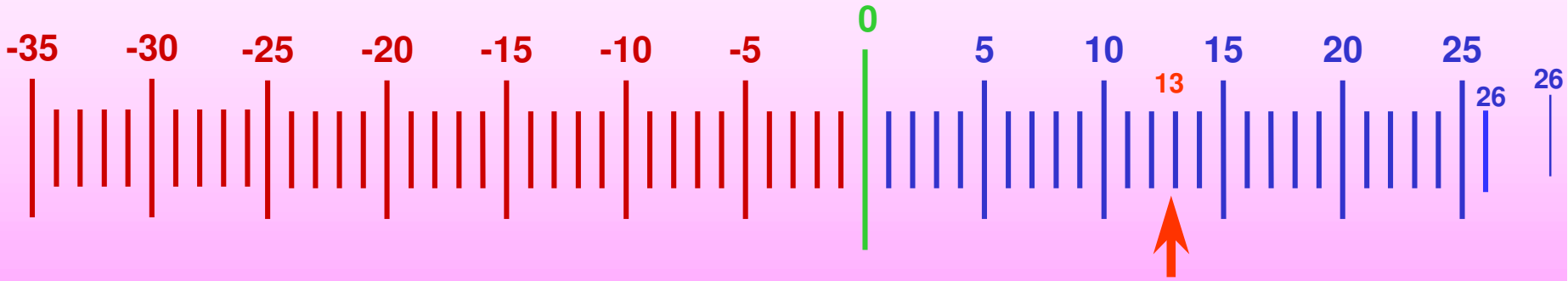
Plutão

Tempo de viagem da luz:

- Do RJ à SP ≈ 0,001 s
- Da Lua à Terra ≈ 1 s
- Do Sol à Terra ≈ 8 min 15 s
- De Plutão à Terra ≈ 5 h

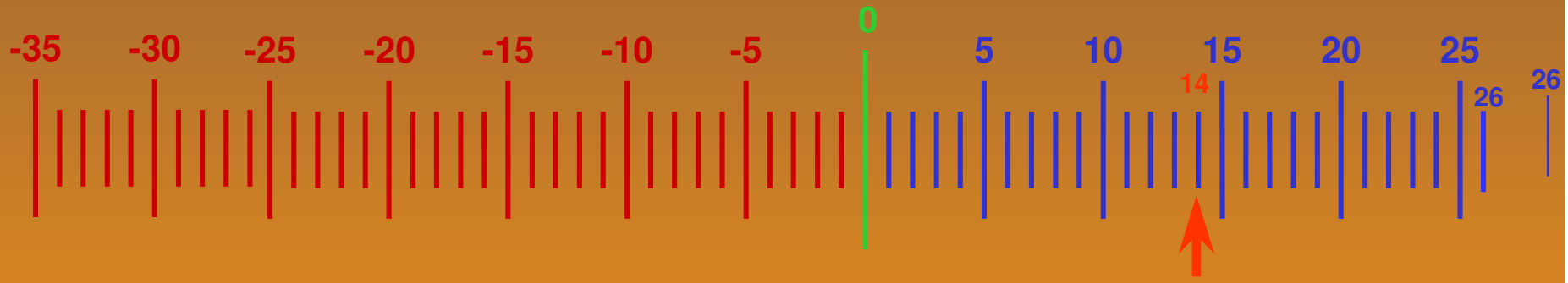
$f = 10^{13}$

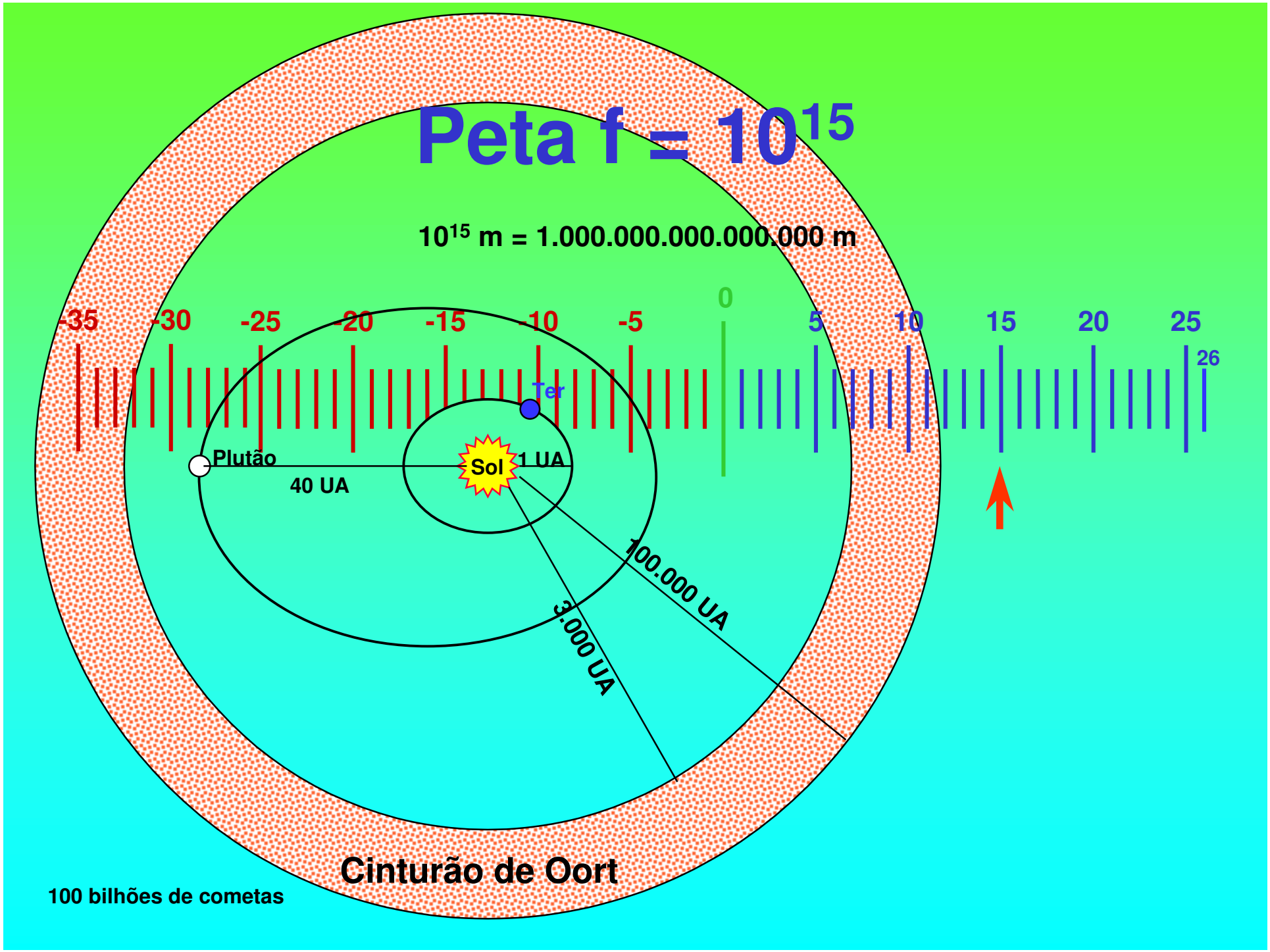
10^{13} m = 10.000.000.000.000 m

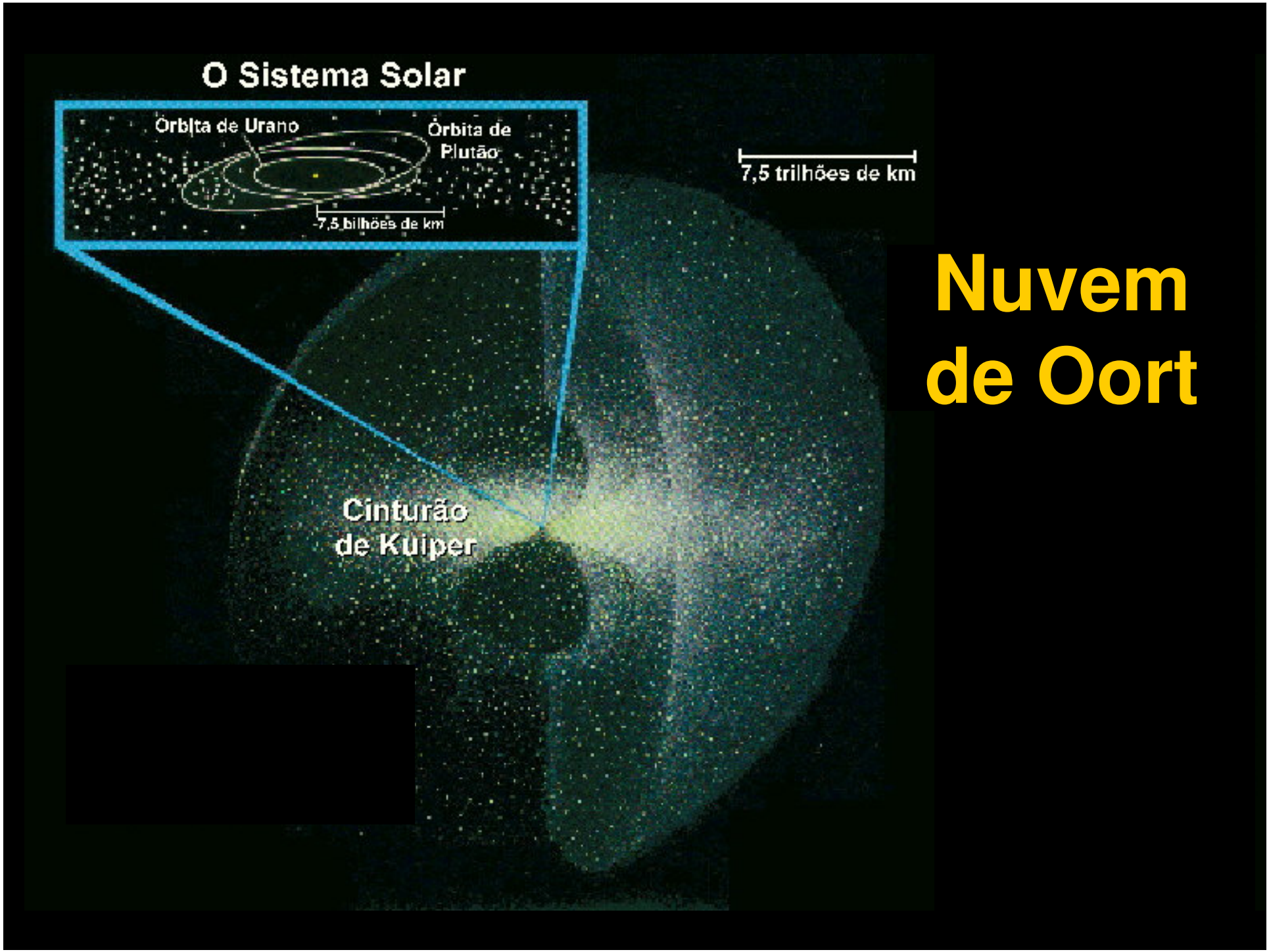


$f = 10^{14}$

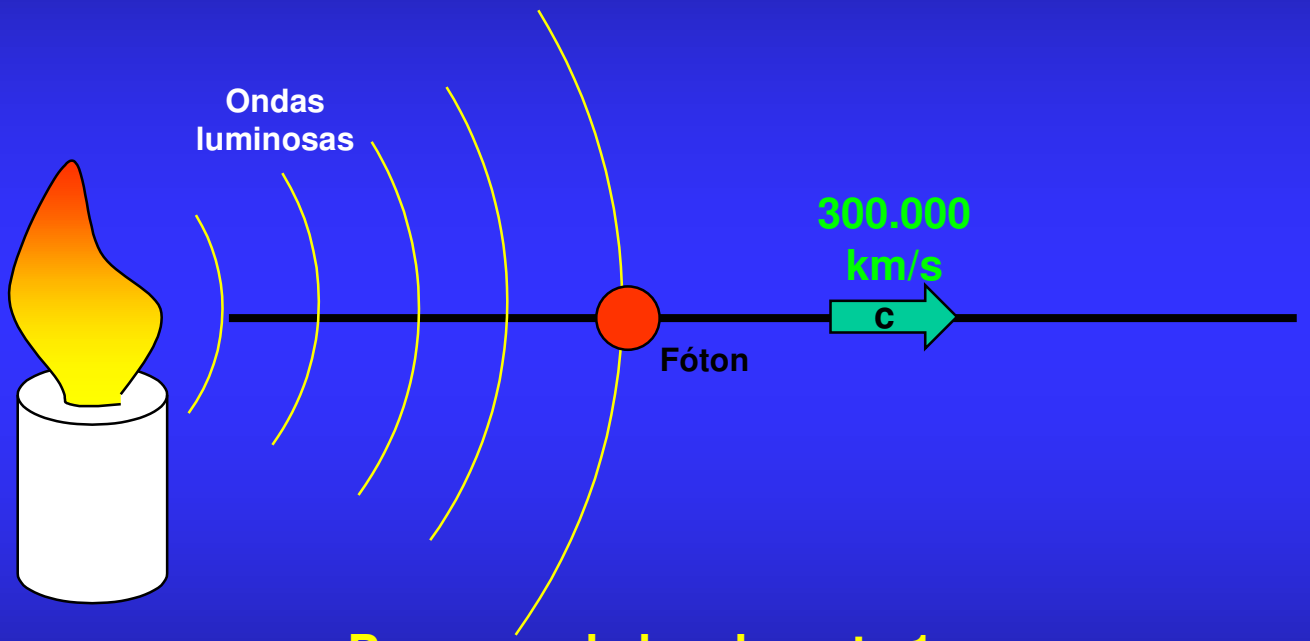
10^{14} m = 100.000.000.000.000 m




Peta f = 10^15
10^15 m = 1.000.000.000.000.000 m
-35
-30
-25
-20
-15
-10
-5
0
5
10
15
20
25
26
Ter
Plutão
40 UA
Sol
1 UA
100.000 UA
3.000 UA
Cinturão de Oort
100 bilhões de cometas


O Sistema Solar
Órbita de Urano
Órbita de Plutão
7,5 bilhões de km
7,5 trilhões de km
Cinturão de Kuiper
Nuvem de Oort

Ano-luz



Percurso da luz durante 1 ano

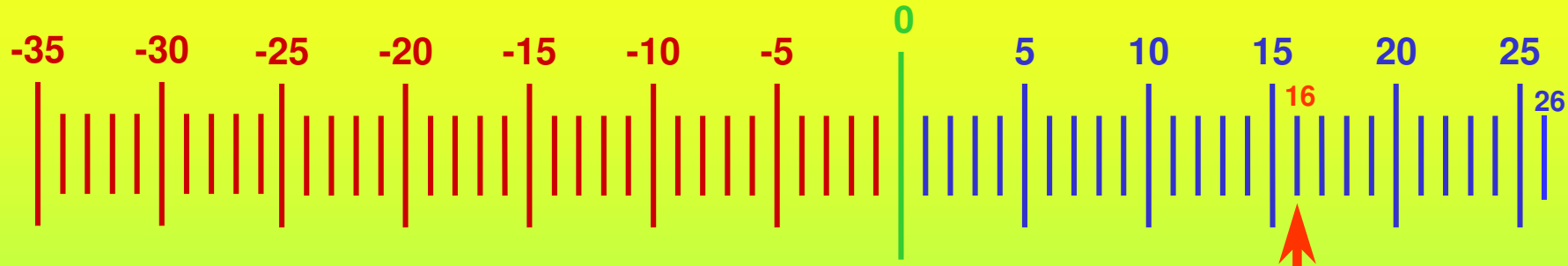
1 ano-luz

9,5 trilhões de km

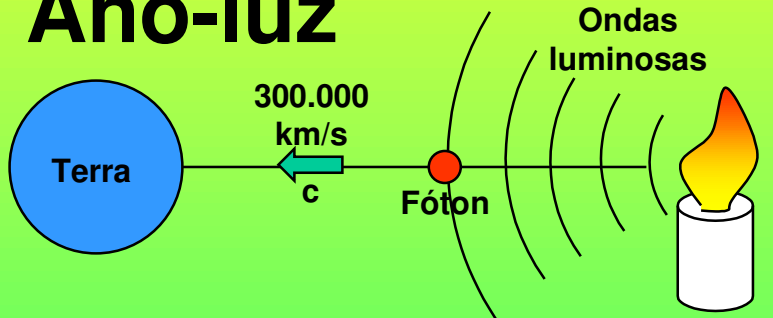
63.240 UA

$f = 10^{16}$

10^{16} m = 10.000.000.000.000.000 m

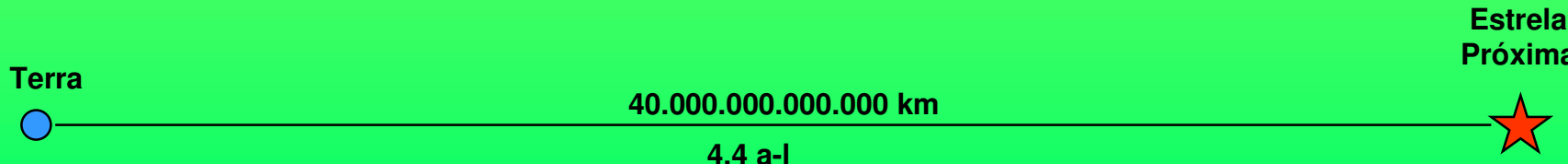


Ano-luz

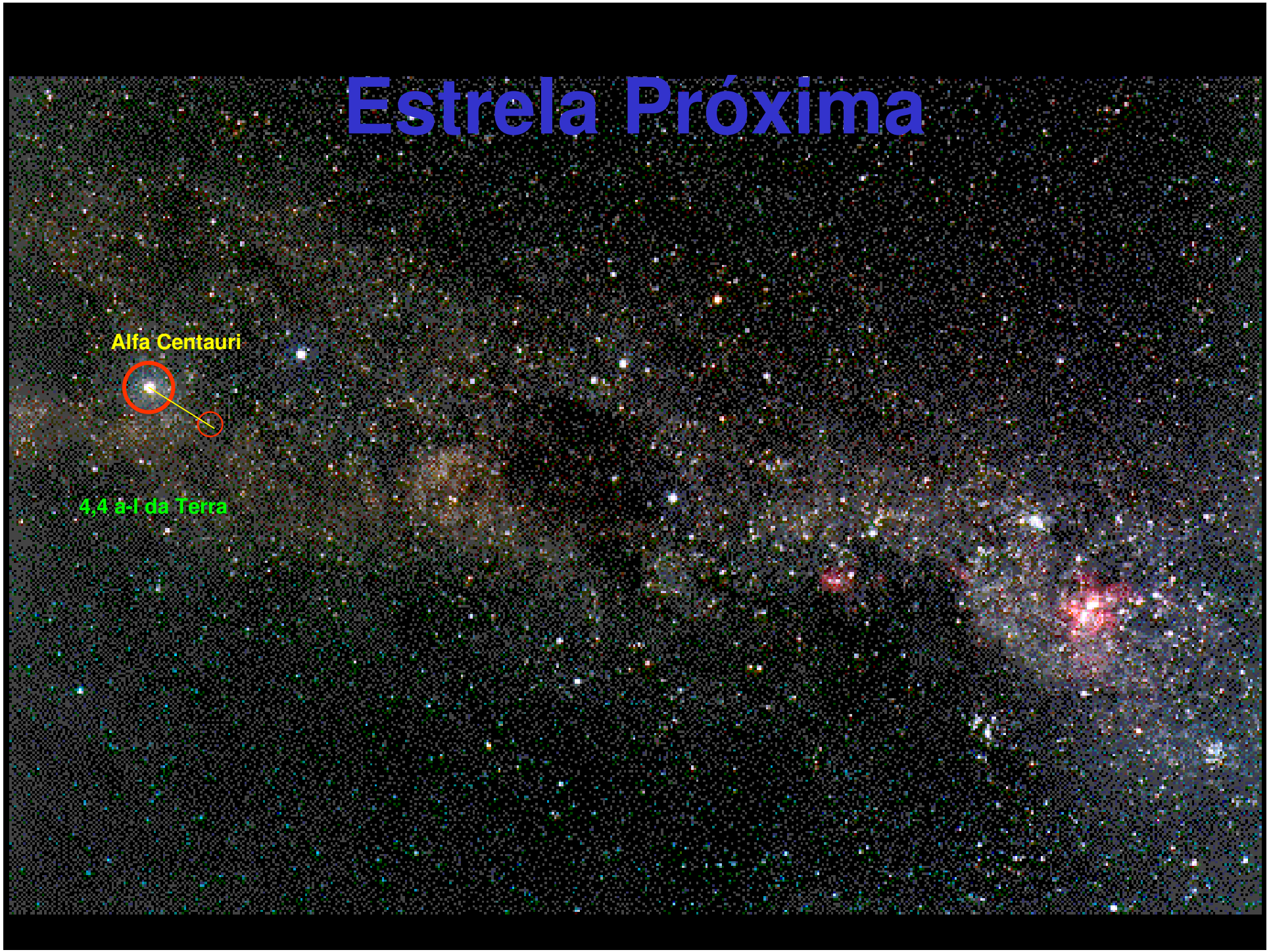


Tempo de viagem da luz:

- Do RJ à SP ≈ 0,001 s
- Da Lua à Terra ≈ 1 s
- Do Sol à Terra ≈ 8 min 15 s
- De Plutão à Terra ≈ 5 h
- Alfa Centauro à Terra ≈ 4,4 anos



Estrela Próxima

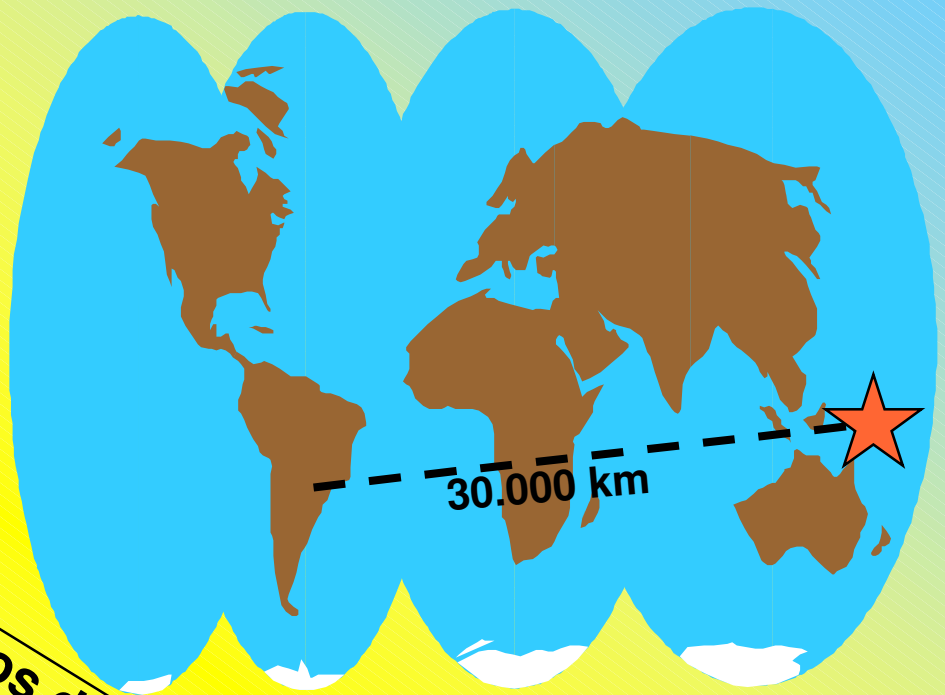


Distâncias e tamanhos comparados

Se a Terra
D = 1 cm

Sol

4 km = 40 campos de futebol

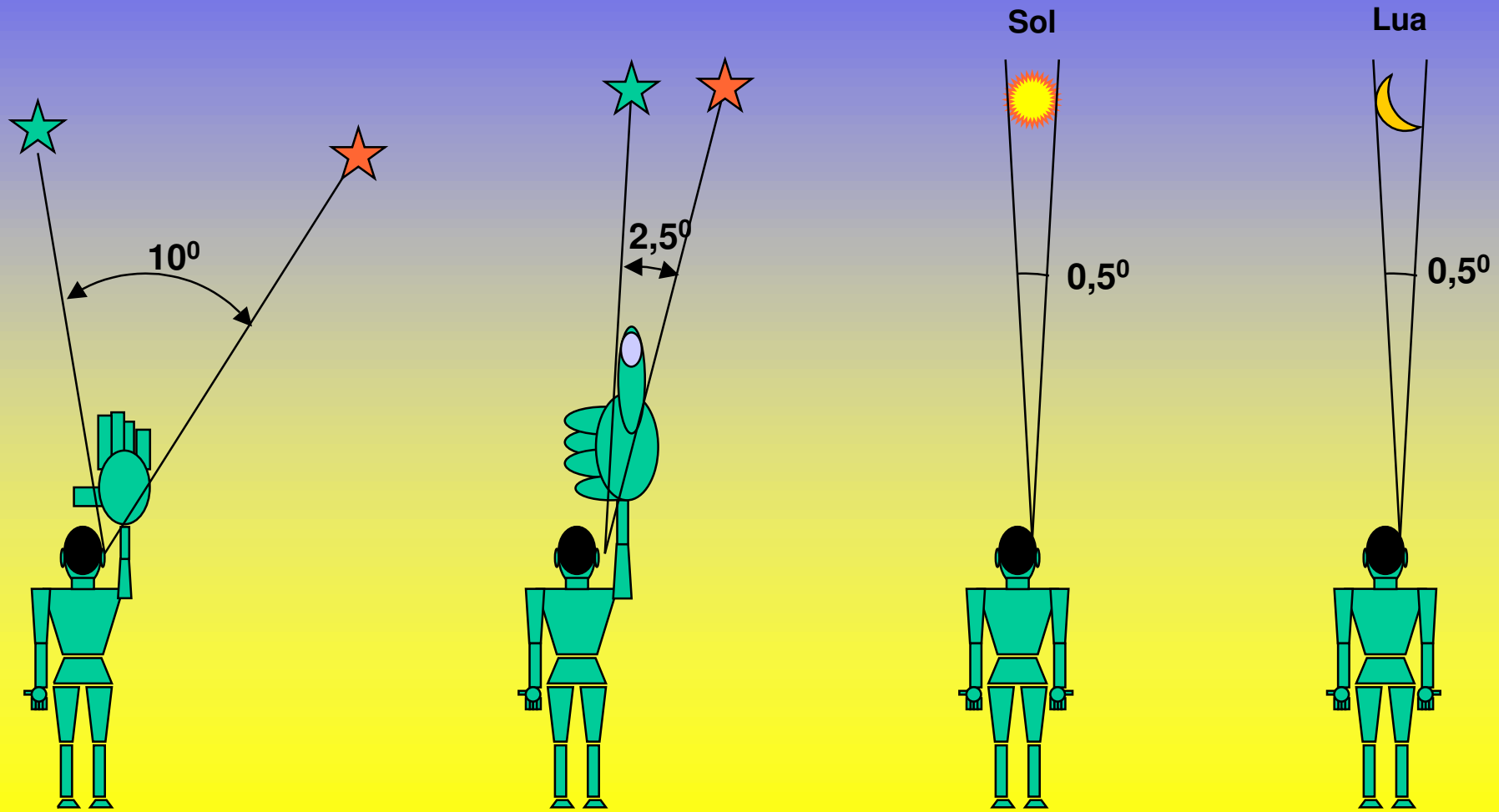


Plutão

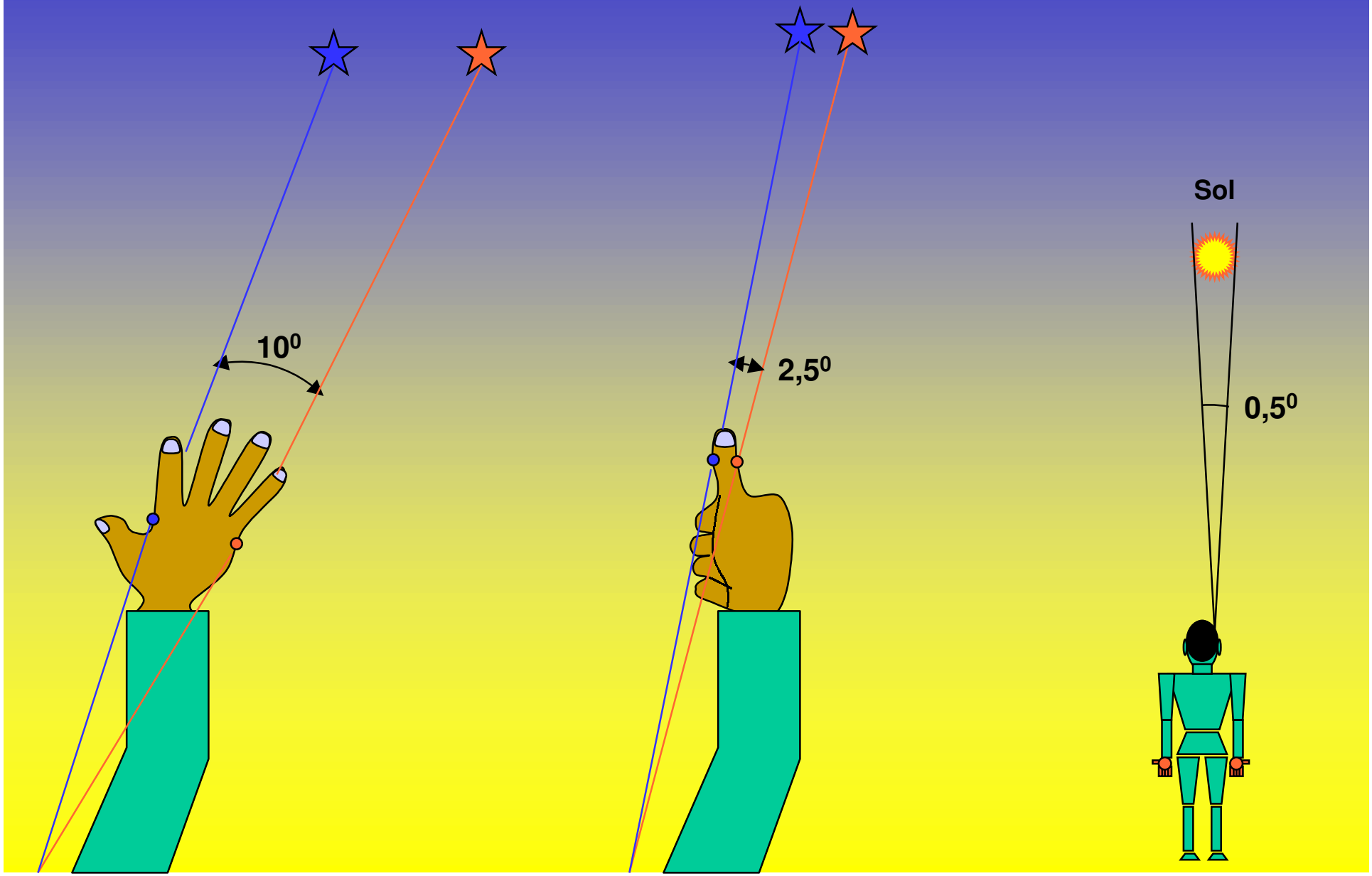
Tempo de viagem da luz:

- Do RJ à SP ≈ 0,001 s
- Da Lua à Terra ≈ 1 s
- Do Sol à Terra ≈ 8 min 15 s
- De Plutão à Terra ≈ 5 h
- Alfa Centauro à Terra ≈ 4,4 anos

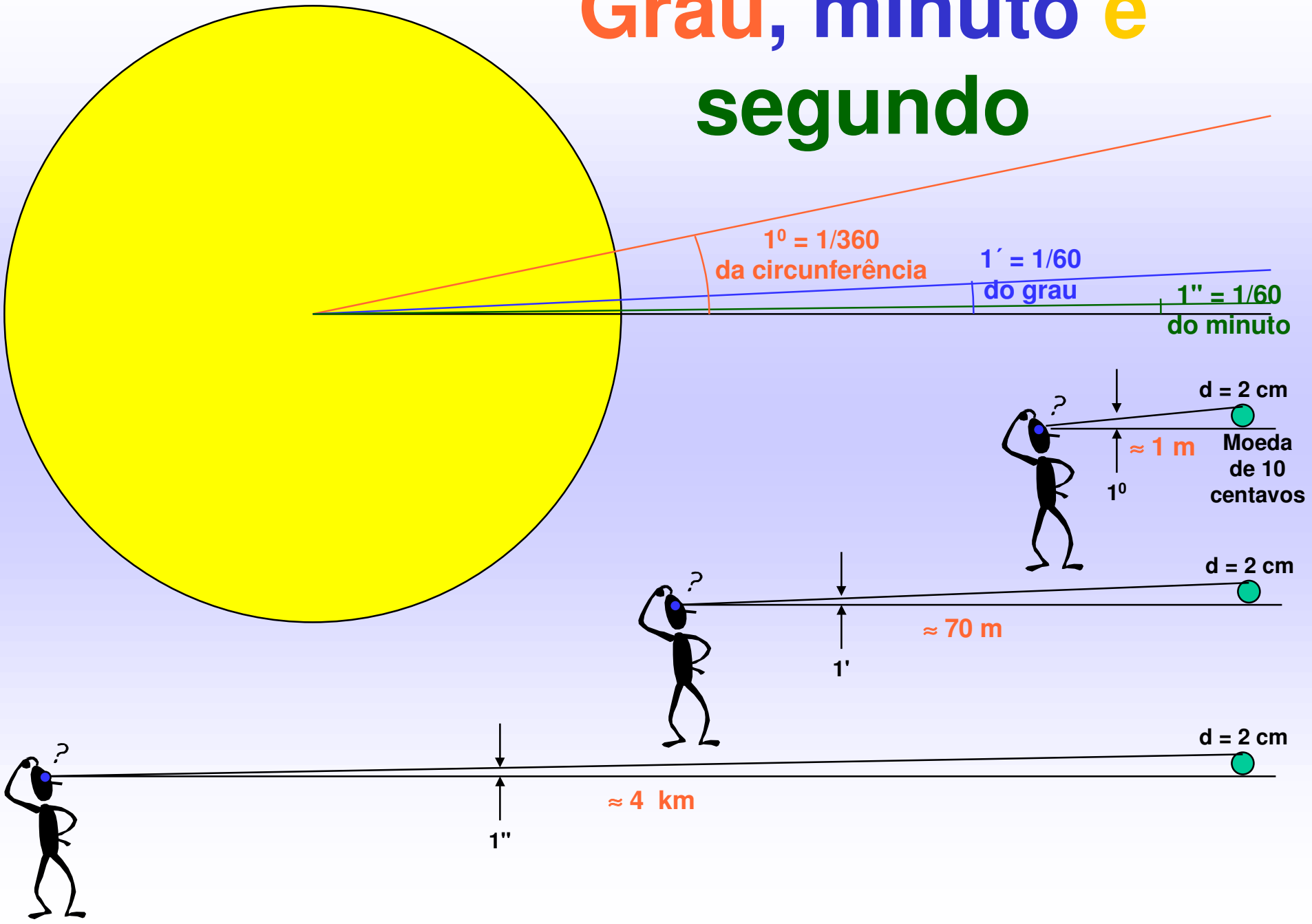
Medidas angulares



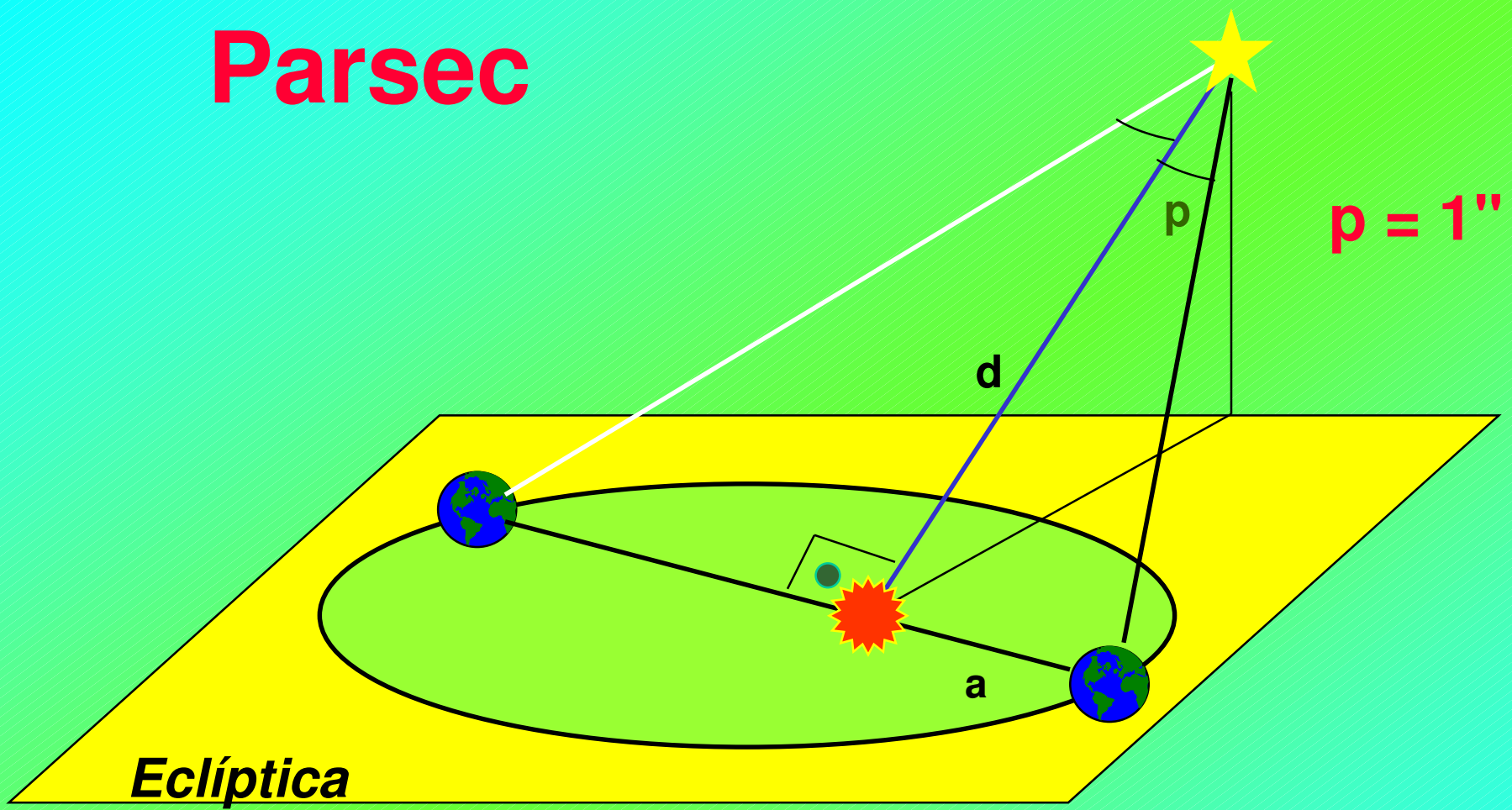
Medidas angulares



Grau, minuto e segundo



Parsec

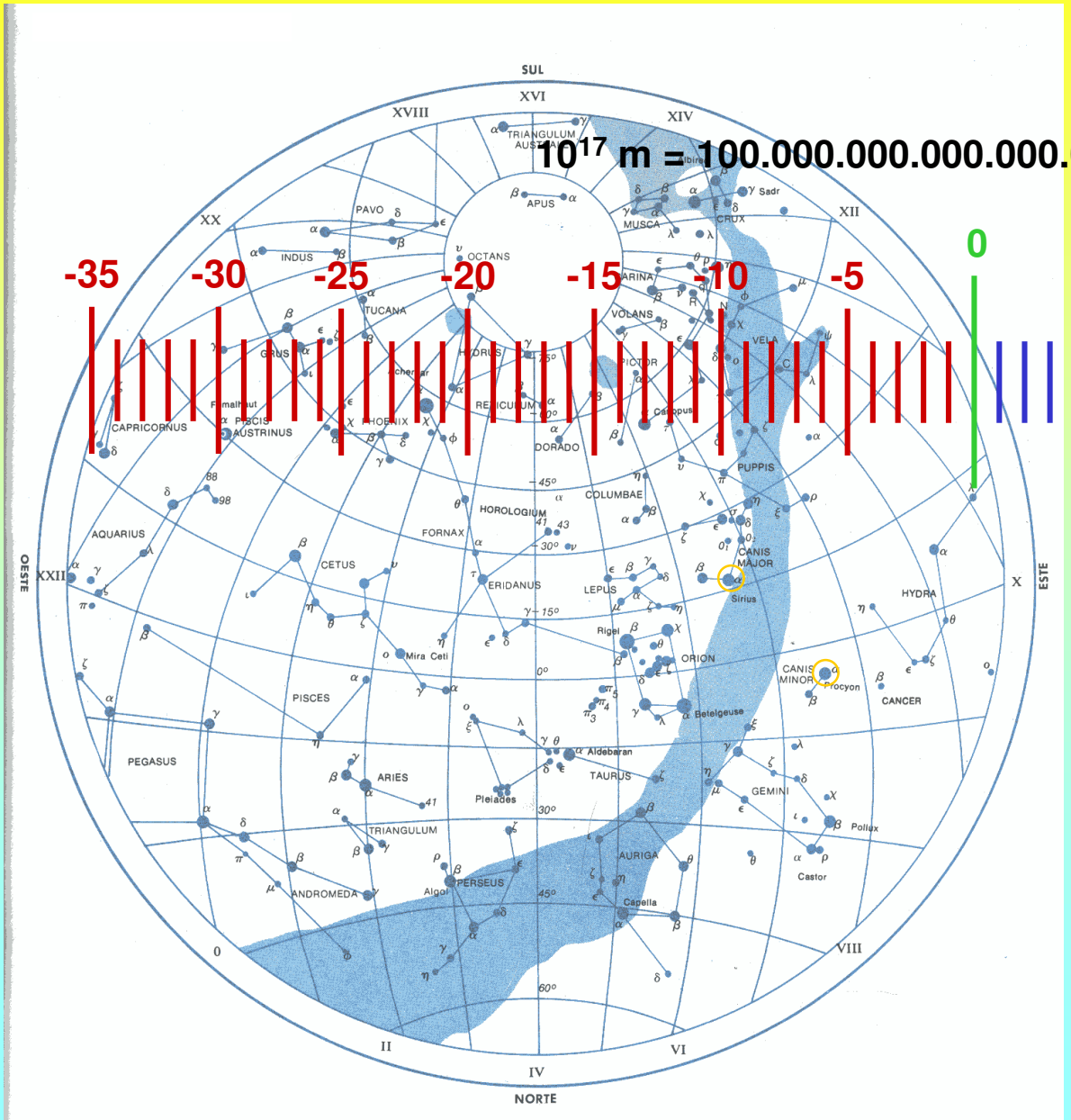


Se p = 1" então d = 1 parsec = 1 pc

1 pc = 3,27 anos-luz

1 pc = 206.265 UA

$f = 10^{17}$



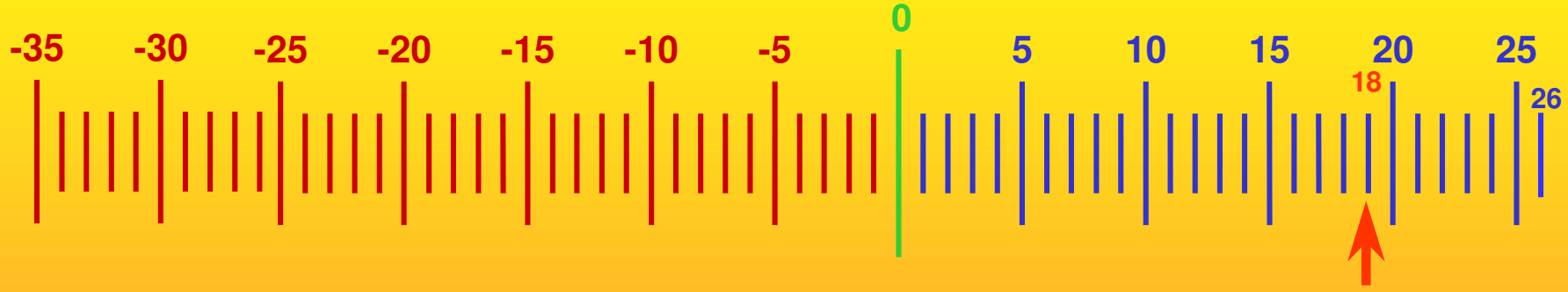
10^{17} m = 100.000.000.000.000.000 m

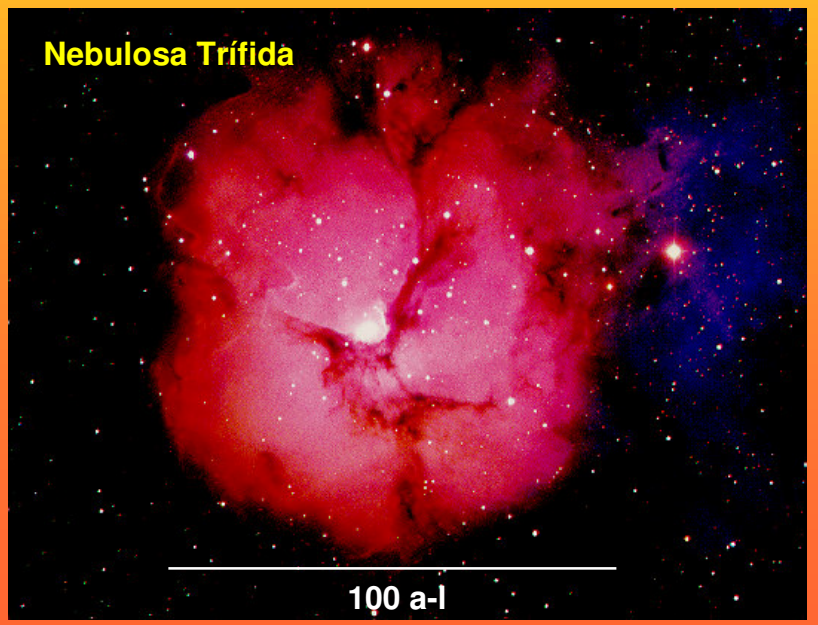
Sirius = 8,8 a-l

Procyon = 11 a-l

Exa f = 10^{18}

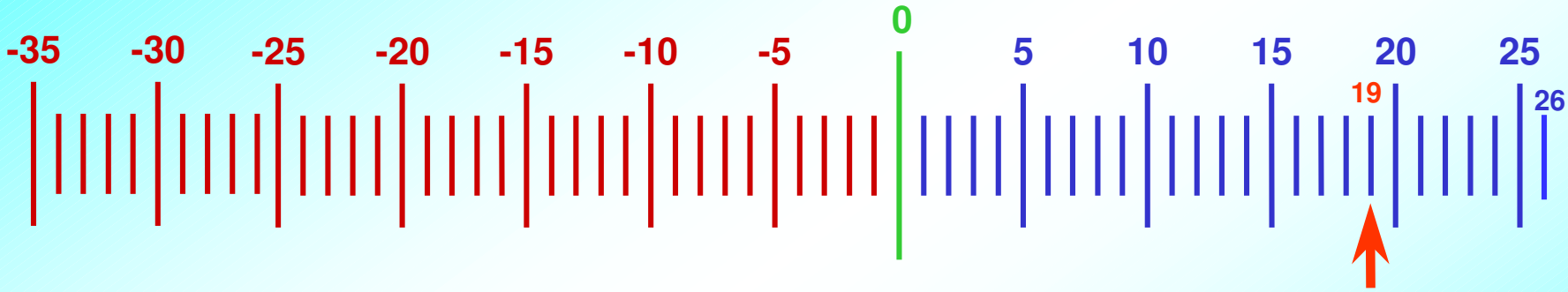
10^{18} m = 1.000.000.000.000.000.000 m





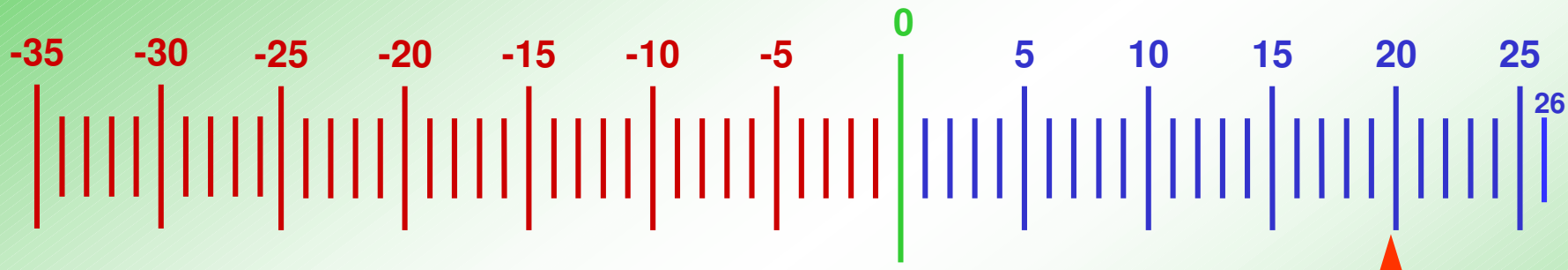
$f = 10^{19}$

10^{19} m = 10.000.000.000.000.000.000 m



$f = 10^{20}$

10^{20} m = 100.000.000.000.000.000.000 m



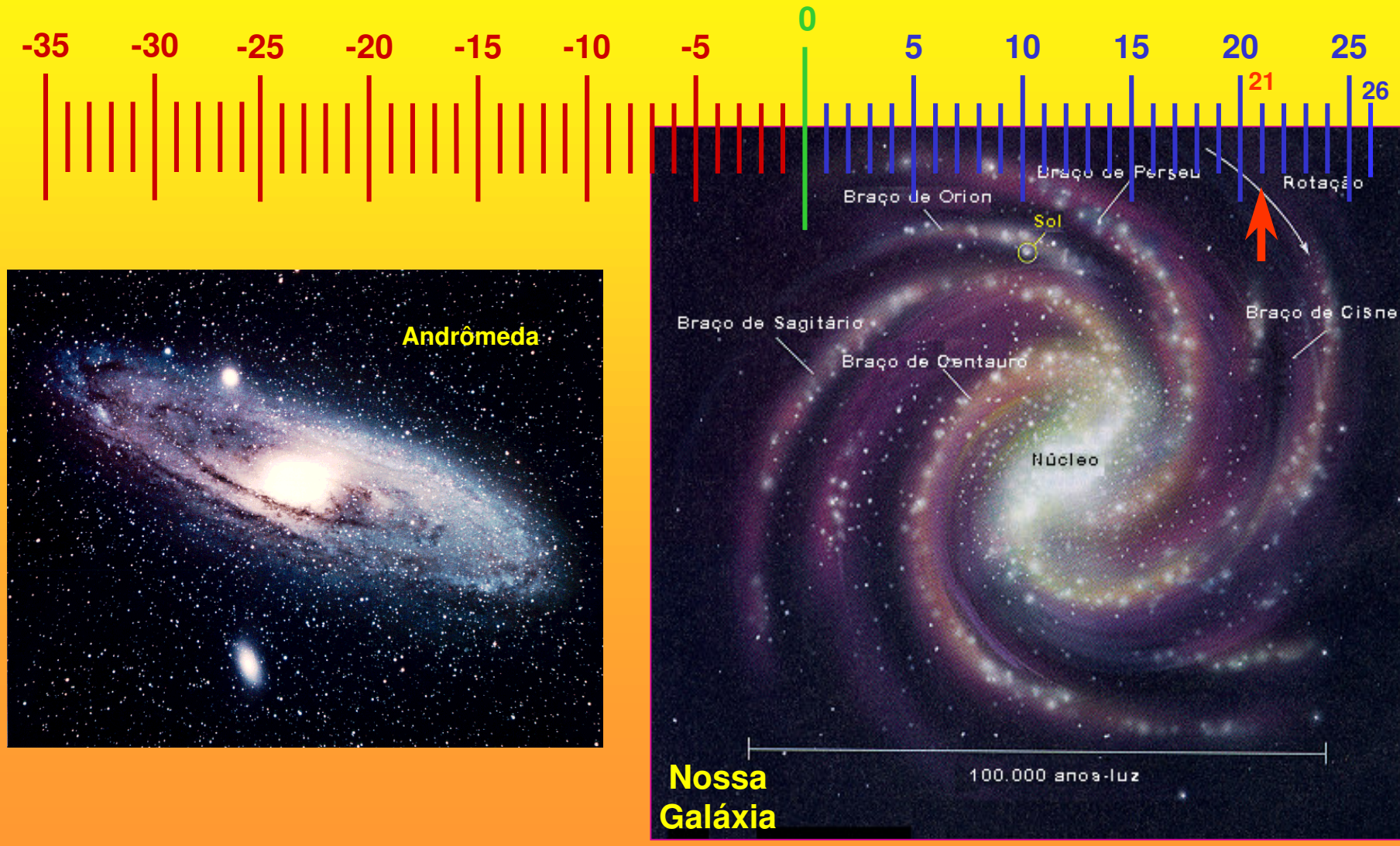
Terra

160.000 a.l.

30.000 a-l

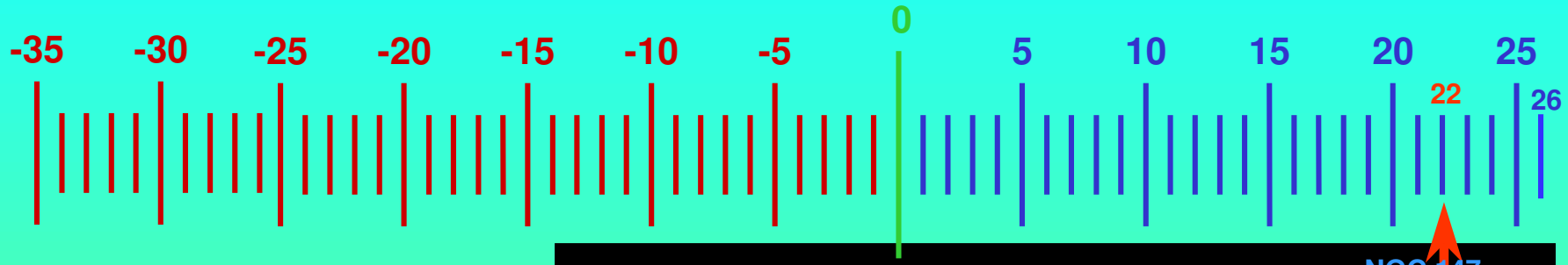
$f = 10^{21}$

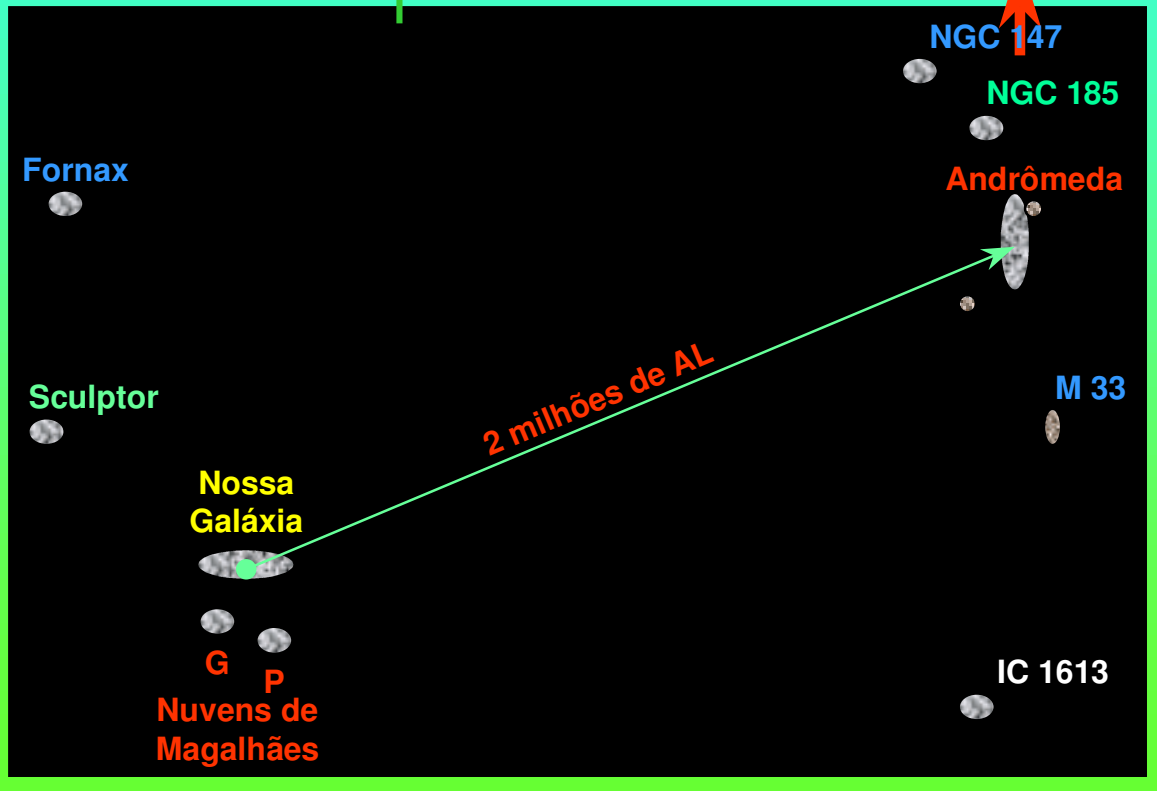
10^{21} m = 1.000.000.000.000.000.000.000 m



$f = 10^{22}$

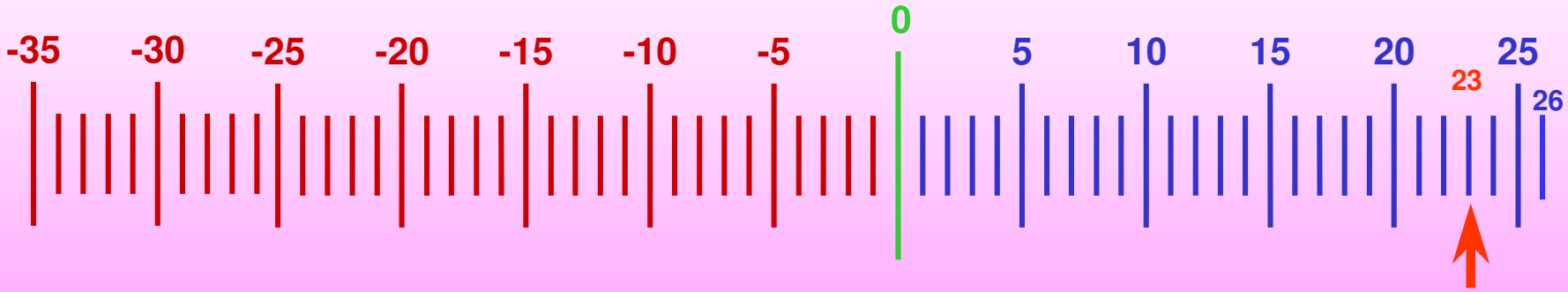
10^{22} m = 10.000.000.000.000.000.000.000 m





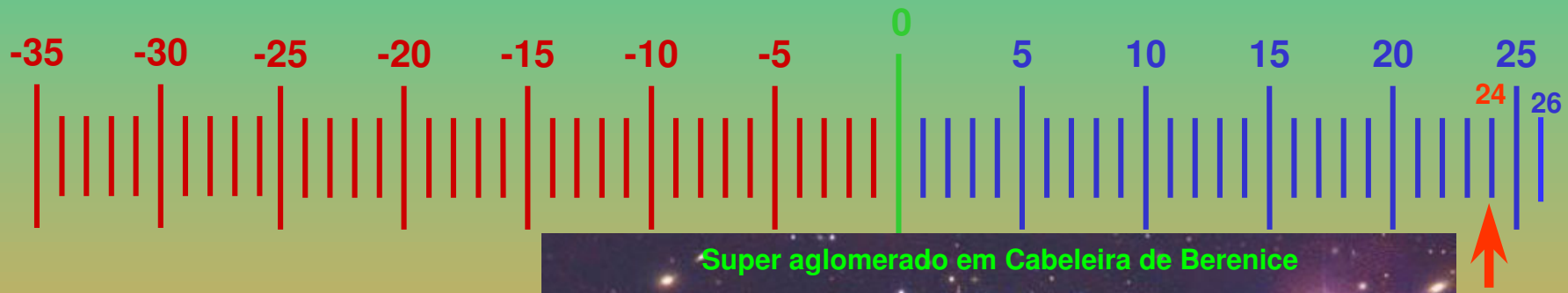
$f = 10^{23}$

10^{23} m = 100.000.000.000.000.000.000.000 m



$f = 10^{24}$

10^{24} m = 1.000.000.000.000.000.000.000.000 m

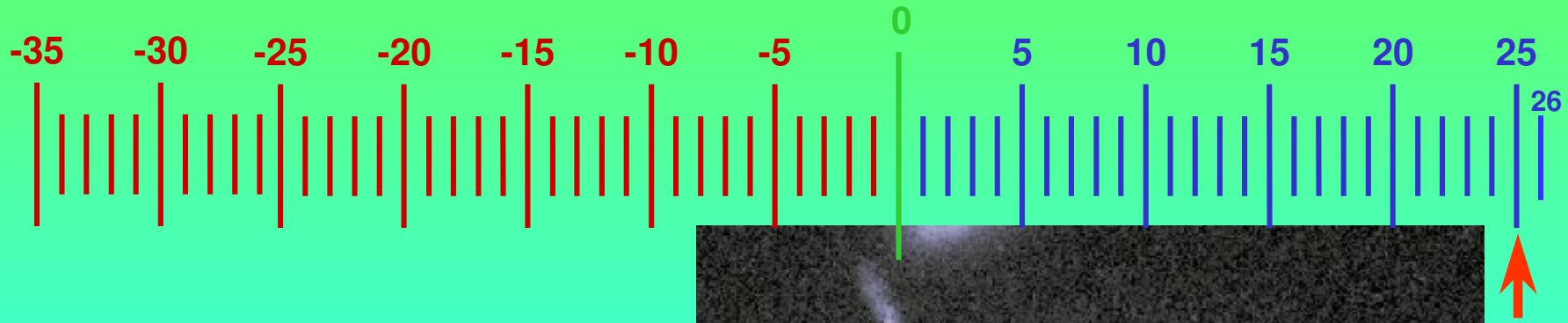


300.000.000 a-l

Sol

$f = 10^{25}$

10^{25} m = 10.000.000.000.000.000.000.000.000 m



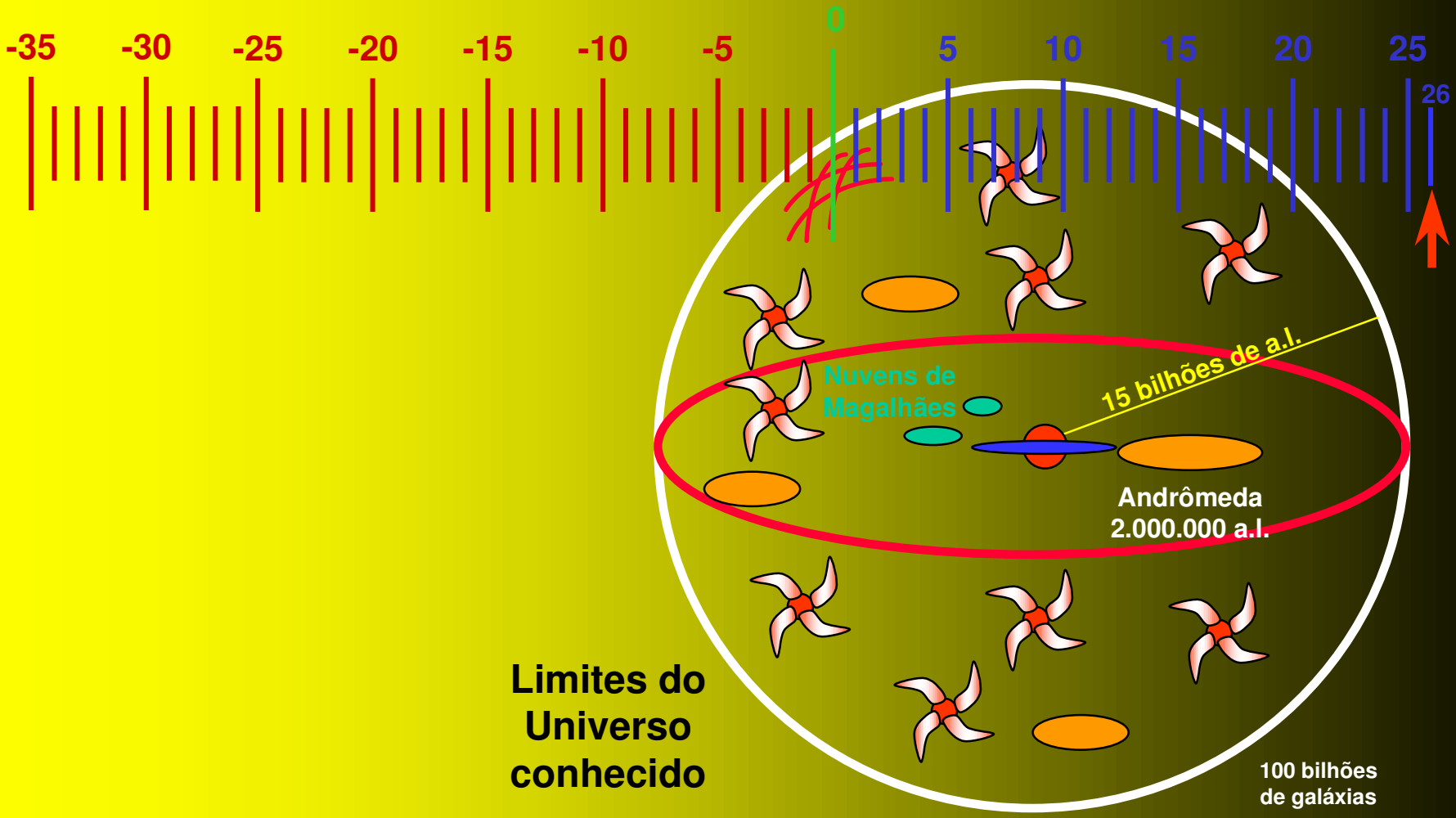
OBJETO QUASE-ESTELAR PKS 2349 (QUASAR)

10.000.000.000 a-l

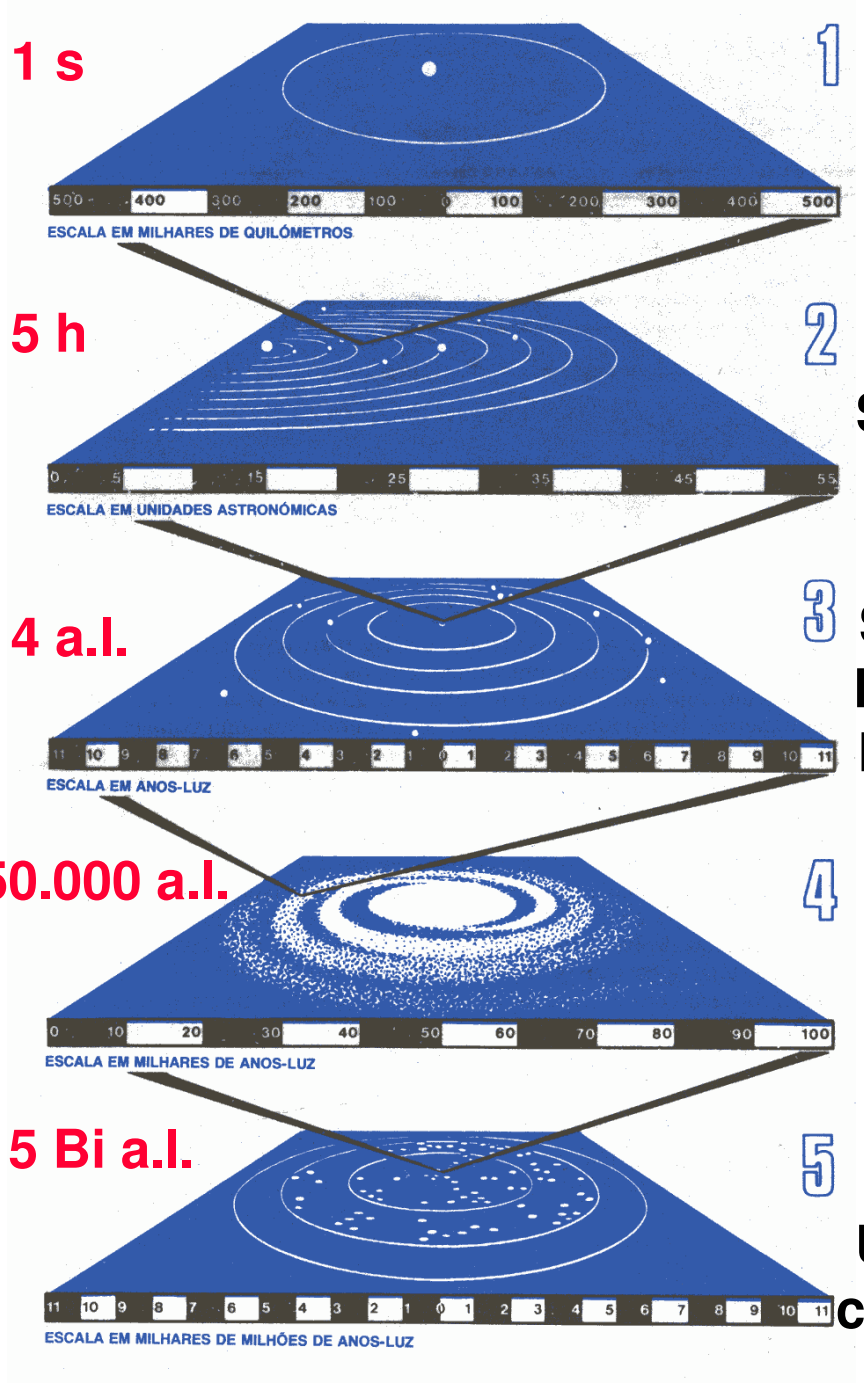
Sol

$f = 10^{26}$

10^{26} m = 100.000.000.000.000.000.000.000.000 m



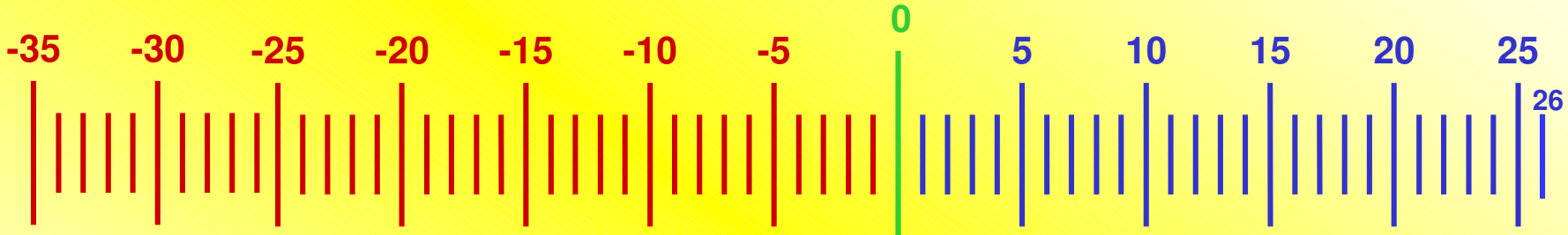
Limites do Universo conhecido

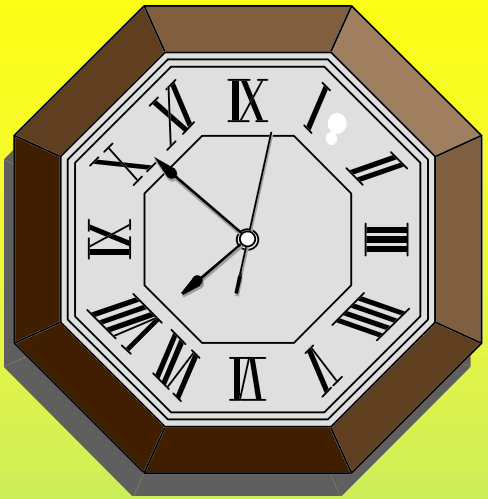


Resumo das estruturas e das escalas no Universo

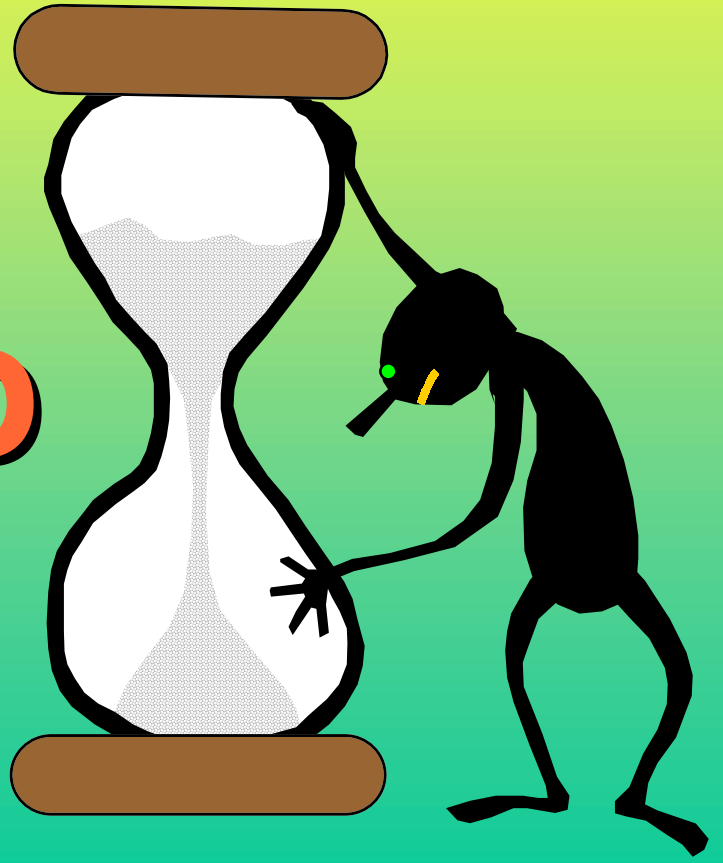
Voltemos à nossa escala!

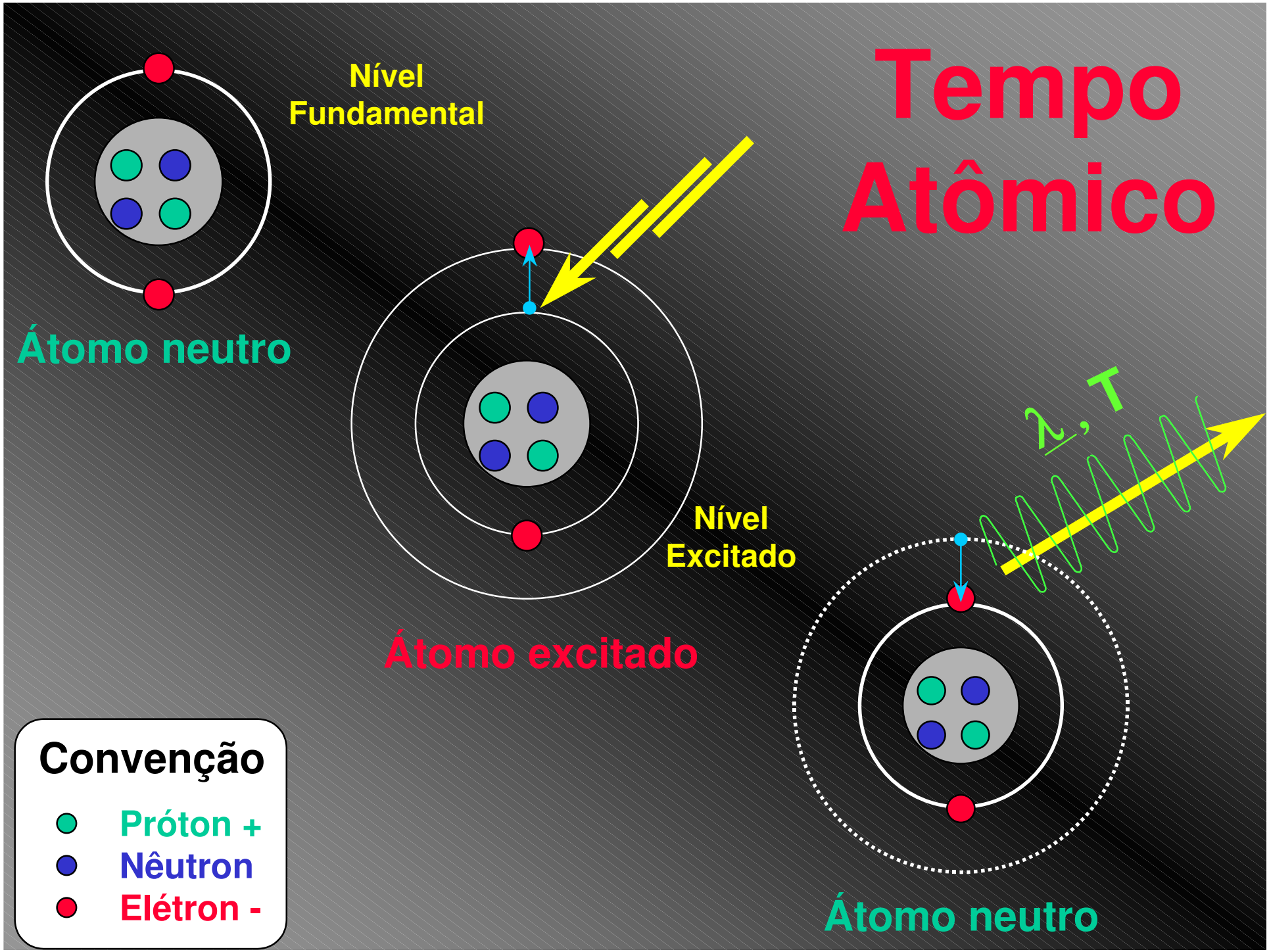
10^0 m = 1 m





Escalas de Tempo

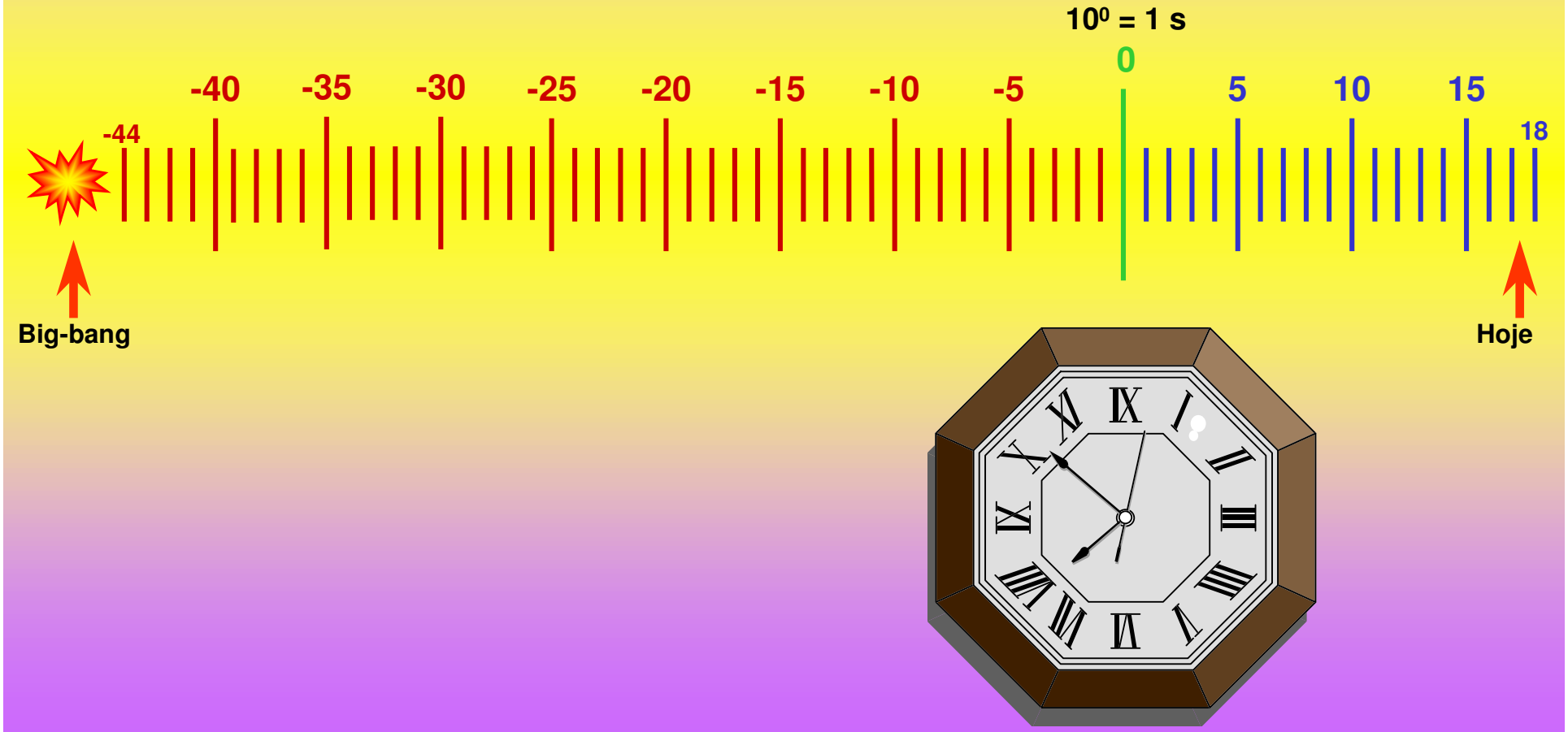



Tempo Atômico
Nível Fundamental
Átomo neutro
Nível Excitado
Átomo excitado
λ, T
Átomo neutro
Convenção
Próton +
Nêutron
Elétron -

Segundo Internacional

É o intervalo de tempo correspondente a
9.192.631.770
períodos da radiação emitida durante a transição entre dois níveis hiperfinos do estado fundamental do átomo de
Césio 133

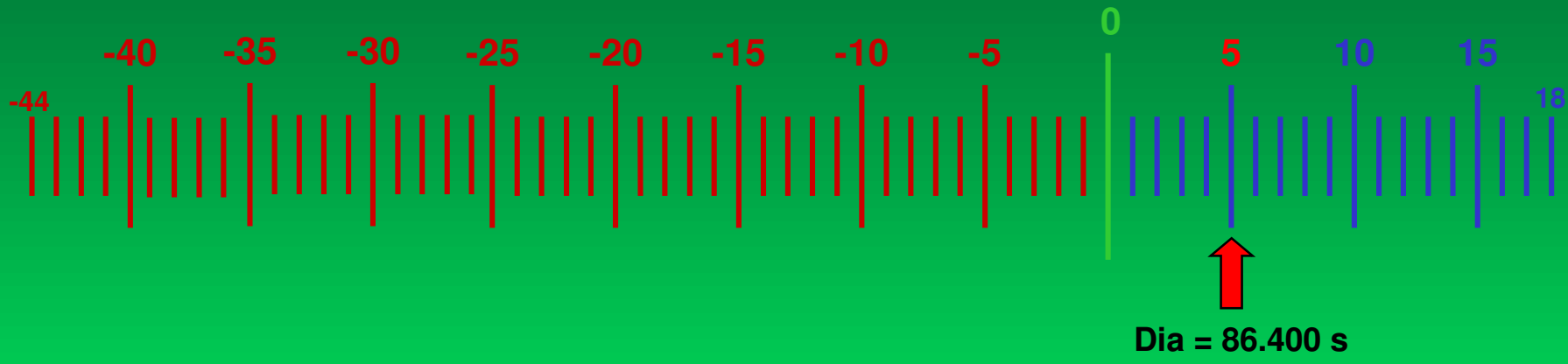
Escalas de Tempo



Unidade primordial de tempo: Dia

Movimento diurno aparente do Sol

Dia



Dia Civil

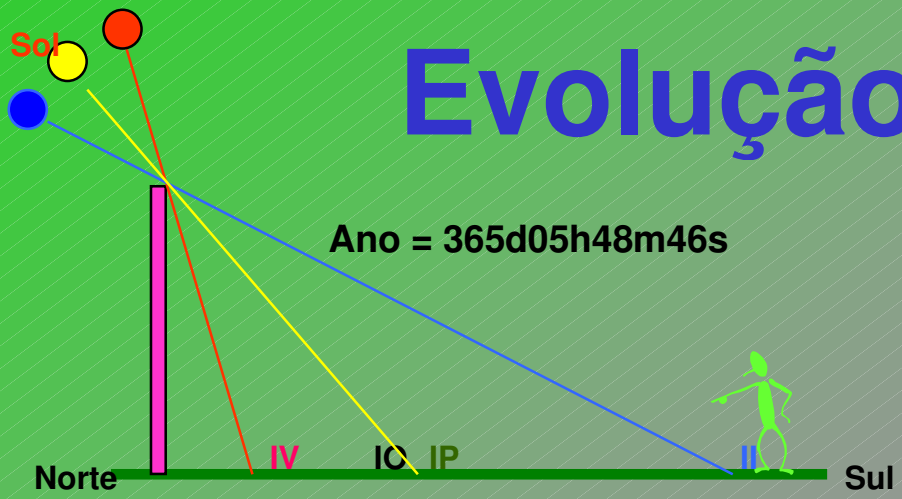
0.1.2 .....12.....24 h

Nascer
Meio Dia
Ocaso
Meia Noite
Nascer
Meio Dia
Ocaso
Meia Noite
Nascer

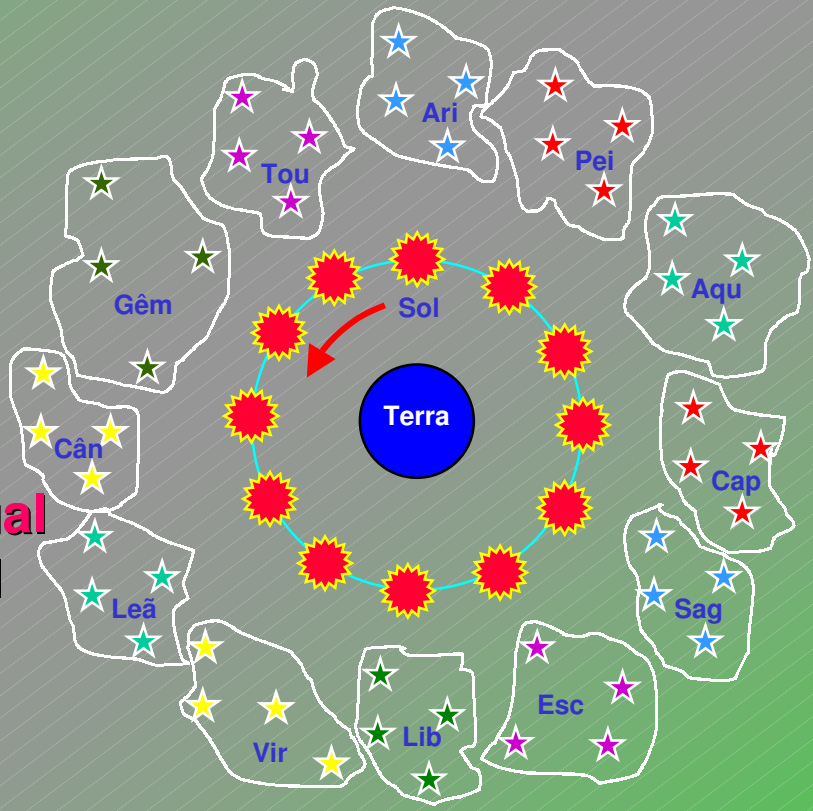
Dia Claro
Noite
Dia Claro
Noite

ANO

Evolução da idéia de Ano

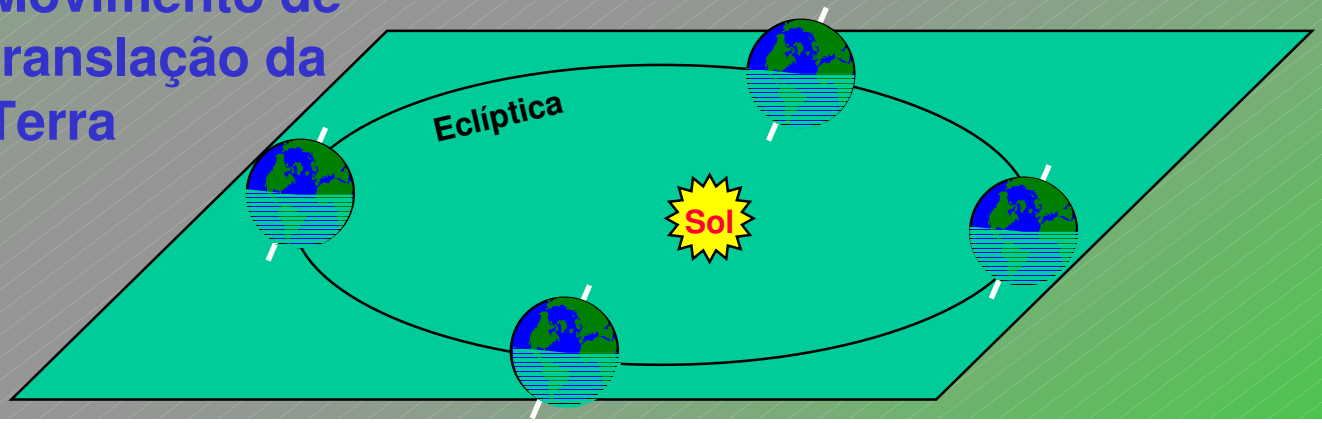


Ano das Estações

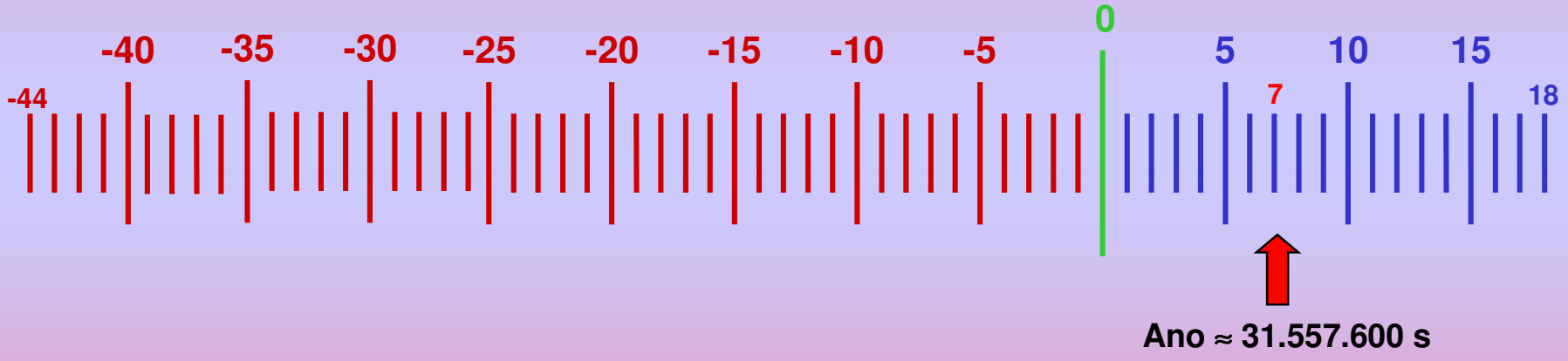


Movimento Anual aparente do Sol

Movimento de translação da Terra

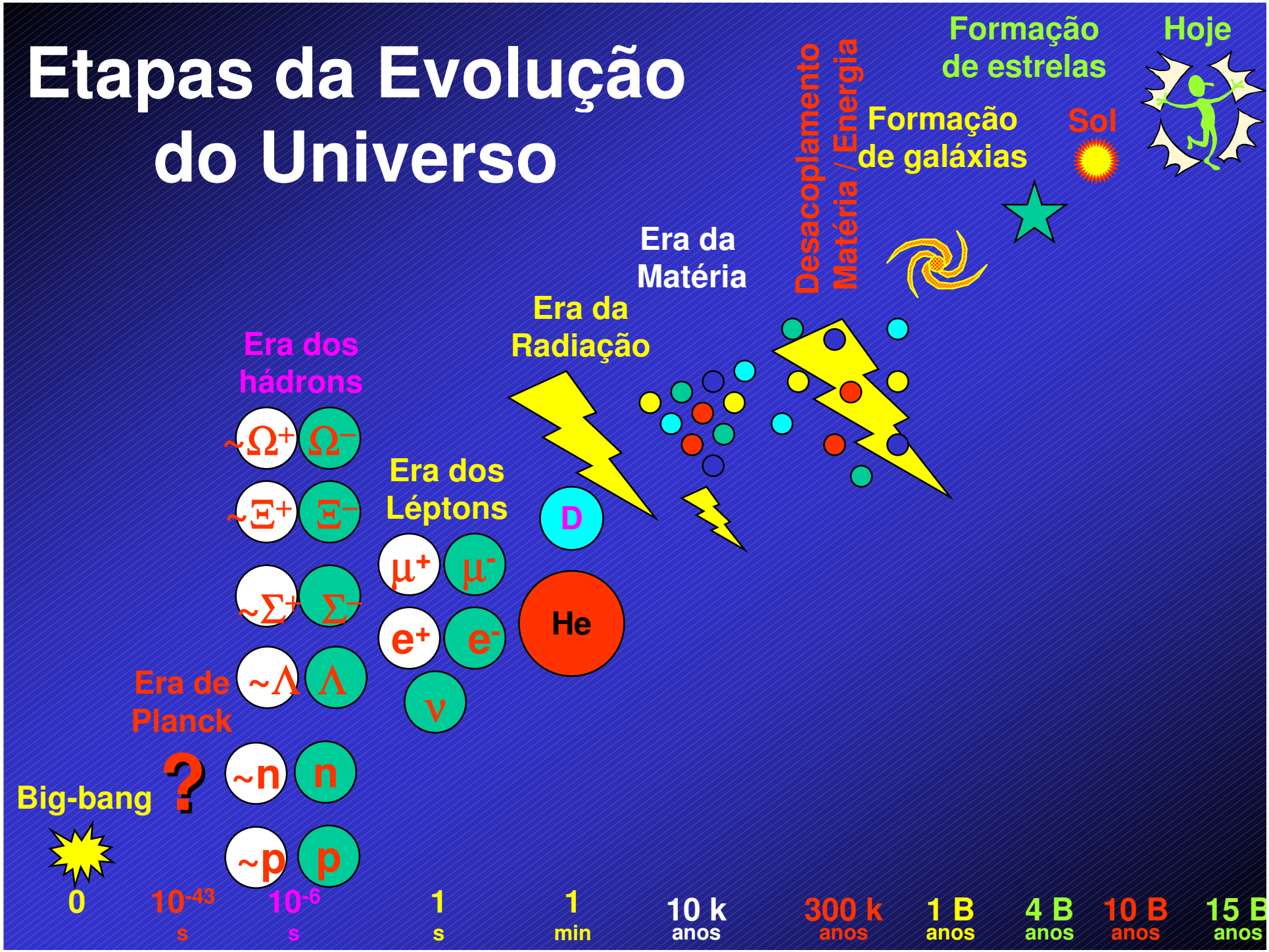


Ano



Evolução do Universo

Etapas da Evolução do Universo



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(Filme e livro)

Fim