

Galáxias

Prof. Jorge Meléndez

Departamento de Astronomia, IAG/USP

AGA 0205 – Elementos de Astronomia
2013-B

Nosso lugar no universo

Milky Way Galaxy



approx. size: 10^4 km

Solar System
(not to scale)



approx. size: 10^{10} km \approx 60 AU

Earth



Universe

Our cosmic address. These diagrams show key levels of structure in our universe; for a more detailed view, see the "You Are Here in Space" foldout diagram in the front of the book.

approx. size: 10^{21} km \approx 100 million ly

Local Supercluster

approx. size: 3×10^{19} km \approx 3 million ly

Local Group

approx. size: 10^{18} km \approx 100,000 ly

Milky Way Galaxy

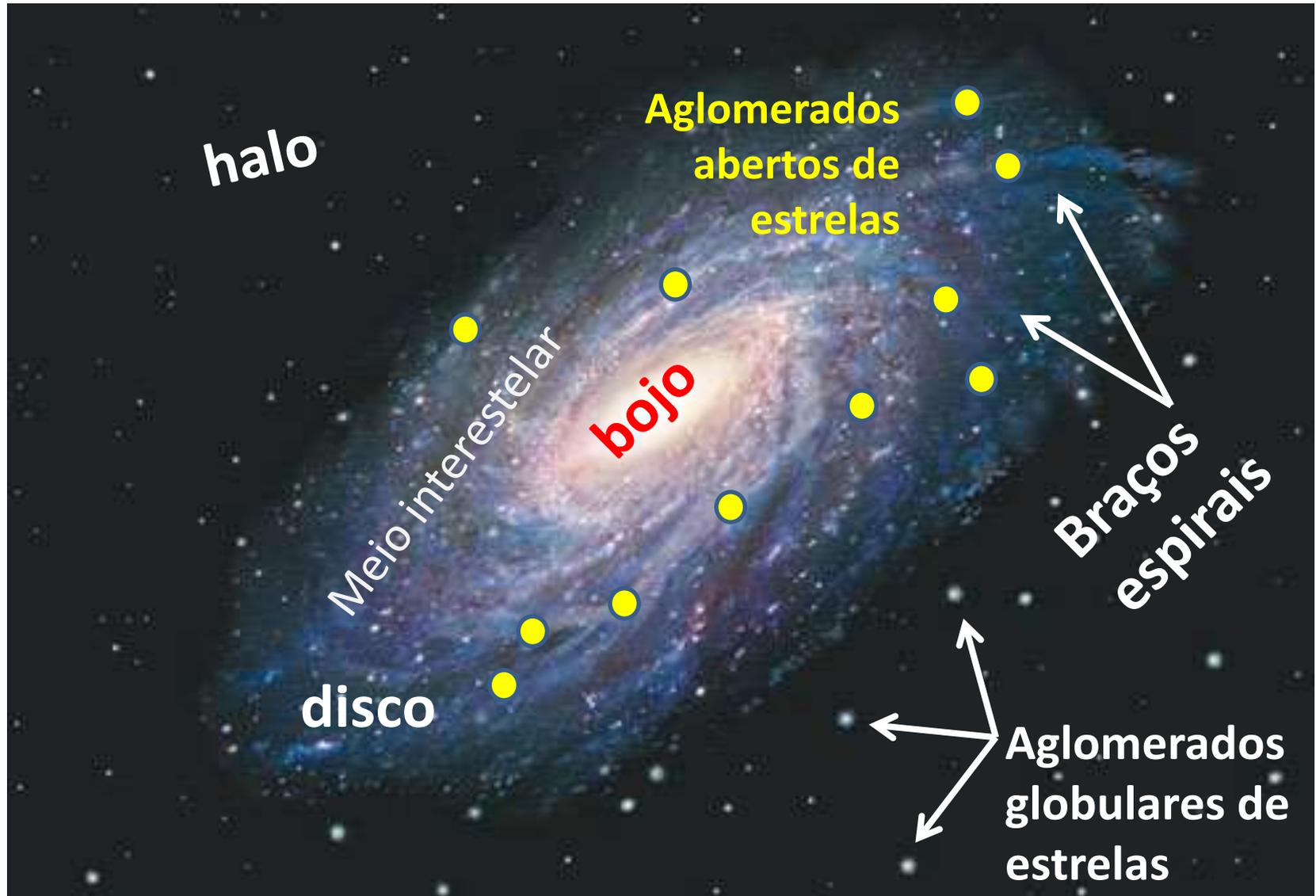
Nosso lugar no universo

Solar System

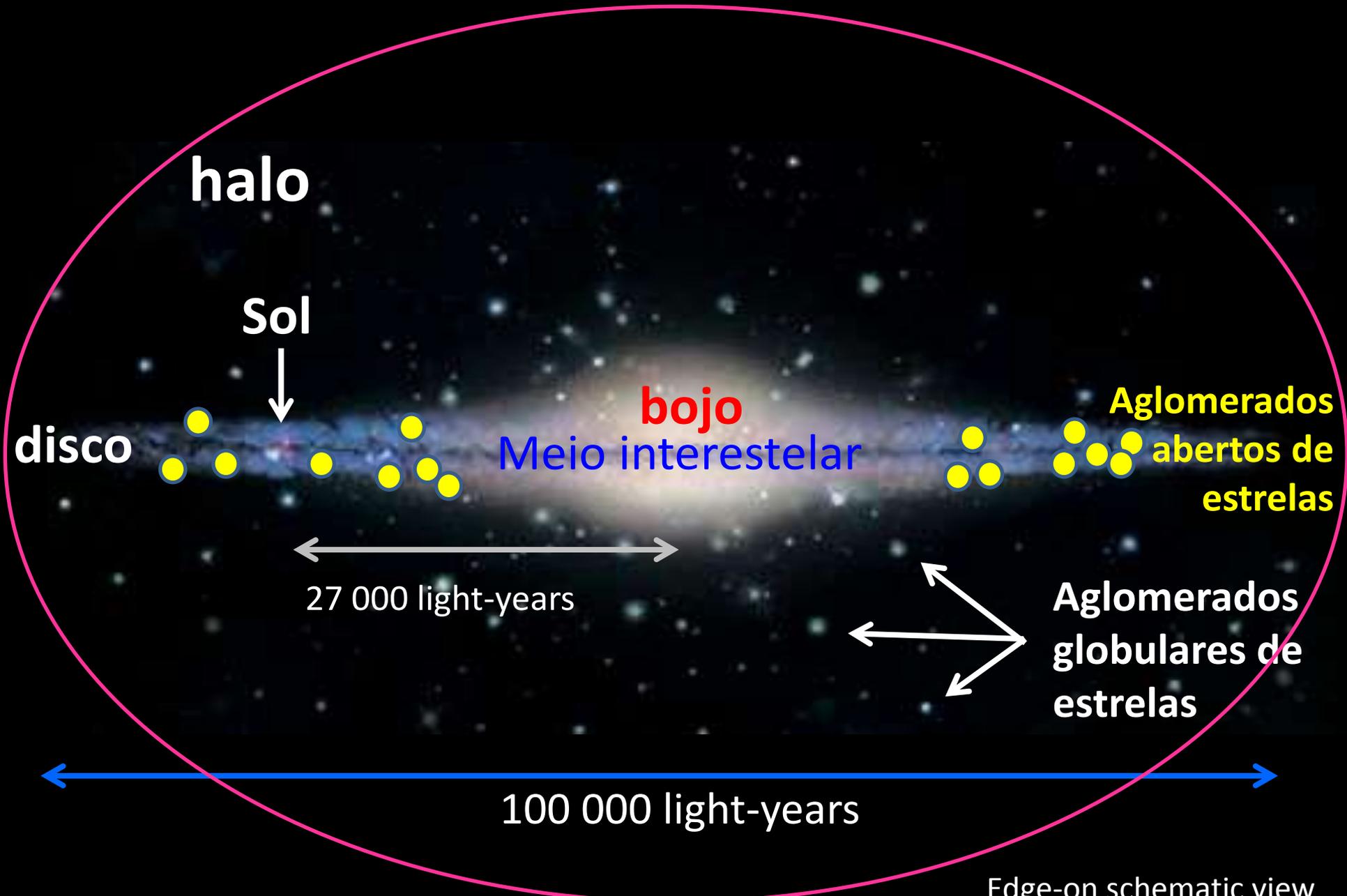
approx. size: 10^{10} km \approx 60 AU



Nossa Galáxia (Via Láctea): estrelas, meio interestelar (gás, poeira) e aglomerados de estrelas



Artist's conception of the Milky Way viewed from the outside. © Cosmic perspective



Nossa Galáxia: a Via Láctea

Edge-on schematic view of the Milky Way
© Cosmic perspective

Aglomerados de estrelas

aglomerados

abertos

(jovens e ricos em metais)



M36

~ 100 – 1000 estrelas

aglomerados

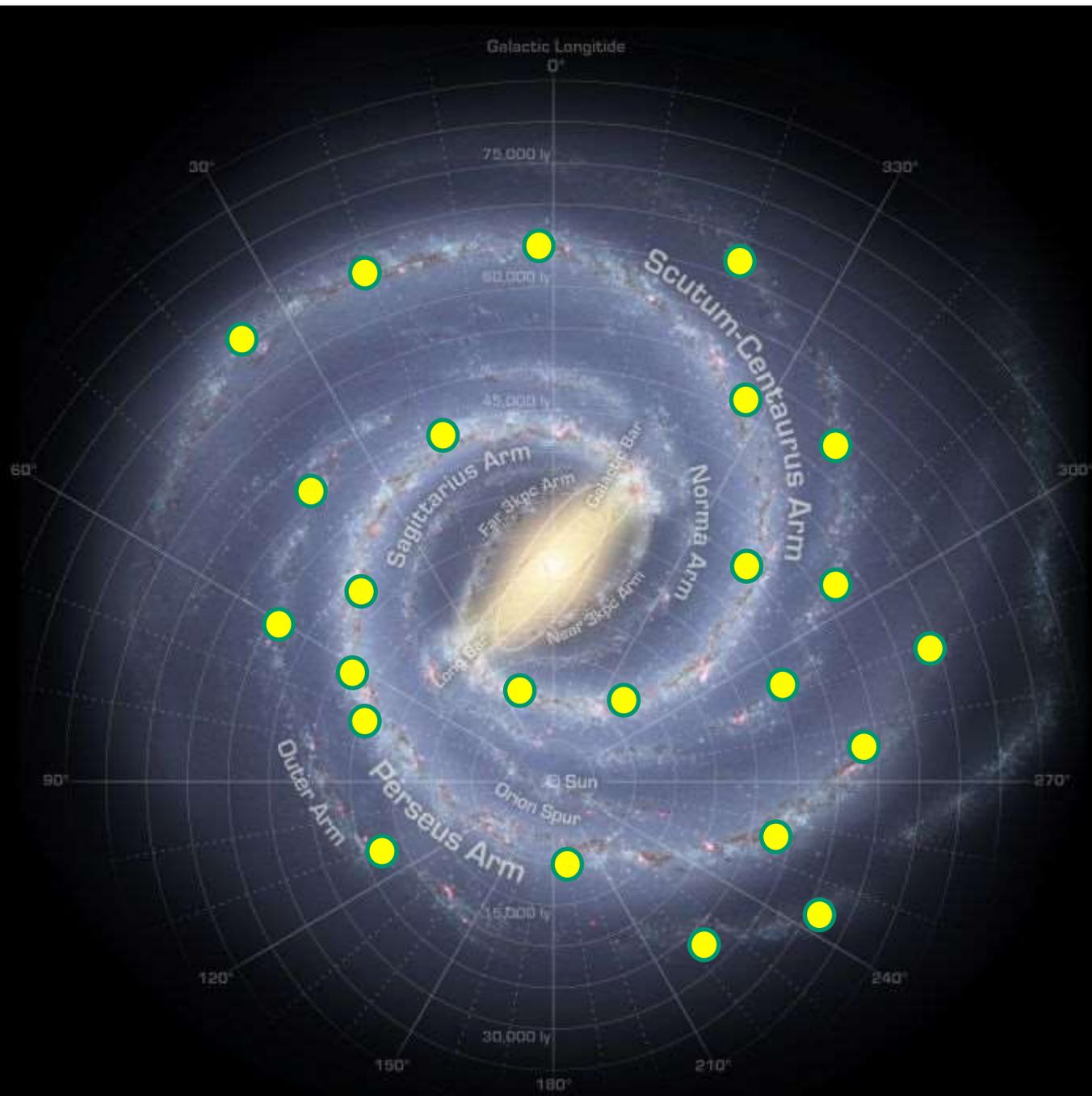
globulares

(velhos e pobres em metais)



M80

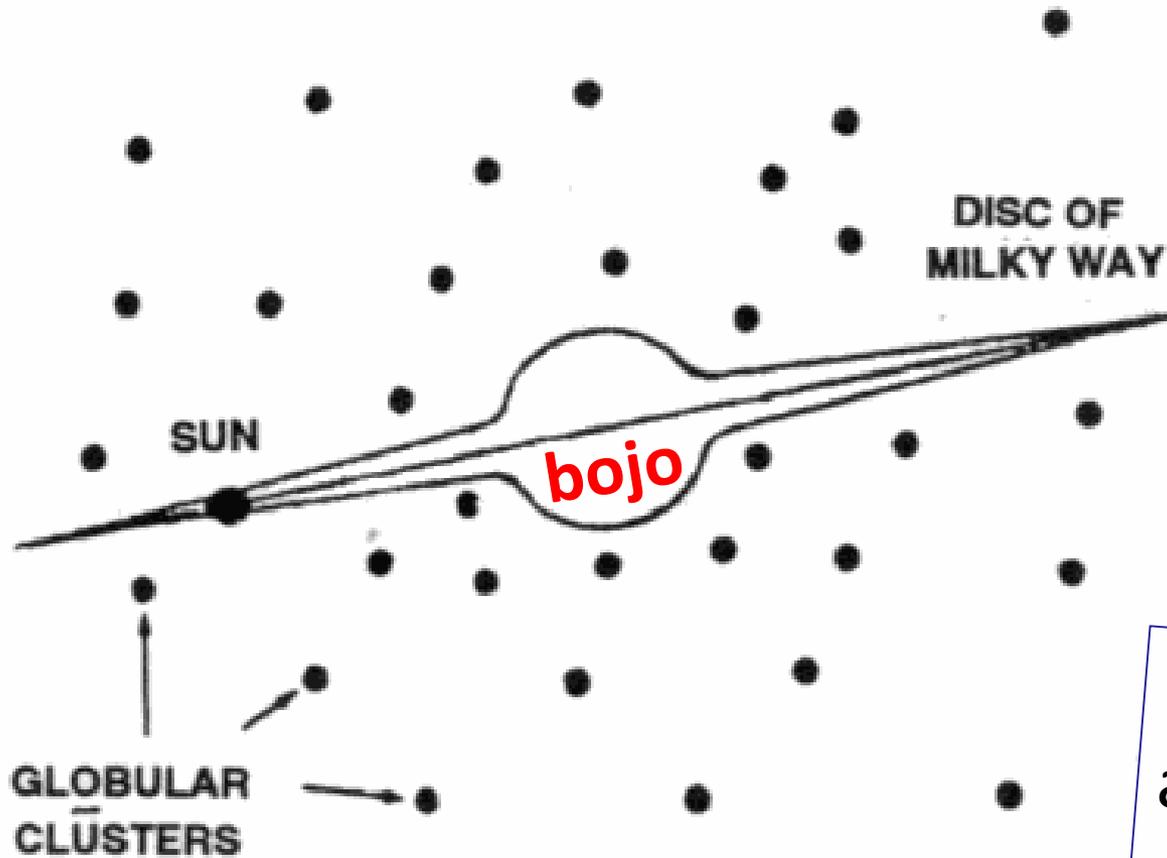
~ 100 mil a 1 milhão de estrelas



**Aglomerados
abertos:
distribuidos
no disco da
nossa
Galáxia**

Mais de 1100
aglomerados
abertos são
conhecidos

Aglomerados globulares: distribuídos no halo da nossa Galáxia



Mais de 150 aglomerados globulares são conhecidos na Via Láctea

Aglomerado aberto:

Plêiades (M45)

(7 Irmãs – Collca - Subaru)

3000 estrelas

$d = 400$ a.l.

$\phi = 13$ a.l.



Aglomerado Aberto (Jovem)

(NGC 3293)



Aglomerado globular M3



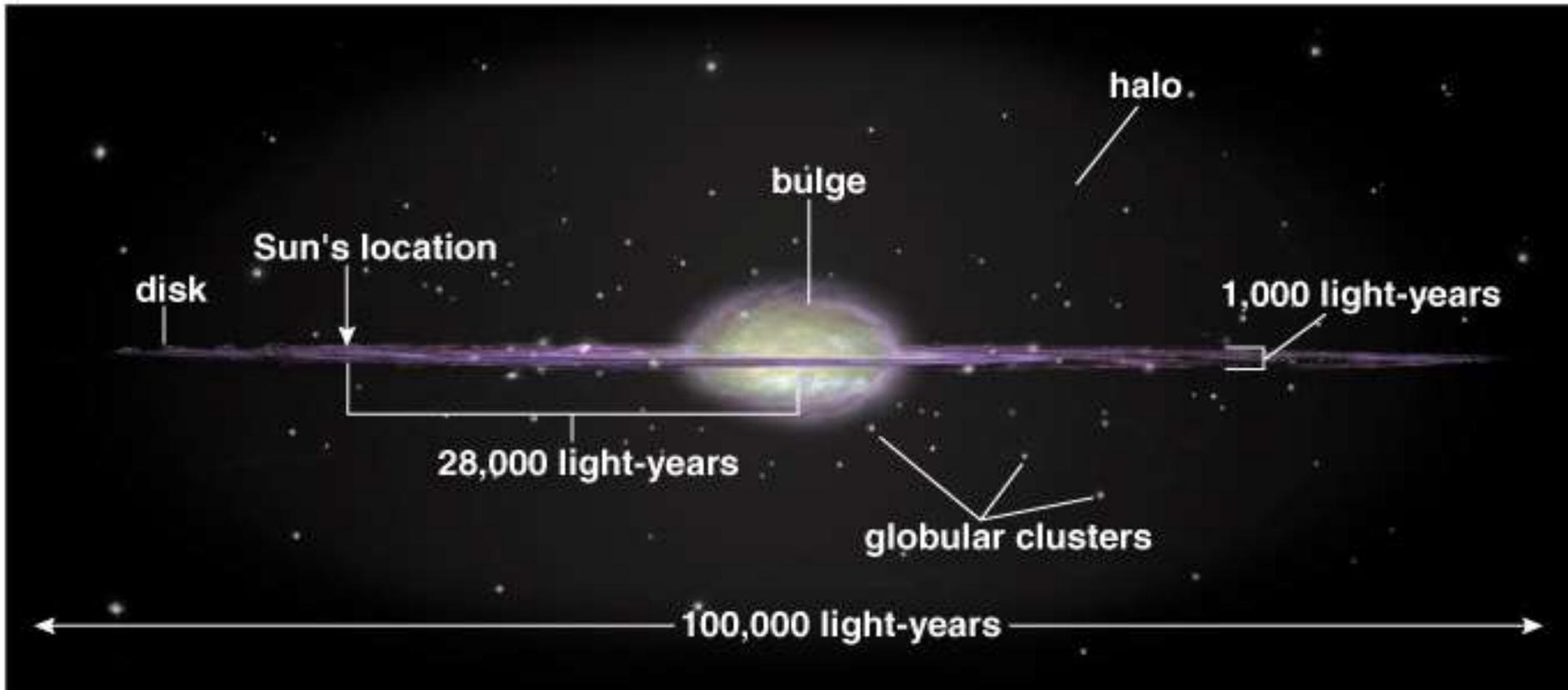
Aglomerado Globular Ômega Centauro



Populações estelares

População I: disco (estrelas jovens e de meia idade)

População II: halo e bojo (estrelas velhas)

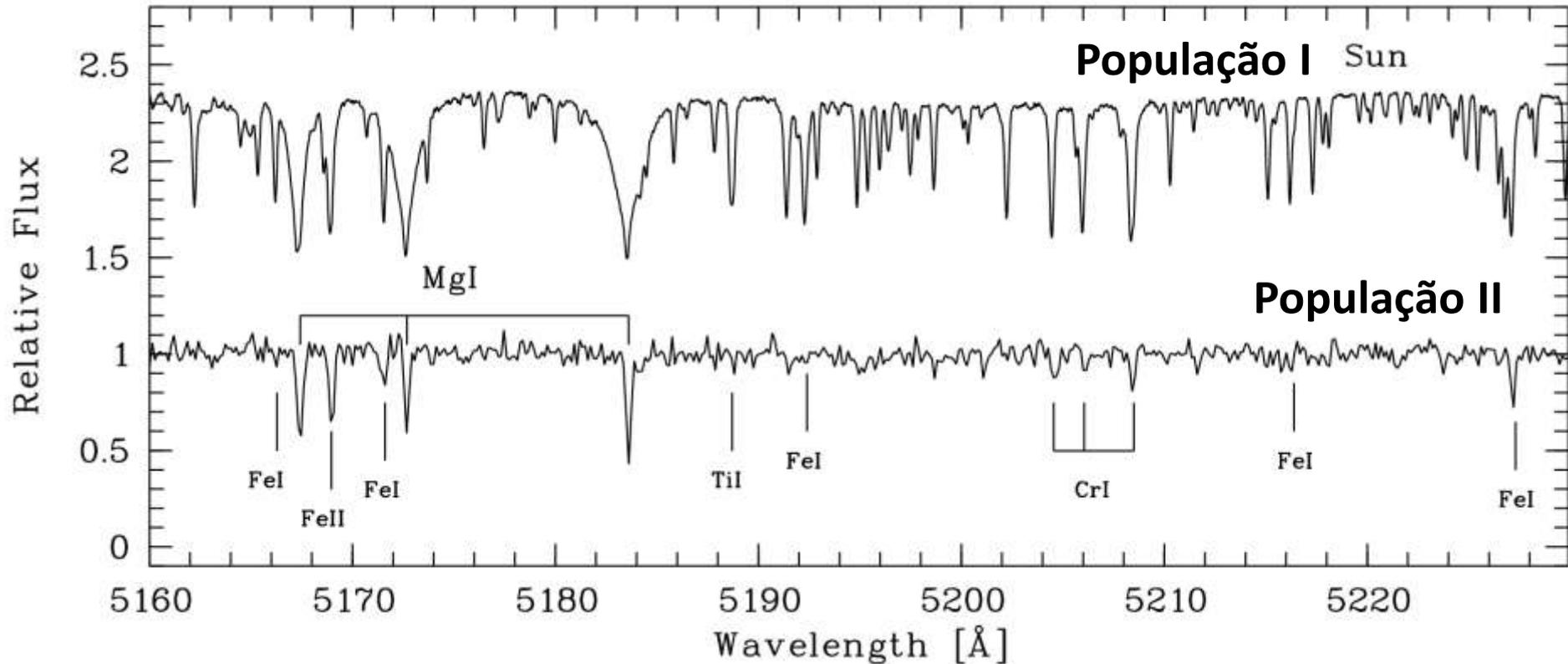


(b)

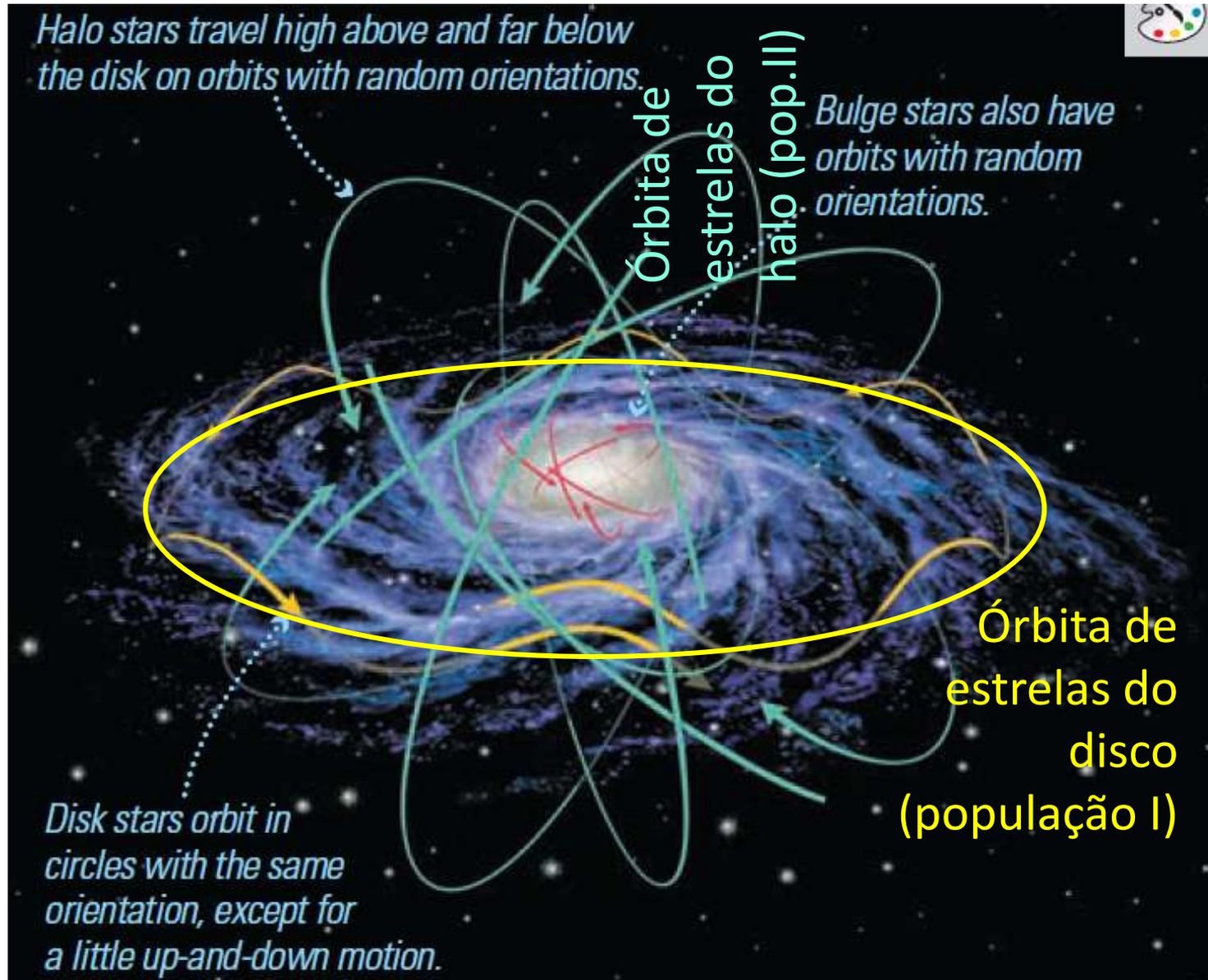
Populações estelares

População I: disco. Rica em metais

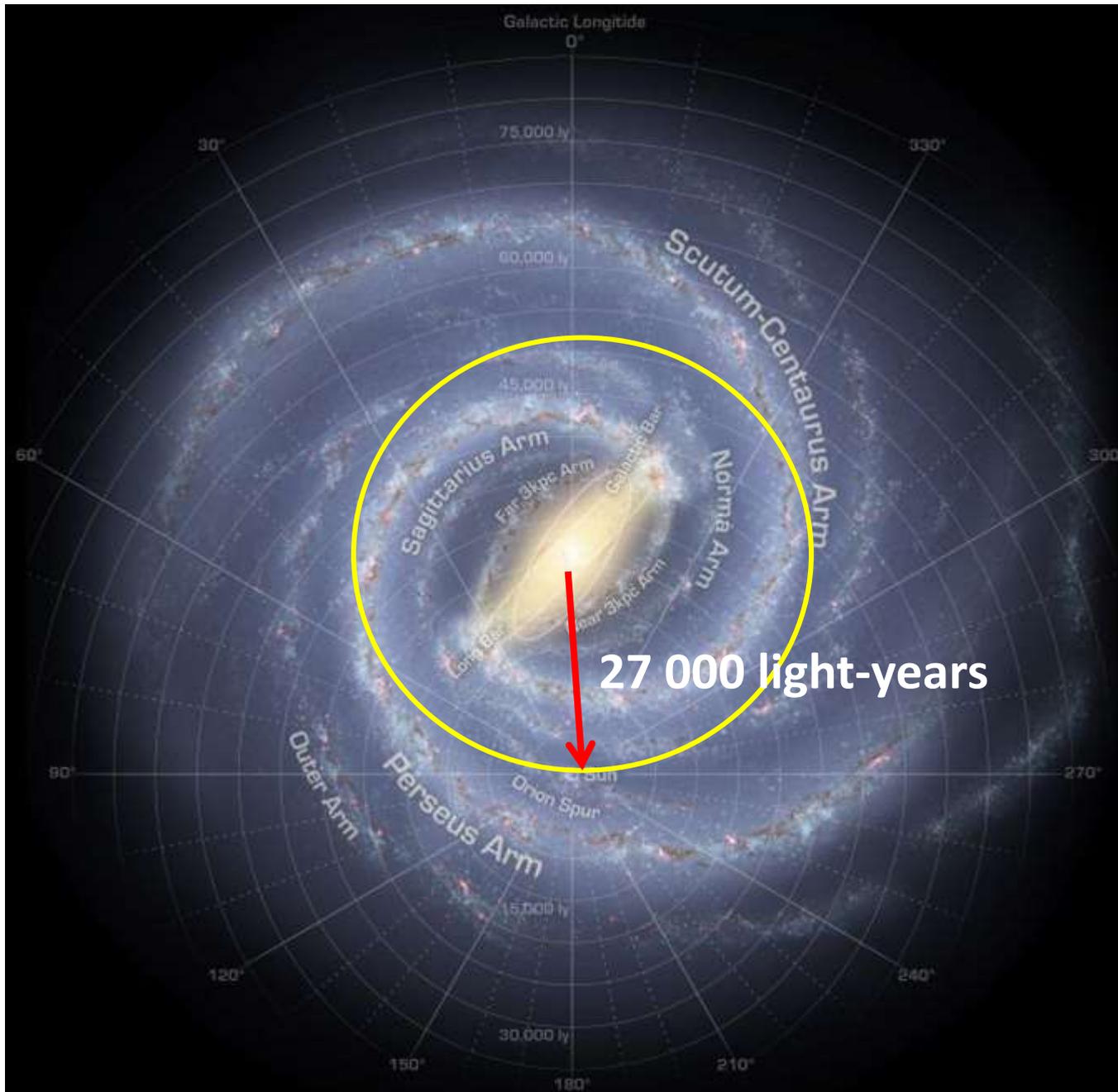
População II: halo e bojo. Pobre em metais



Órbita das estrelas em nossa Galáxia



Órbita do Sol na Galáxia



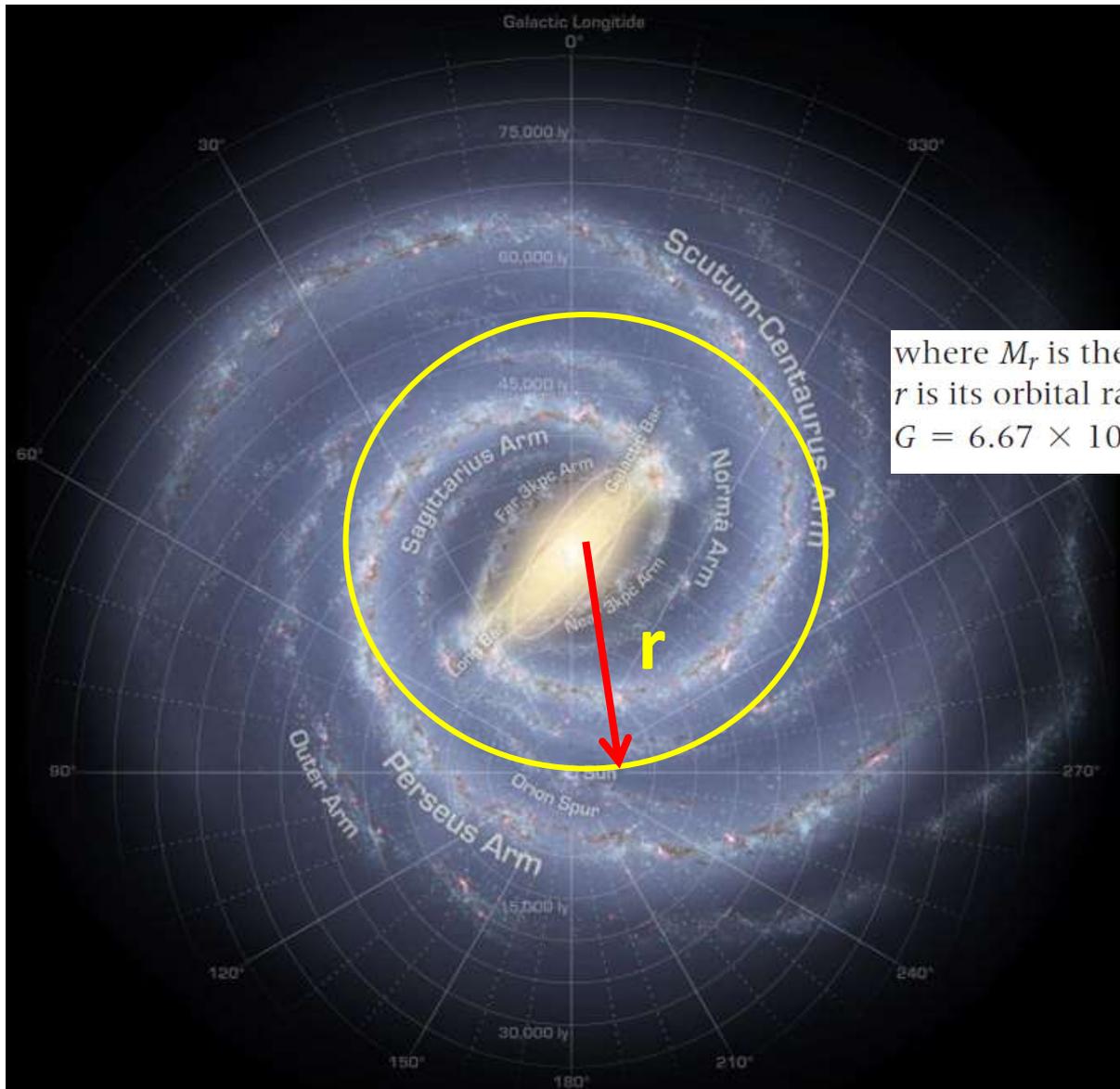
O Sol orbita a Galáxia a uma velocidade de 220 km/s.

Uma revolução completa do Sol leva 230 milhões de anos

Para uma massa interna (M_r) a uma distância r , teremos uma velocidade orbital v :

$$M_r = \frac{r \times v^2}{G}$$

where M_r is the amount of mass contained within its orbit, r is its orbital radius, v is the object's orbital velocity, and $G = 6.67 \times 10^{-11} \frac{\text{m}^3}{\text{kg} \times \text{s}^2}$ is the gravitational constant. Notice



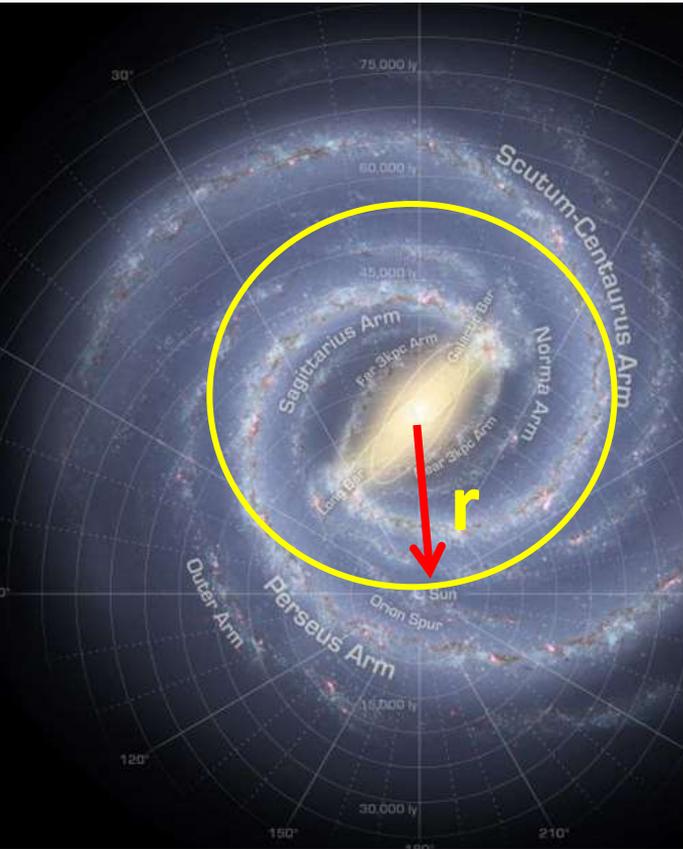
Qual a massa interna (M_r) à orbita do Sol?

Example: Calculate the mass of the Milky Way Galaxy within the Sun's orbit using the orbital velocity law.

Solution: The Sun orbits the center of the Milky Way Galaxy with velocity $v = 220 \text{ km/s} = 2.2 \times 10^5 \text{ m/s}$. The Sun's orbital radius (distance) is 27,000 light-years, which is equivalent to $(27,000 \text{ ly}) \times (9.46 \times 10^{15} \text{ m/ly}) = 2.6 \times 10^{20} \text{ m}$. Substituting these values for v and r into the orbital velocity law, we obtain

$$\begin{aligned} M_r &= \frac{r \times v^2}{G} \\ &= \frac{(2.6 \times 10^{20} \text{ m}) \times (2.2 \times 10^5 \frac{\text{m}}{\text{s}})^2}{6.67 \times 10^{-11} \frac{\text{m}^3}{\text{kg} \times \text{s}^2}} \\ &= 1.9 \times 10^{41} \text{ kg} \end{aligned}$$

The mass of the Milky Way Galaxy within the Sun's orbit is about $2 \times 10^{41} \text{ kg}$. Dividing this mass by the Sun's mass of $2 \times 10^{30} \text{ kg}$, we find that the mass of the galaxy within the Sun's orbit is about 10^{11} (100 billion) solar masses.



Formação de nossa Galáxia

1. Nuvem proto-galáctica de H e He



A protogalactic cloud contains only hydrogen and helium gas.

2. Estrelas e aglomerados do halo começam a se formar no colapso da Nuvem protogaláctica de H e He



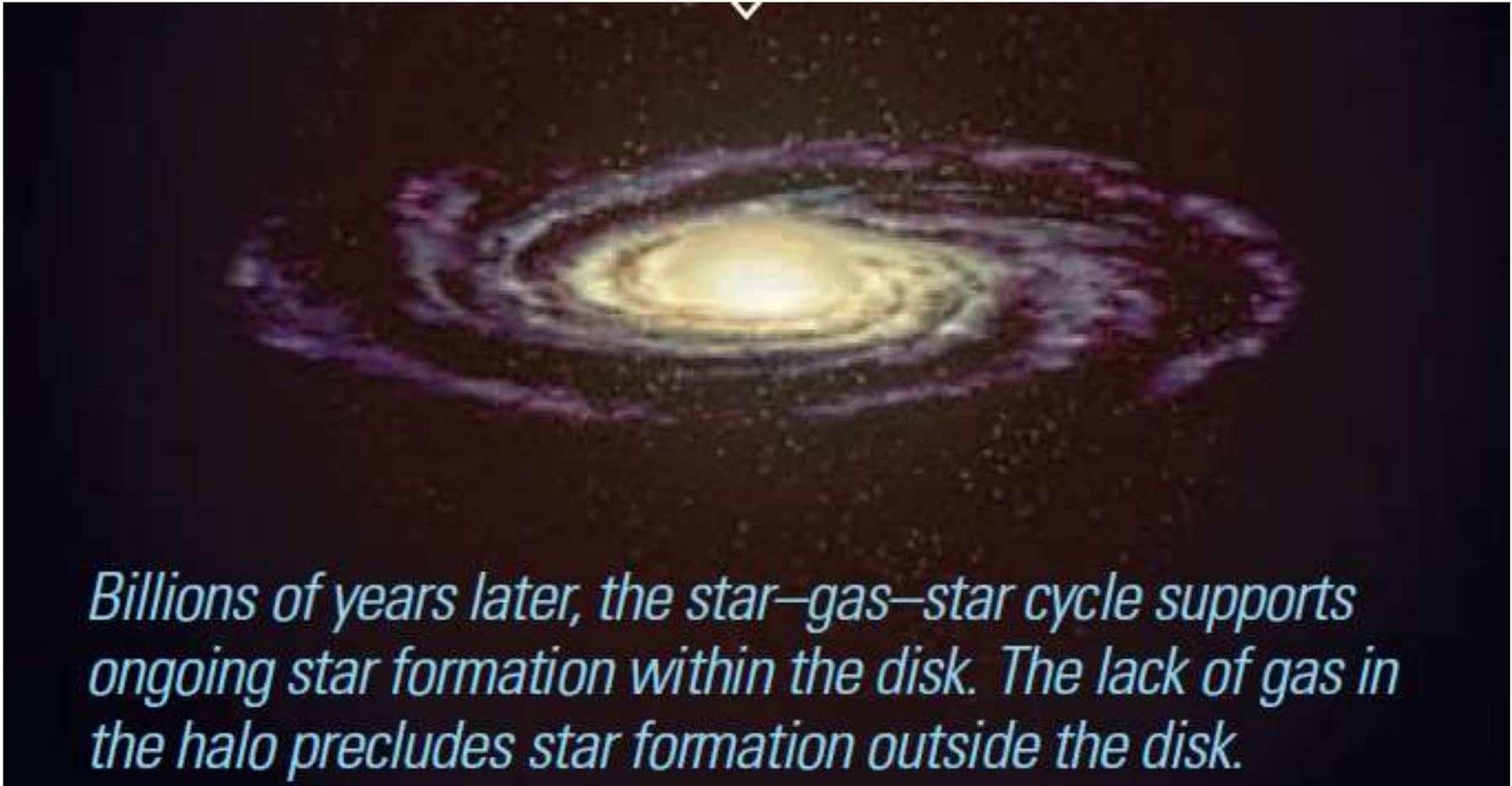
Halo stars begin to form as the protogalactic cloud collapses.

3. Devido à conservação de momento angular o gás residual se achata formando um disco em rotação



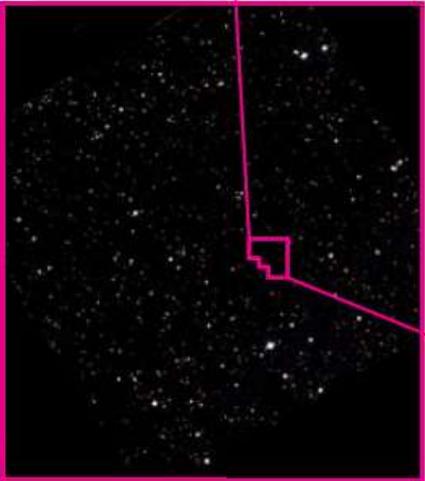
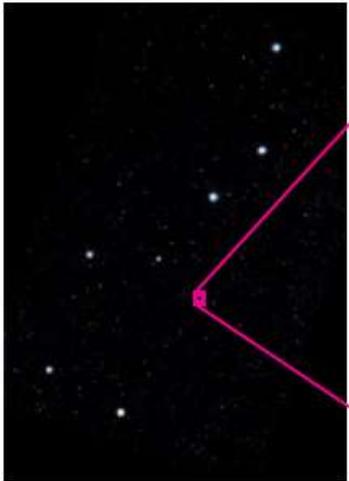
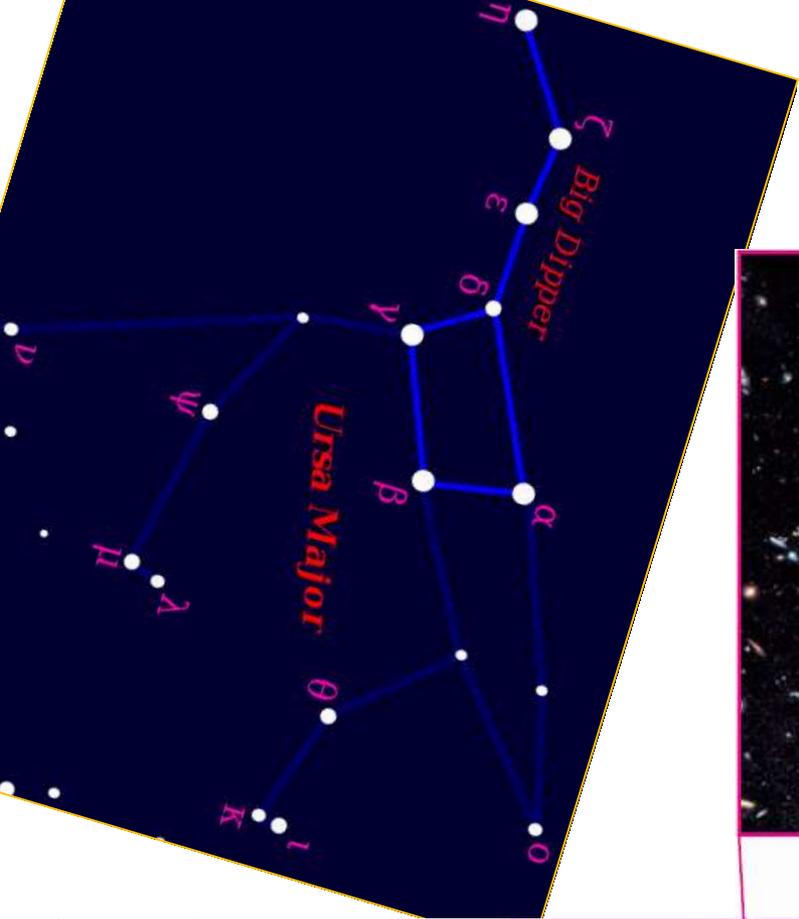
Conservation of angular momentum ensures that the remaining gas flattens into a spinning disk.

4. Bilhões de anos depois o ciclo de gás-estrelas soporta a continua formação de estrelas no disco. A falta de gás no halo impede formação de novas estrelas nessa região



Billions of years later, the star–gas–star cycle supports ongoing star formation within the disk. The lack of gas in the halo precludes star formation outside the disk.

O Universo está cheio de galáxias



x50

x30

The Hubble Deep Field

What are the three major types of galaxies?



Espiral

The giant spiral galaxy M101. It is about 170 000 light-years in diameter.

The Large Magellanic Cloud, an irregular galaxy that is a small companion to the Milky Way. It is about 30 000 light-years across.



Irregular



Elíptica

M87, a giant elliptical galaxy in the Virgo Cluster, is one of the most massive galaxies in the universe. The region shown is more than 300,000 light-years across.

Há também galáxias espirais com barra



NGC 1300, a barred spiral galaxy about 110 000 light-years in diameter.

Classificação de galáxias



Edwin Hubble's Classification Scheme

Ellipticals



Sa



Sb



Sc



Spirals

SBa



SBb

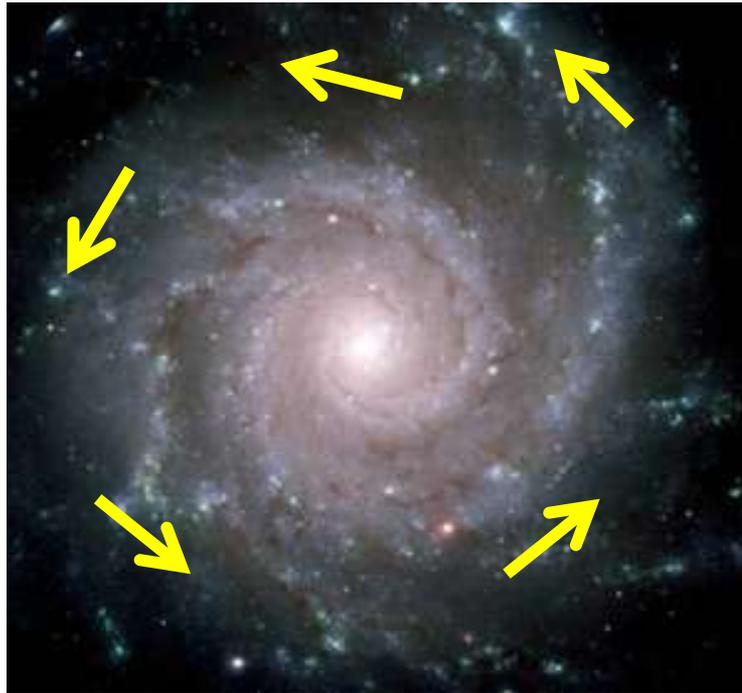


SBc

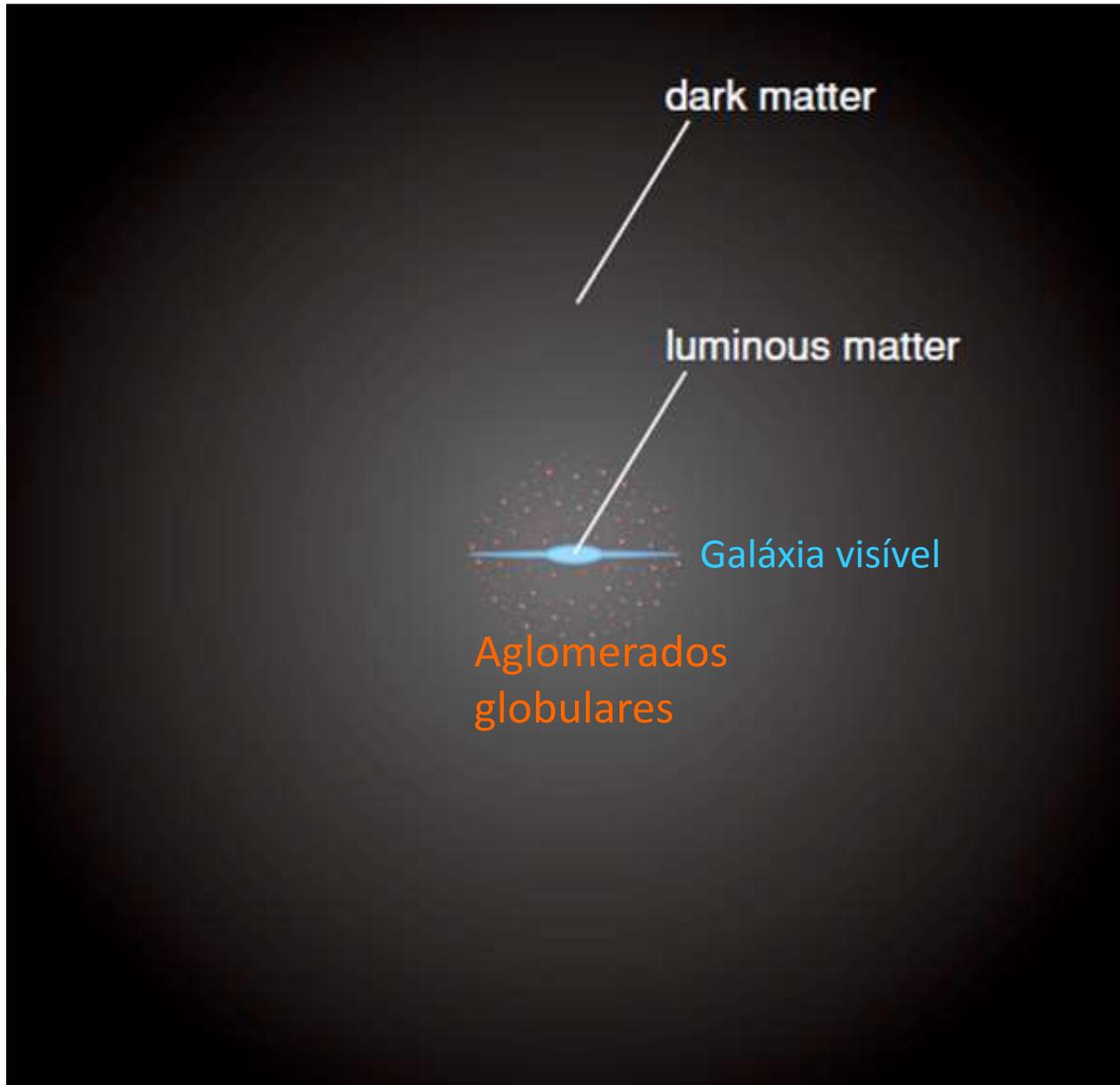


Matéria escura

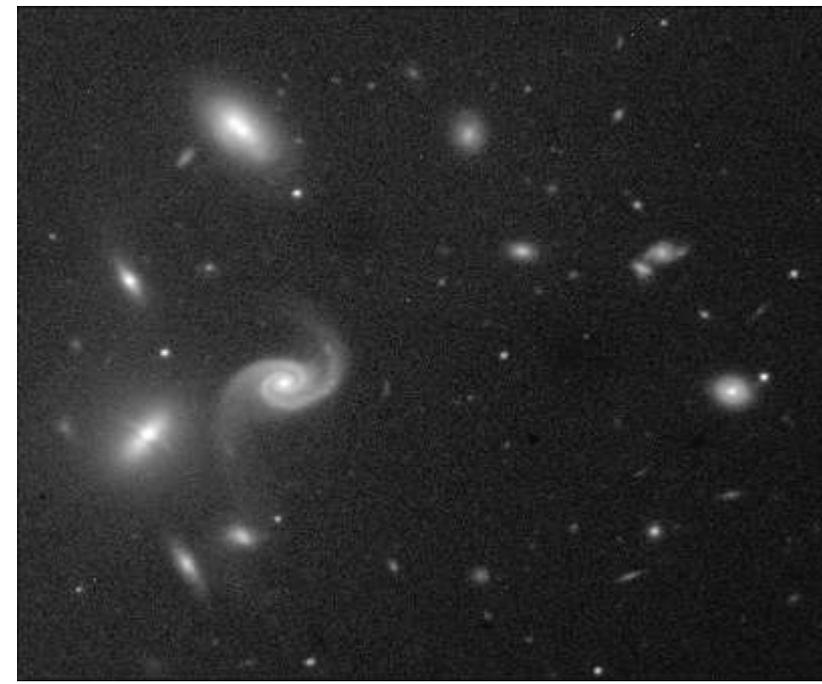
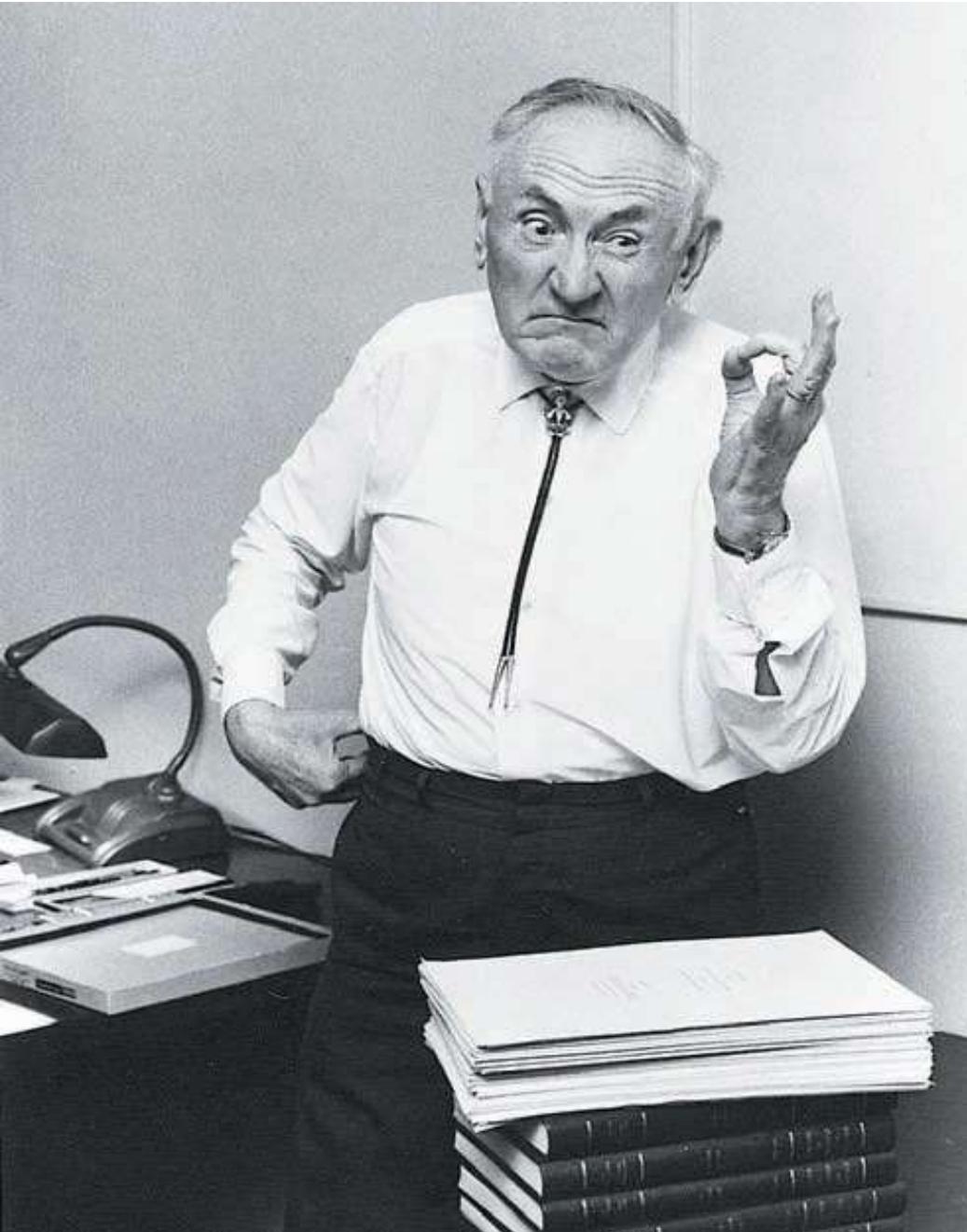
Regiões mais afastadas do centro de galáxias têm velocidades muito maiores do que as devidas à matéria visível → **deve existir matéria escura!**



Matéria escura



Fritz Zwicky (Feb 14, 1898 – Feb 8, 1974)



Fritz Zwicky, discoverer of dark matter in clusters of galaxies. Zwicky had an eccentric personality, but some of his ideas that seemed strange in the 1930s proved correct many decades later.