

Astronomía práctica: fonte de recursos para as áreas de ciencias

Lugo, febreiro de 2011

A vida das estrelas e das galaxias

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Universidad de La Laguna



Clube Compostelán de
Astronomía Vega

Contidos

•As estrelas:

- Parámetros fundamentais (magnitudes, espectros)
- O diagrama de Hertzsprung-Russell (H-R)
- Propiedades (masas, tamaños)
- A azarosa vida das estrelas
- Estrelas especiais (enanas brancas, estrelas de neutróns e buratos negros)
- Estrelas binarias e variables

•Os cúmulos estelares

- Cúmulos abertos
- Cúmulos globulares

•As galaxias

- A Vía Láctea
- Estructura das galaxias
- Clasificación das galaxias
- Galaxias activas
- Grupos e cúmulos de galaxias
- O desprazamento ó roxo e a estrutura do Universo

As estrelas: constelaci3es

Hai 88 constelaci3es
recoñecidas pola Uni3n
Astron3mica Internacional

A maior: Hydra (1302⁰²)
A menor: Crux (68⁰²)



Copyright 1998 Thor Olson



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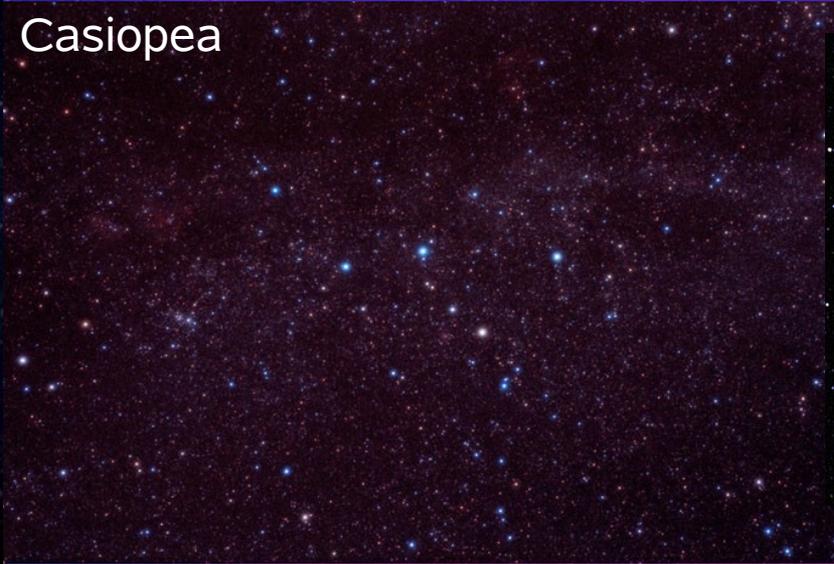
Estrelas e galaxias

As estrelas: o que vemos

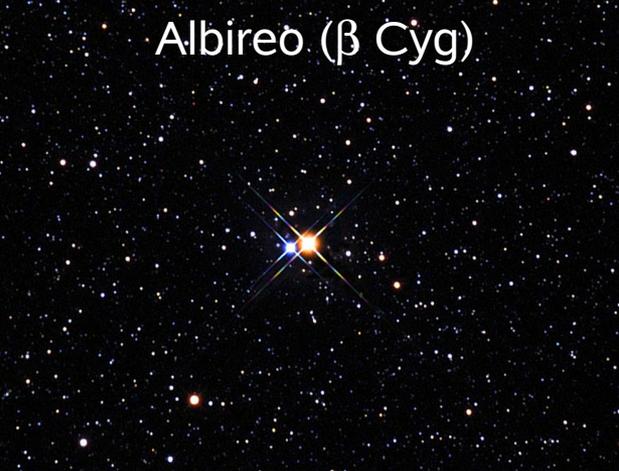
A Osa Maior



Casiopea



Albireo (β Cyg)



Tauro



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Escorpio

Orión



As estrelas: magnitudes estelares

Hiparco de Nicea (~135 AC)

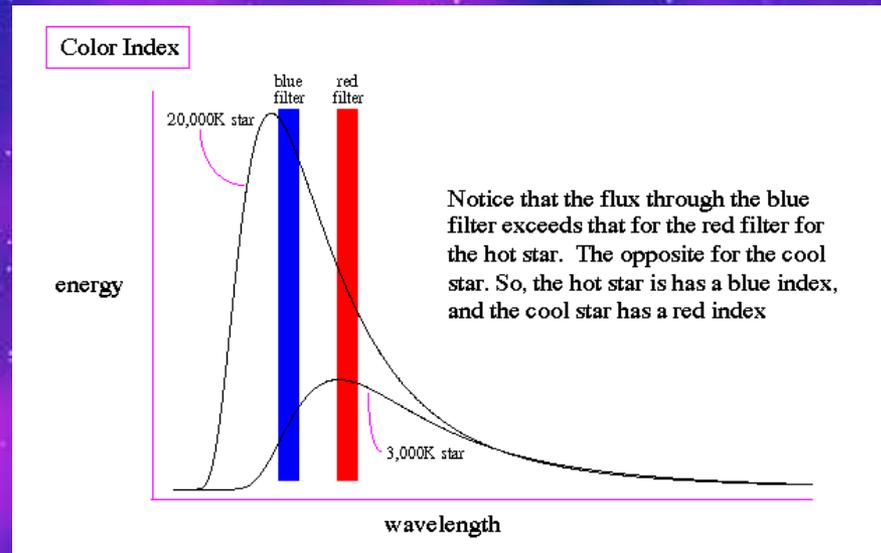
1º magnitude: as 20 estrelas máis brillantes

...

6º magnitude: as que están no límite de visión

Obxeto Mag. aparente

Sol	-26.5
Lúa chea	-12.5
Venus	-4.0
Xúpiter	-3.0
Sirio	-1.4
Polaris	2.0
límite do ollo	6.0
Plutón	15.0
límite para telesc.	25.0



Índice de cor:
 $C=B-V$

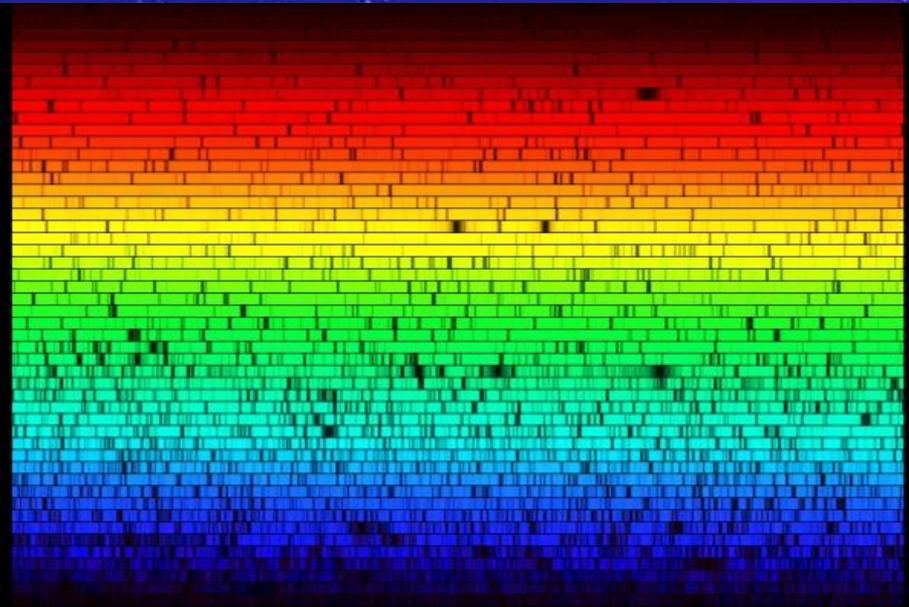
No caso de obxectos extensos: magnitude integrada

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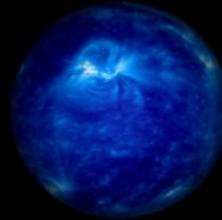
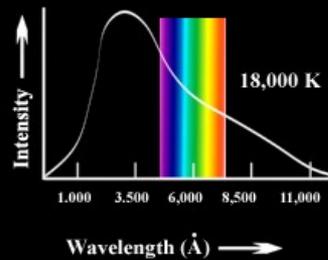
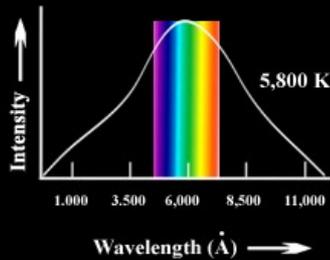
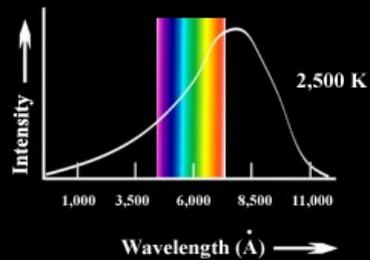
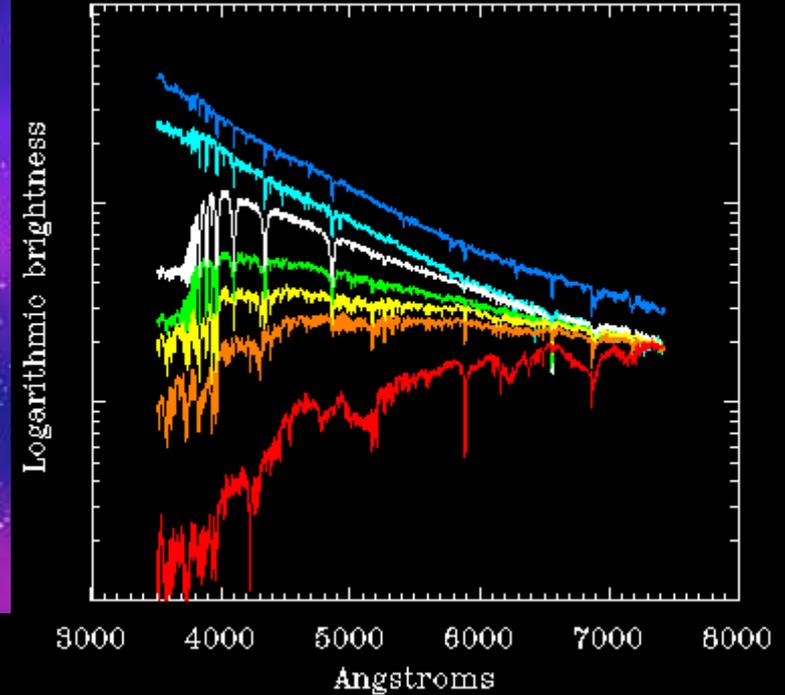
Estrelas e galaxias



As estrelas: espectros



Espectro de Arturo (α Boo)

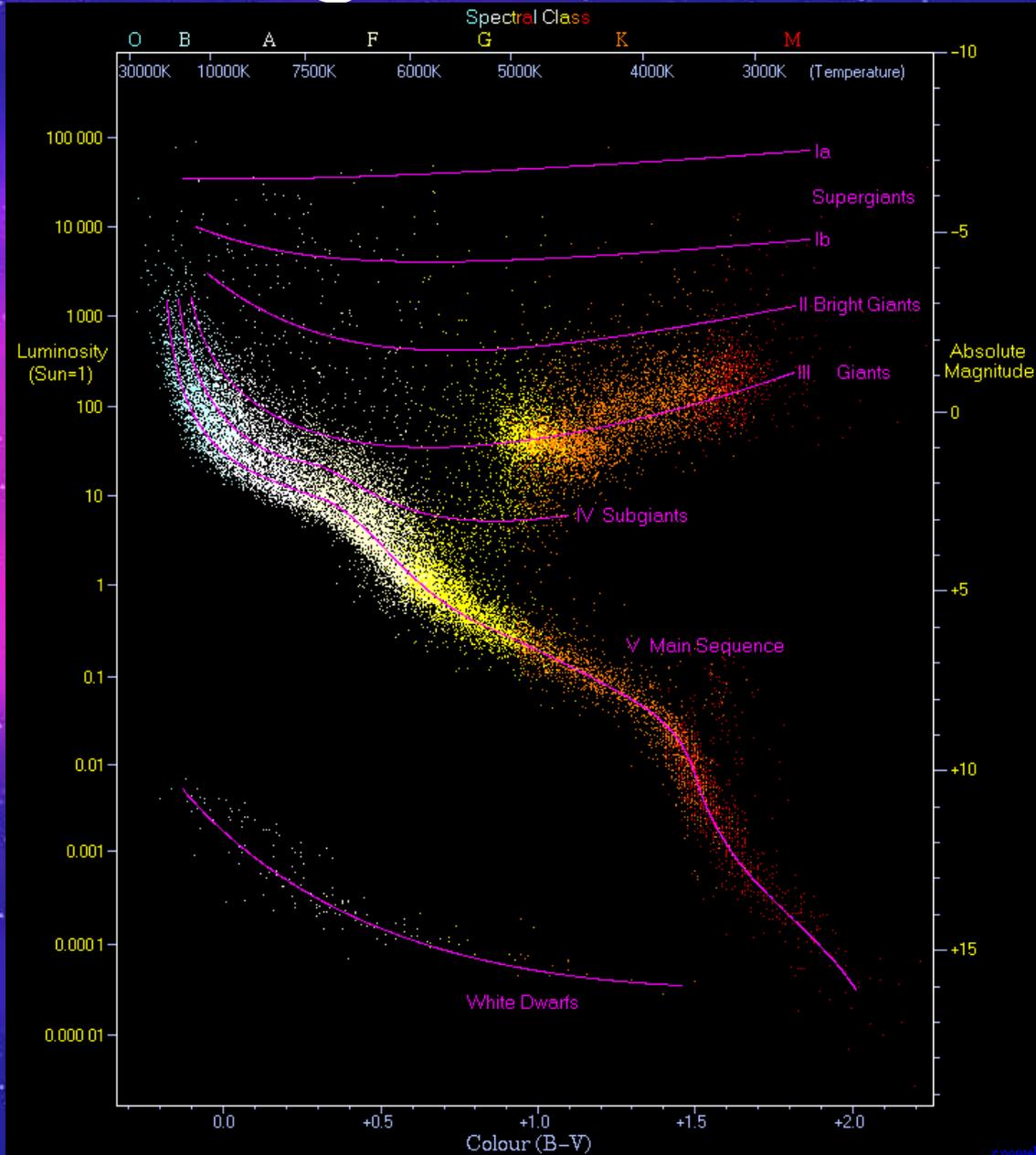
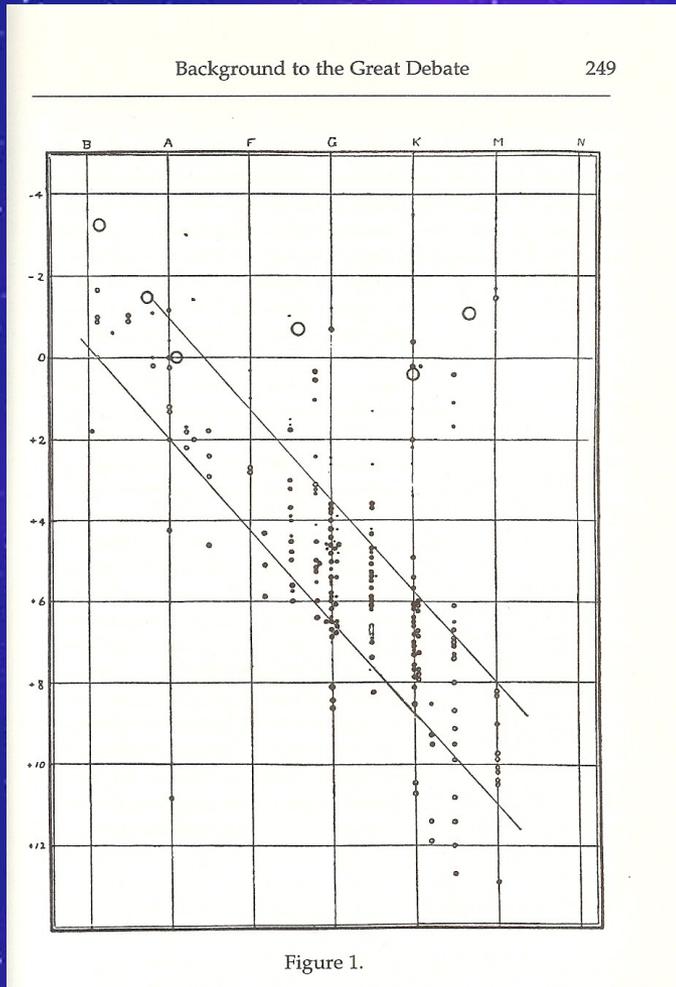


Colors are exaggerated

Este é o motivo das cores das estrelas

As estrelas: o diagrama H-R

Ejnar Hertzsprung (1908) e
Henry Norris Russell (1910)



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As estrelas: propriedades

Spectral Class	Effective Temperature (K)	Colour	H Balmer Features	Other Features	M/M_{Sun}	R/R_{Sun}	L/L_{Sun}	Main Sequence Lifespan
O	28,000 - 50,000	Blue	weak	ionised He ⁺ lines, strong UV continuum	20 - 60	9 - 15	90,000 - 800,000	1 - 10 Myr
B	10,000 - 28,000	Blue-white	medium	neutral He lines	3 - 18	3.0 - 8.4	95 - 52,000	11 - 400 Myr
A	7,500 - 10,000	White	strong	strong H lines, ionised metal lines	2.0 - 3.0	1.7 - 2.7	8 - 55	400 Myr - 3 Gyr
F	6,000 - 7,500	White-yellow	medium	weak ionised Ca ⁺	1.1 - 1.6	1.2 - 1.6	2.0 - 6.5	3 - 7 Gyr
G	4,900 - 6,000	Yellow	weak	ionised Ca ⁺ , metal lines	0.85 - 1.1	0.85 - 1.1	0.66 - 1.5	7 - 15 Gyr
K	3,500 - 4,900	Orange	very weak	Ca ⁺ , Fe, strong molecules, CH, CN	0.65 - 0.85	0.65 - 0.85	0.10 - 0.42	17 Gyr
M	2,000 - 3,500	Red	very weak	molecular lines, eg TiO, neutral metals	0.08 - 0.05	0.17 - 0.63	0.001 - 0.08	56 Gyr
L7	<2,000	Tentative new (2000) classification for very low mass stars.			<0.08	May or may not be fusing H in cores?		

Temperaturas:
2000 a 30000 K

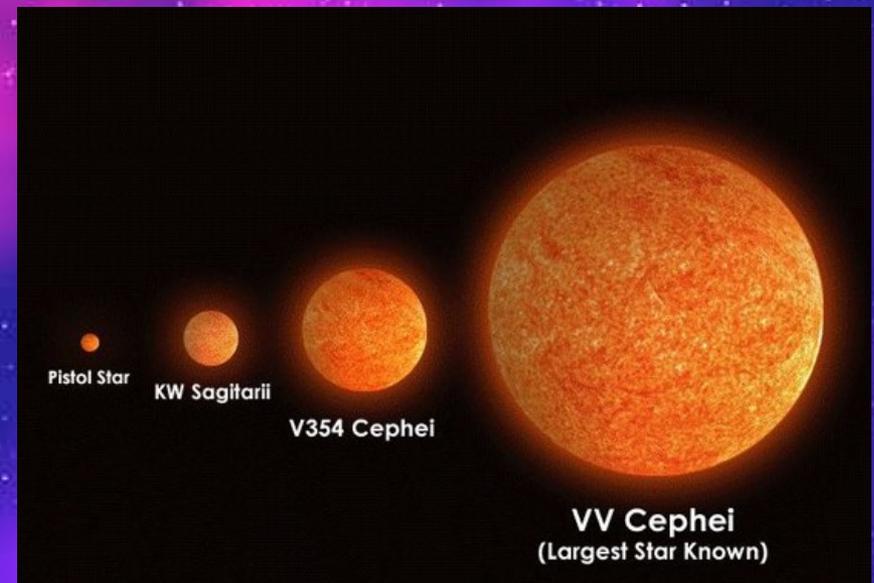
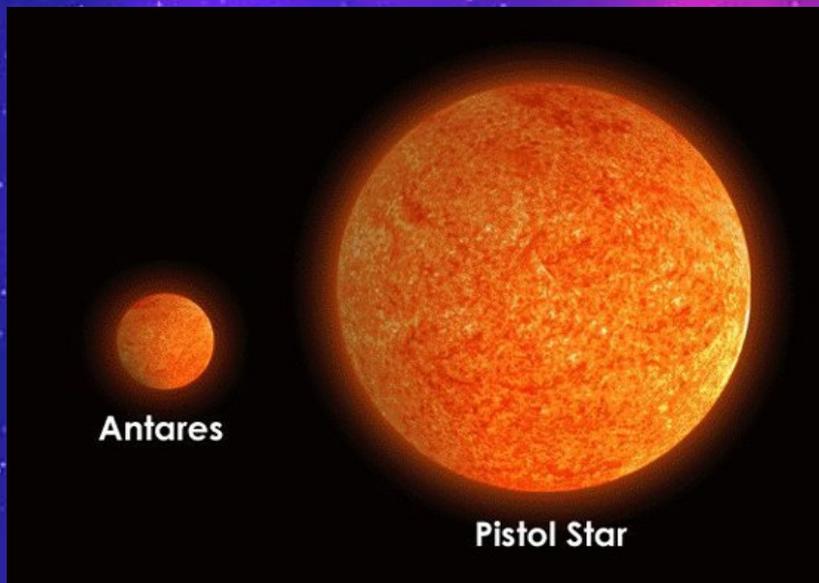
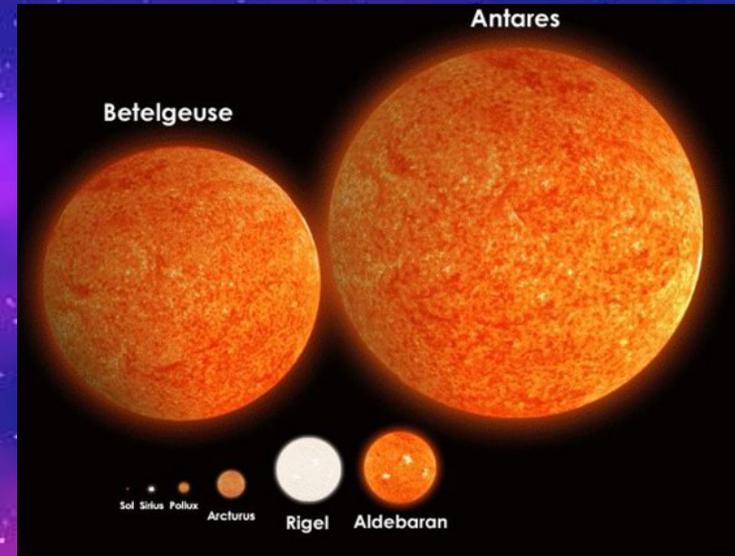
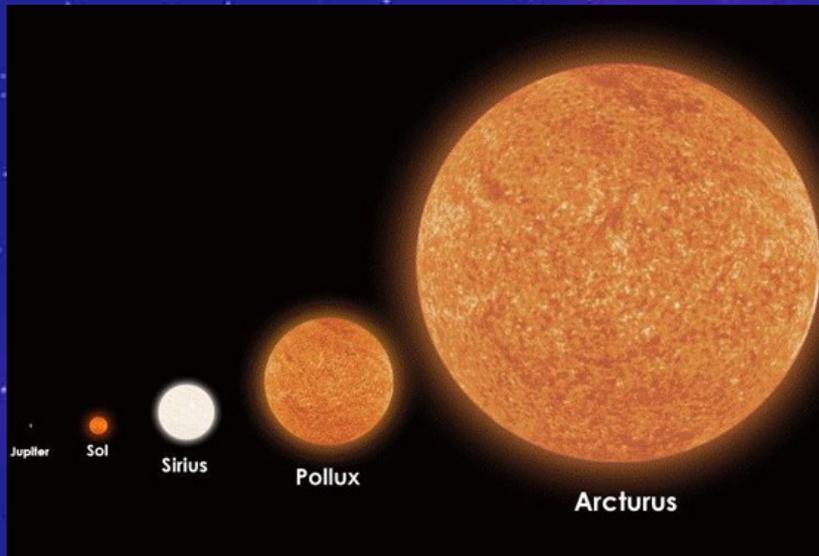
Masas:
0,08 a 100 M_{sol}

Radios:
0,1 a 1000 R_{sol}

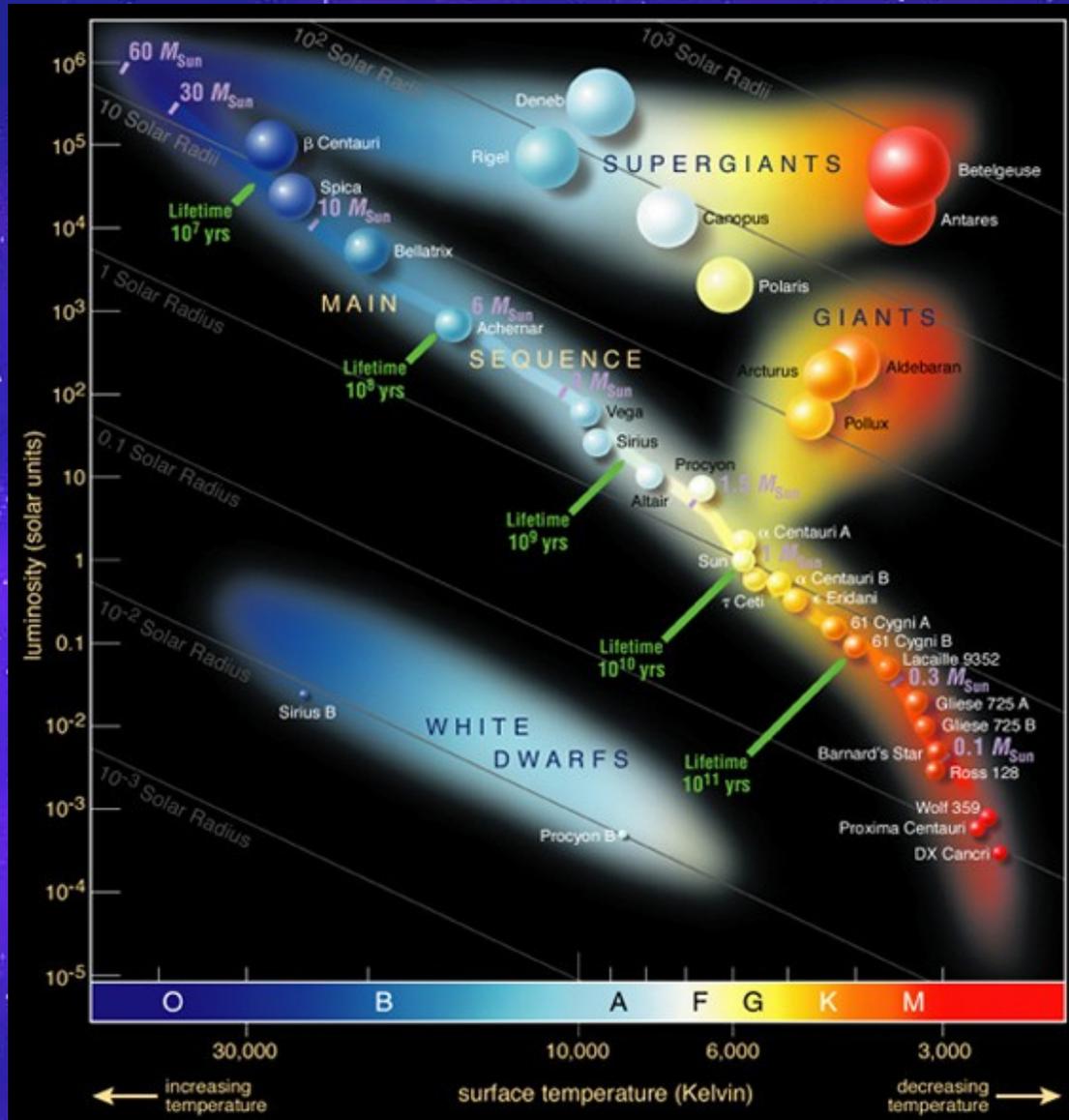
Luminosidades:
0,001 a 10⁶ L_{sol}

Tempo de vida:
1 Myr a 56 Gyr

As estrelas: propriedades



As estrelas: propriedades



As estrelas: o medio interestelar



Nebulosa de reflexión
(M45)

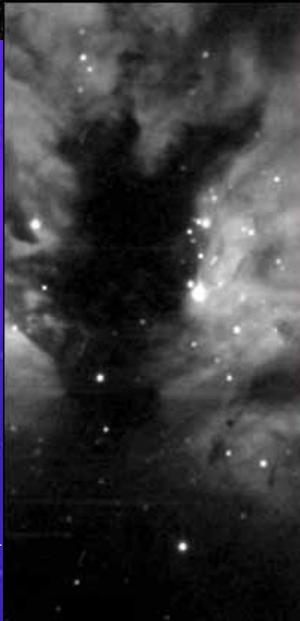


1/3 Globules in IC 2944



Hubble
Heritage

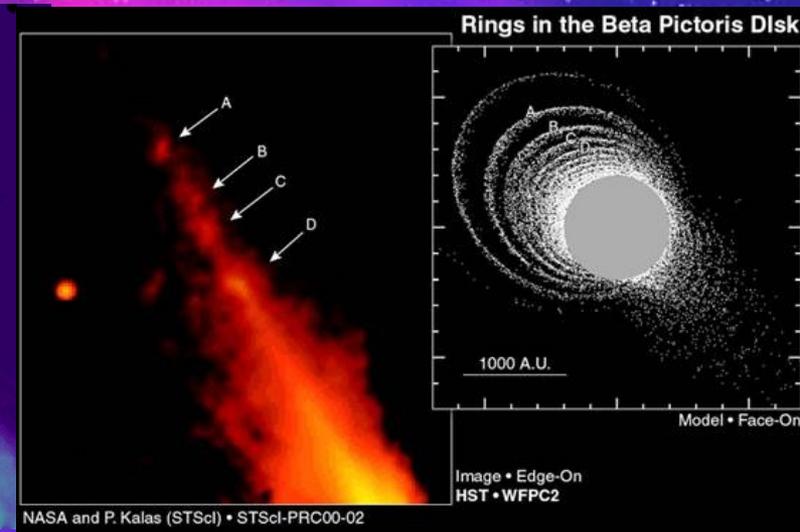
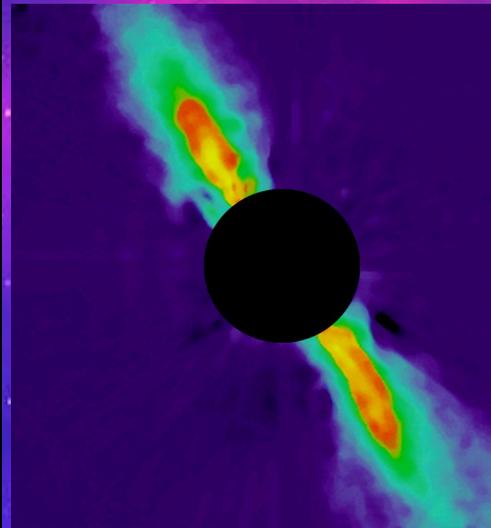
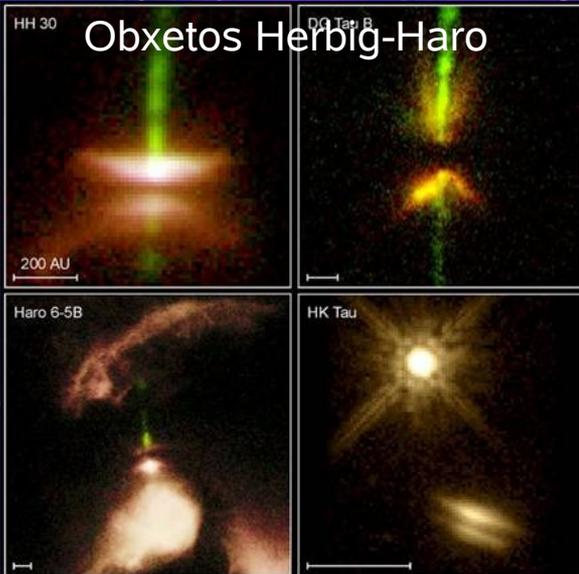
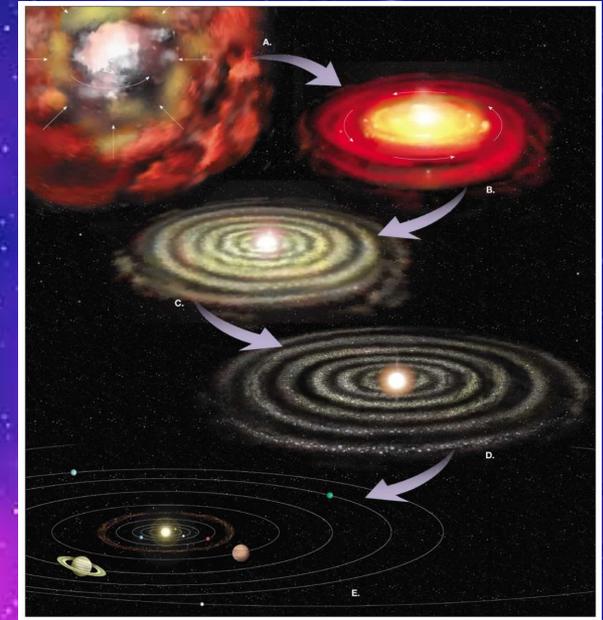
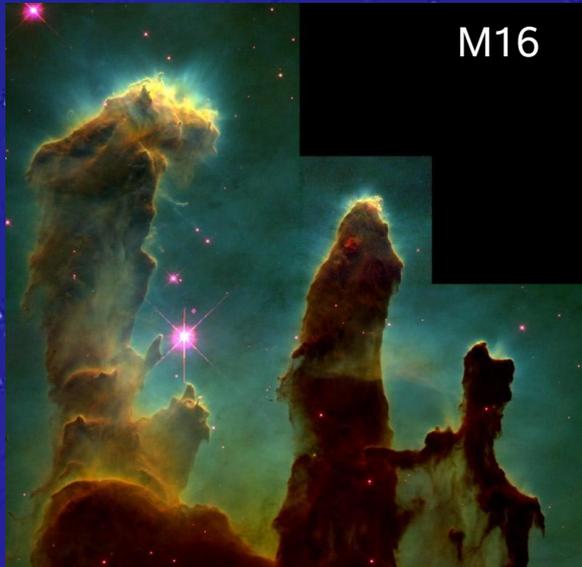
and The Hubble Heritage Team (STScI/AURA) • Hubble Space Telescope WFPC2 • STScI-PRC02-01



Nebulosa oscura (IC2944)

Comparación
Visible - IR

As estrelas: como nacen



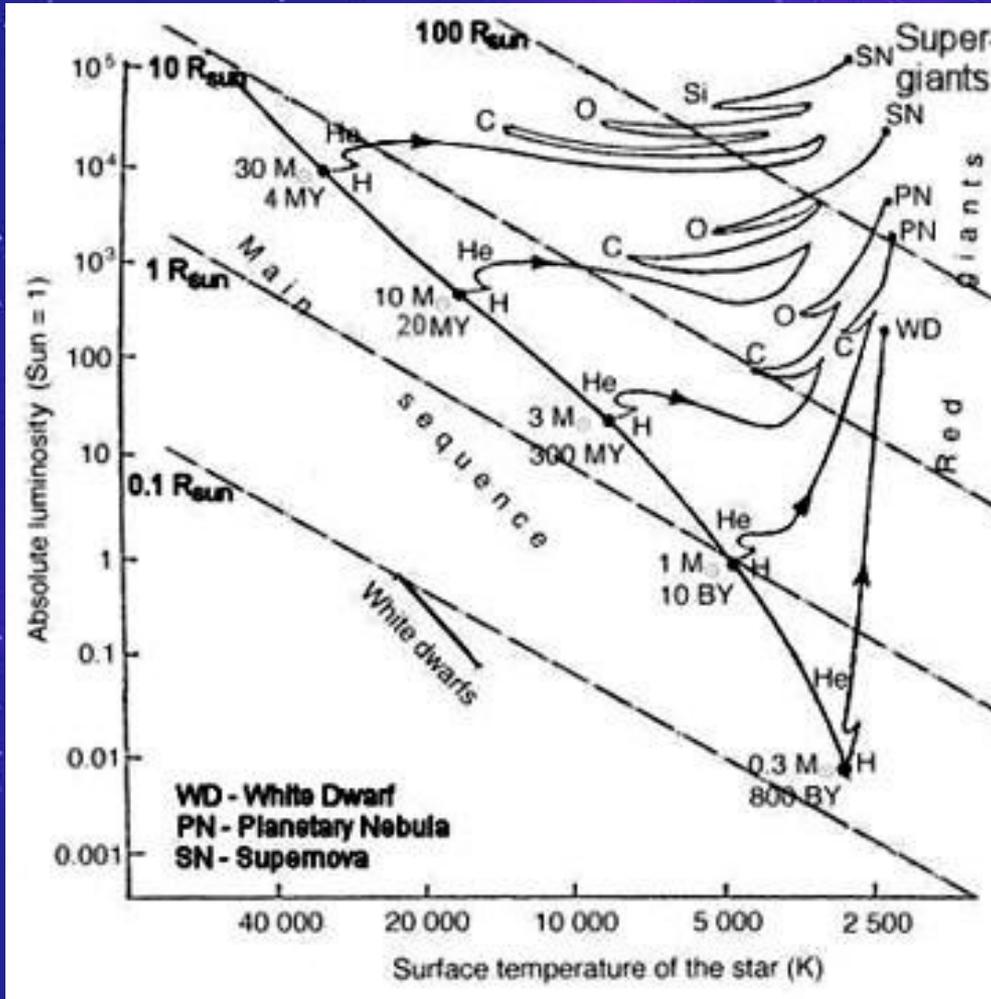
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Estrelas e galaxias

Disco planetario ó redor de β Pic

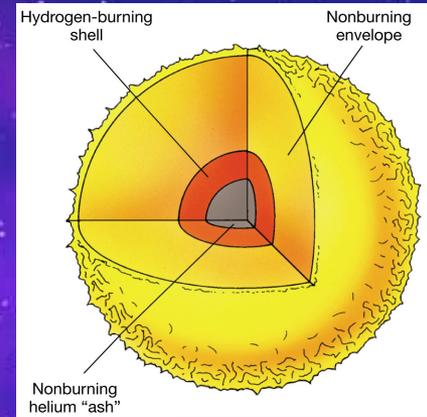
As estrelas: como viven

“As estrelas son como as pizzas: o secreto está na masa”. Anónimo.

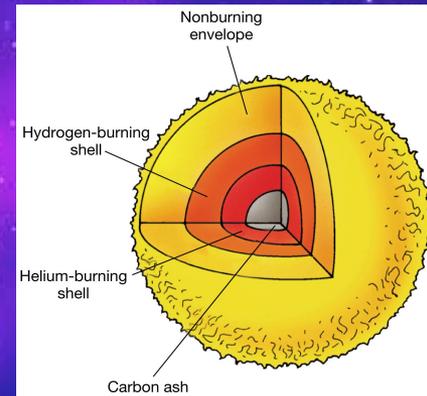


simulación de evolución

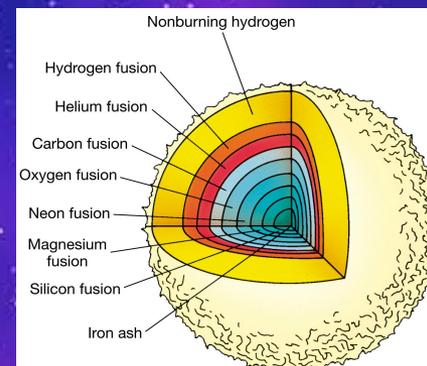
estrela de masa pequena



estrela de masa intermedia

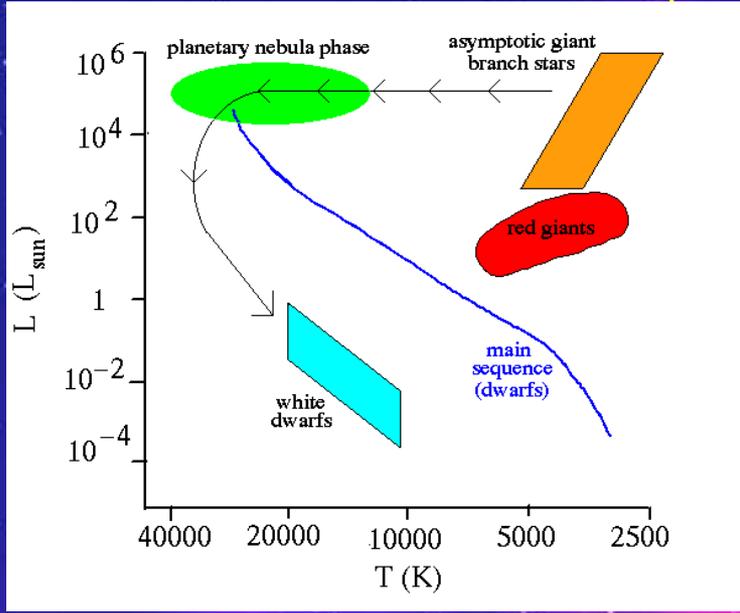


estrela moi masiva

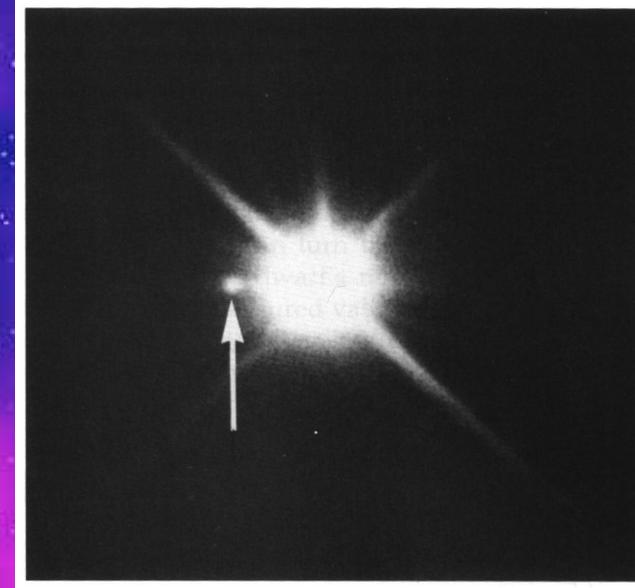


As estrelas: a morte

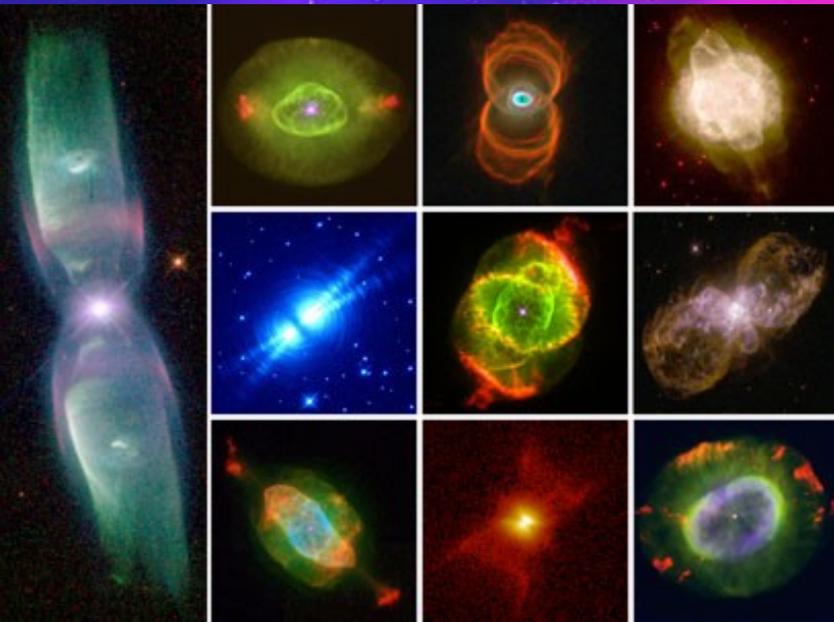
Estrelas de pouca masa: nebulosas planetarias



Enana branca
Sirio B



simulación



As formas
das nebulosas
planetarias

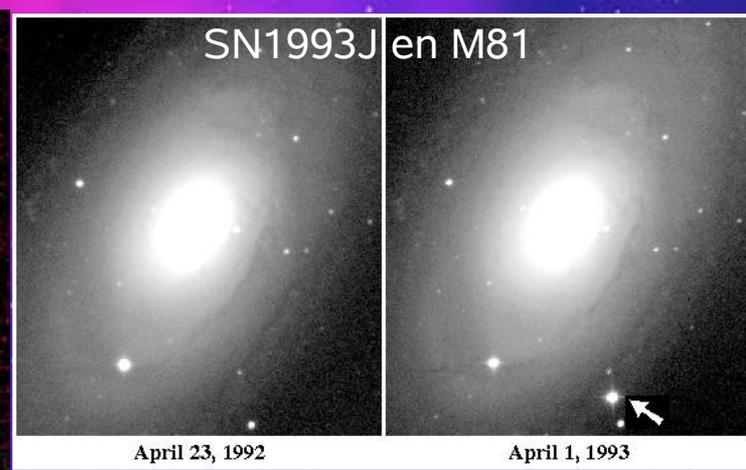
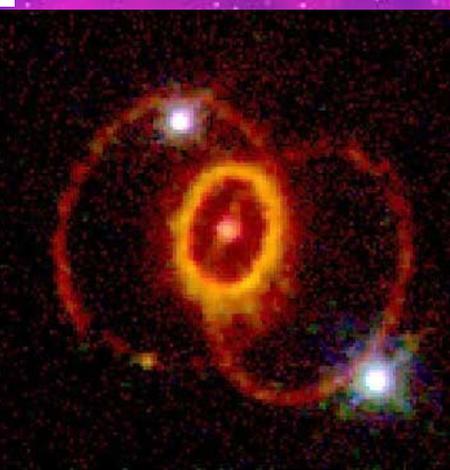
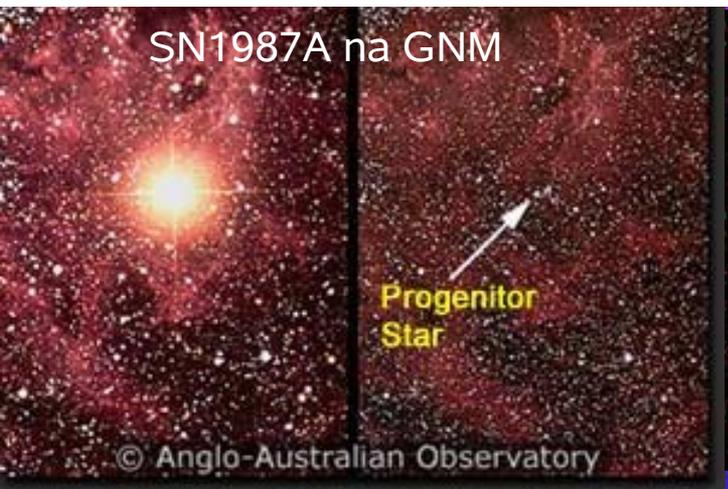
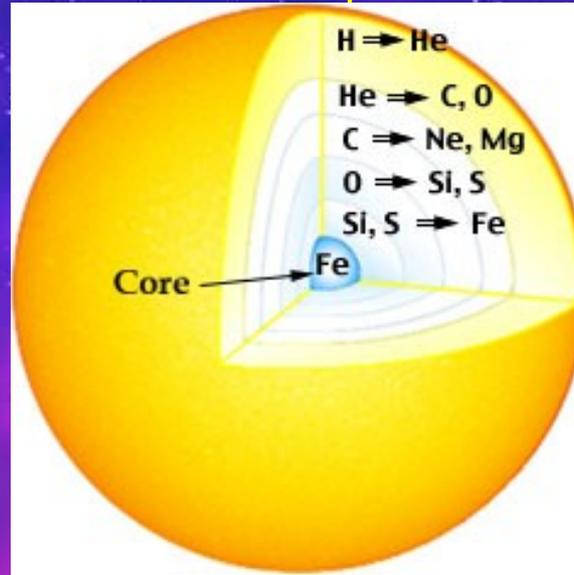
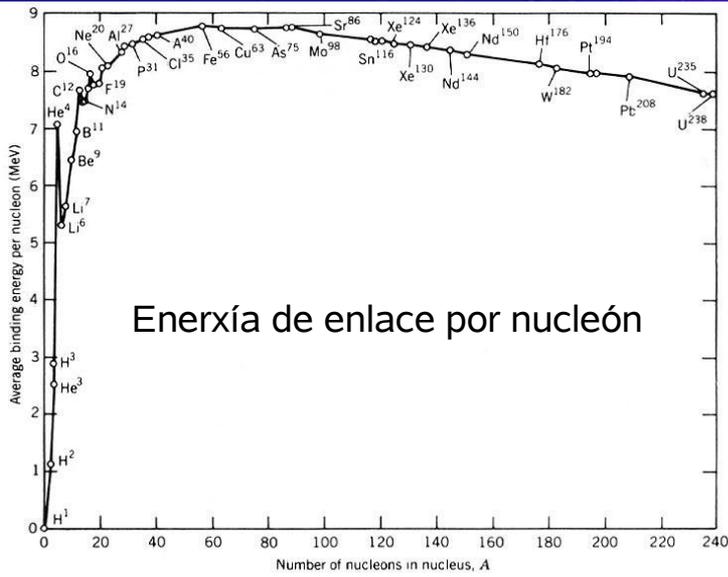


NGC2392
“o esquimal”

Estrelas e galaxias

As estrelas: a morte

Estrelas masivas: supernovas

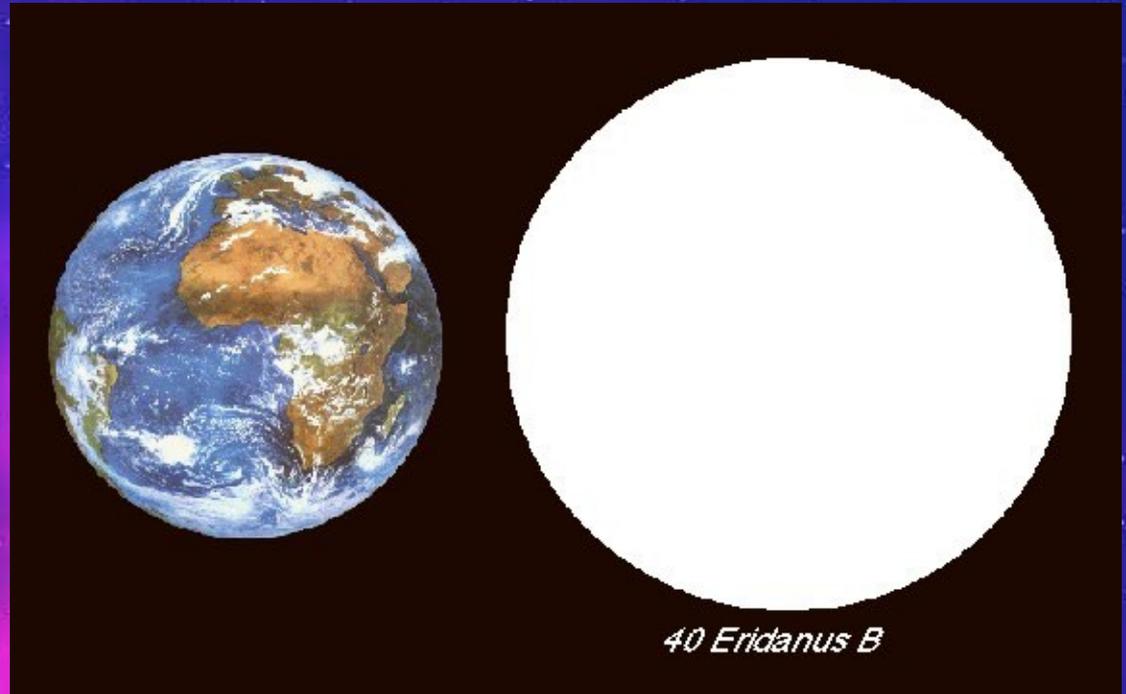
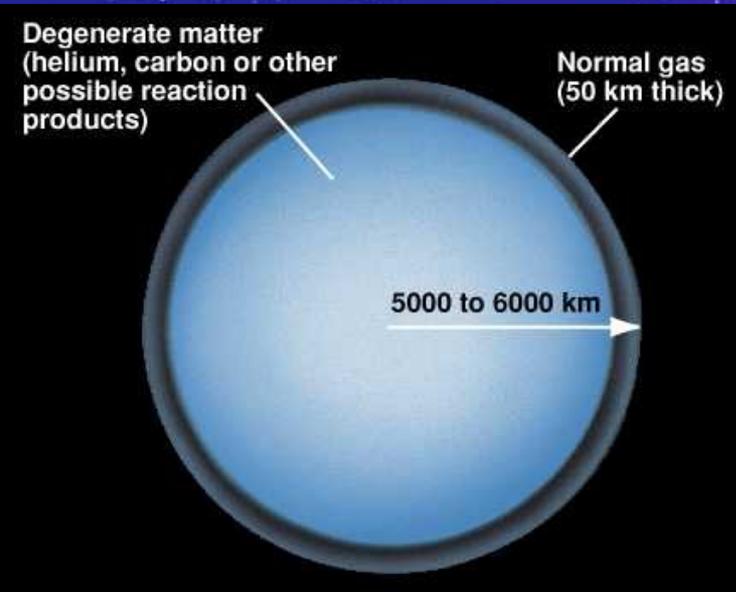


simulação Nebulosa do Cangrexo
01-marzo 2010

simulação SN en EB
Estrelas e galaxias

simulação SN en sistema planetario
16

As estrelas: enanas brancas

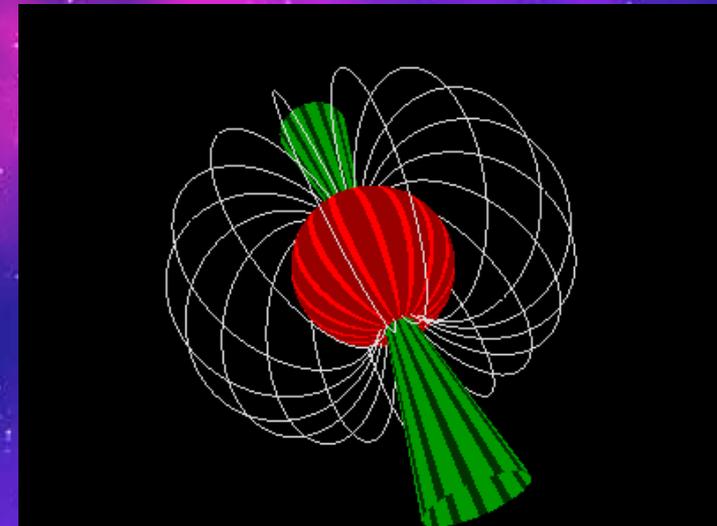
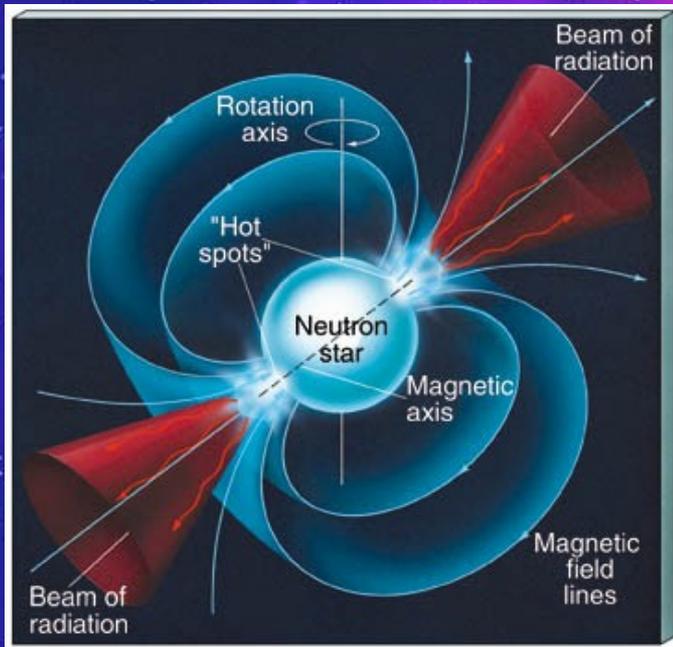
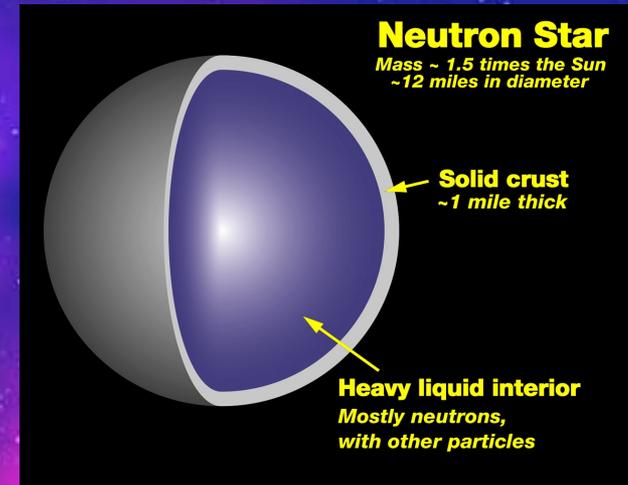


As estrelas: estrelas de neutróns

Púlsares: un premio Nobel controvertido



Jocelyn Bell (1967, radiotelescopio de Jodrell Bank)



Sons púlsares

Sons púlsares 2

Animación raios X

Animación púlsar

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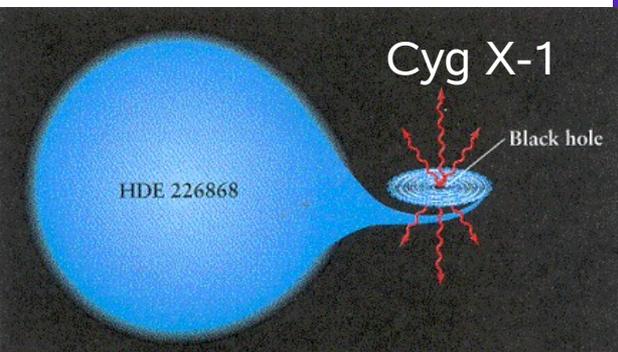
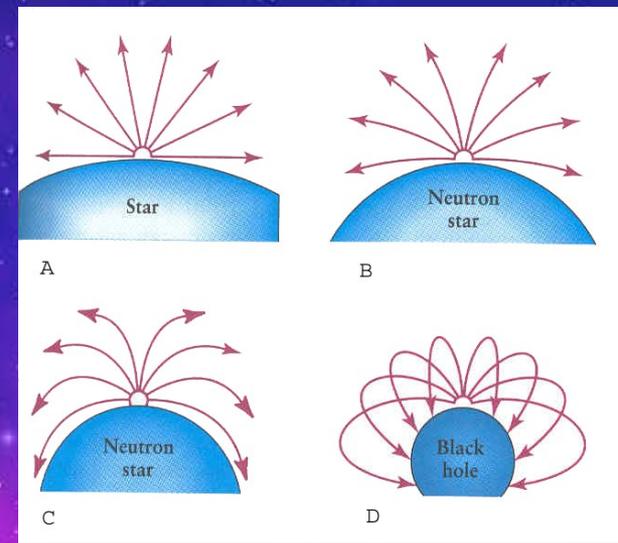
Estrelas e galaxias

As estrelas: buratos negros



- Candidatos a buratos negros:
- Sistema binario espectroscópico
 - A primaria non se detecta
 - Período é moi corto
 - A masa da primaria supera $3-4 M_{\text{sol}}$
 - Emite raios X intensamente
 - Aparecen chorros en radio

"It's black, and it looks like a hole.
I'd say it's a black hole."



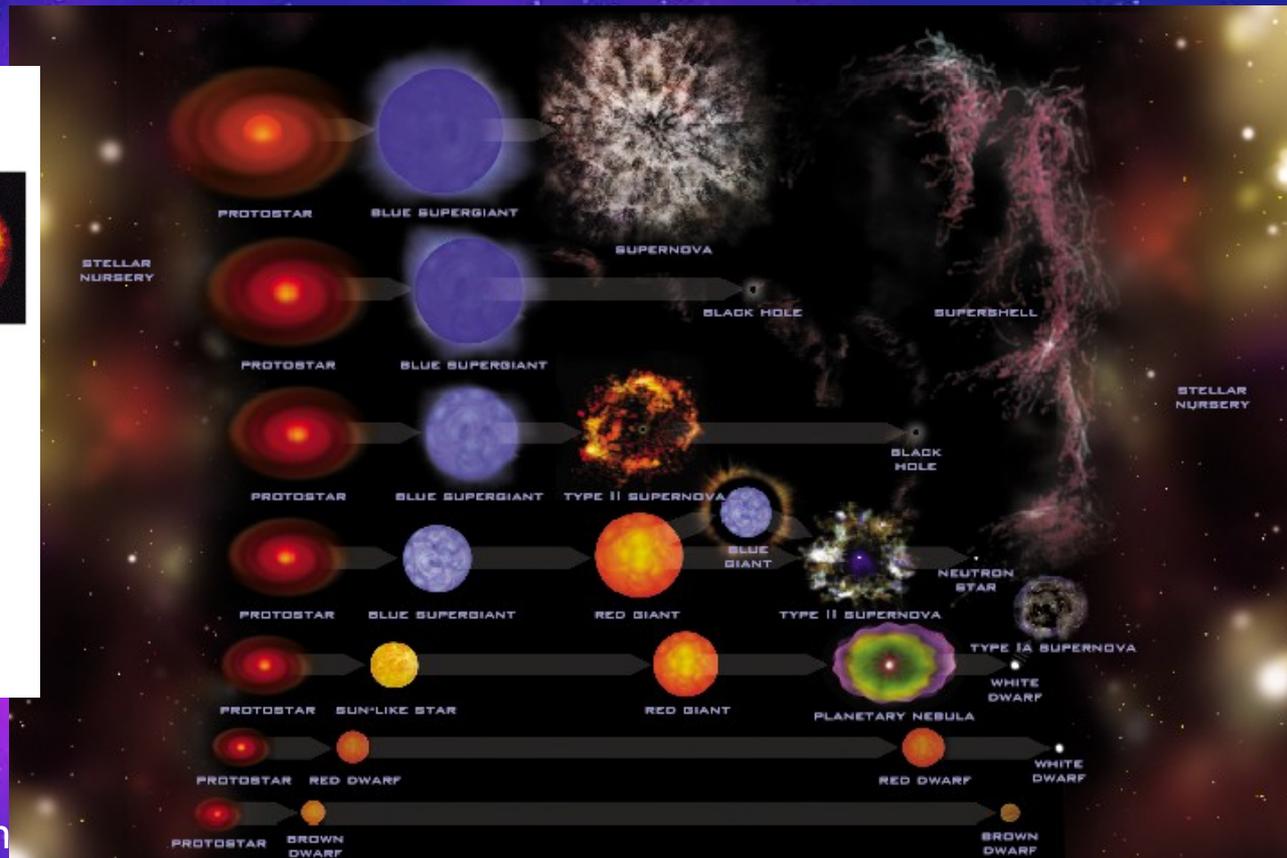
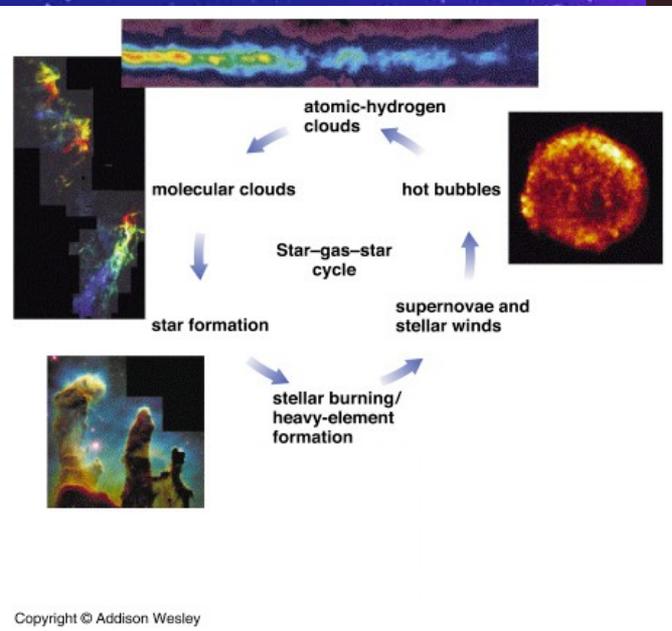
Simulación de burato negro de fronte
Simulación de burato negro dende órbita

Os mellores candidatos:

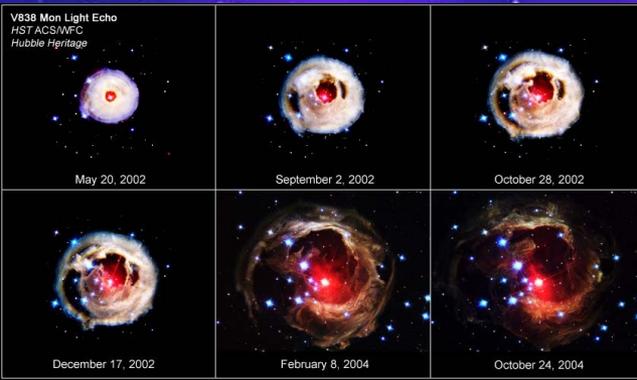
Candidato	Tipo	Masa prim. (M_{sol})
A0620-00	nova de raios X	3,82
V404 Cyg (Cyg X-3)	nova de raios X	6,3
Cyg X-1	binaria de raios X masiva	11-21
LMC X-3	binaria de raios X	4-9

As estrelas: reciclaxe do M.I.

Tarde ou cedo o material das estrelas volve ó espacio



Expulsión de masa de V838 Mon



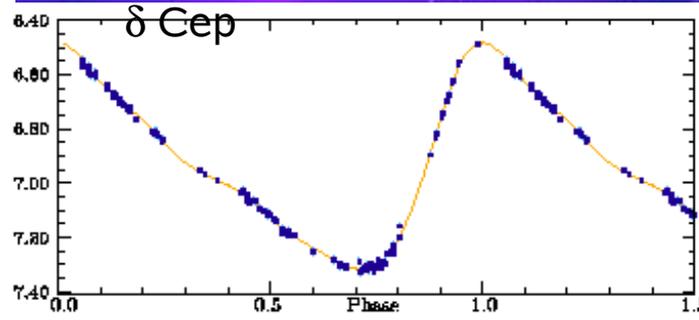
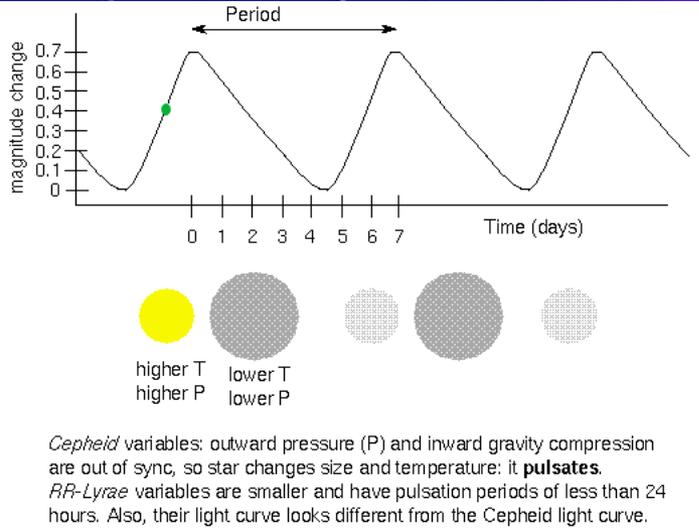
Nebulosa do Velo
(resto de SN)

Nebulosa do Cangrexo
(resto de SN)

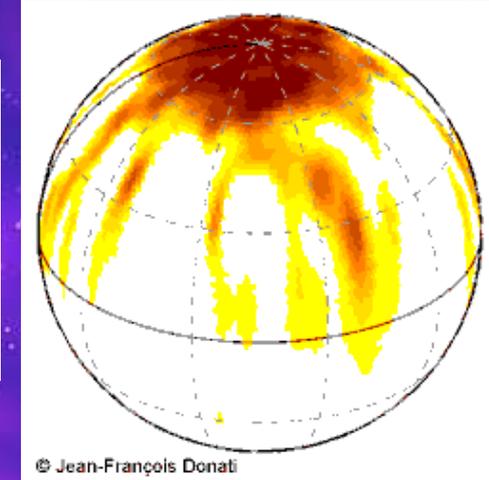


As estrelas variables

Pulsantes



Rotantes

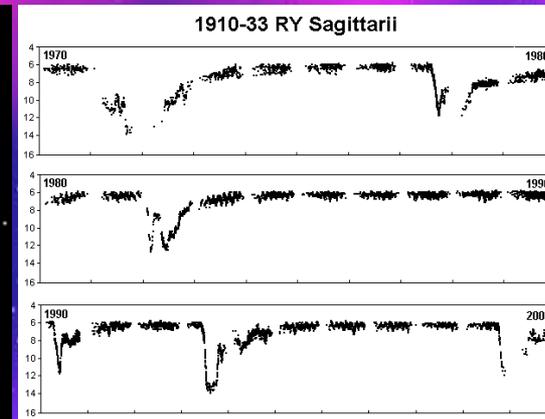


Cataclísmicas

V838 Mon



Eruptivas



Eclipsantes

(a continuación)

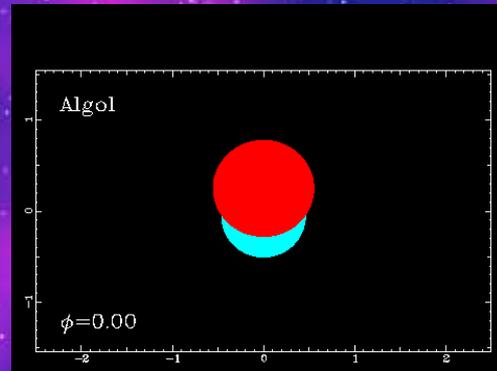
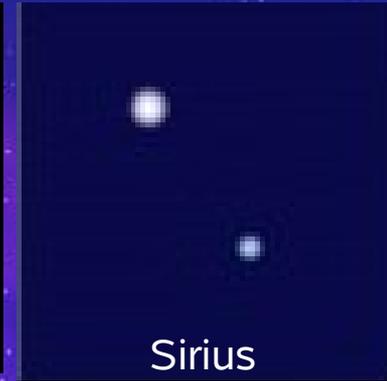
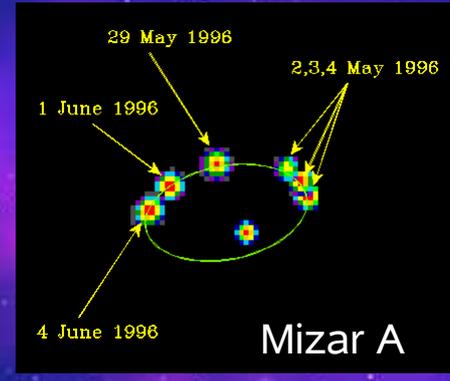
As estrelas: estrelas binarias

Laboratorios para medir as massas estelares

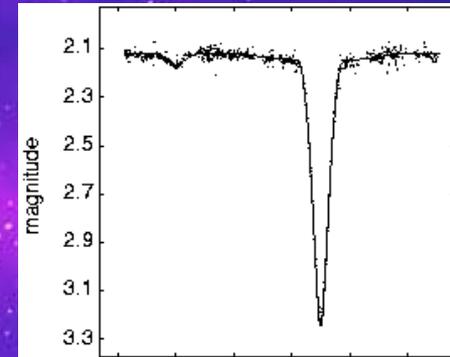
Dobles visuales:

Animación doble circular

Animación doble excéntrica



Algol (β Per)

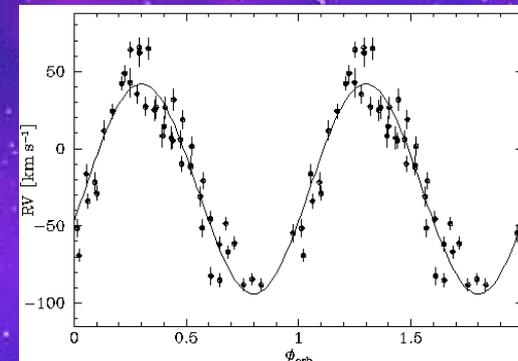


Binarias eclipsantes:

Animación eclipsante

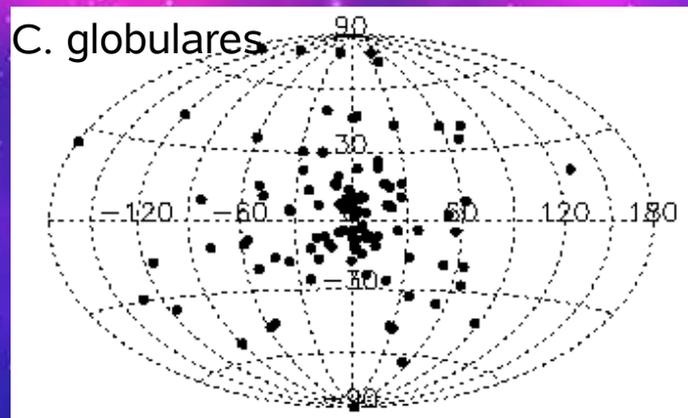
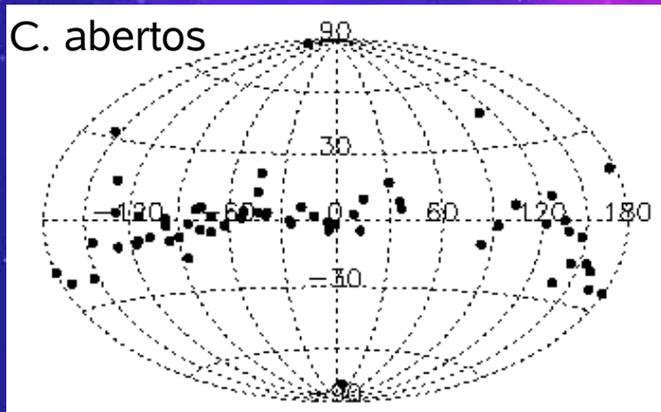
Binarias espectroscópicas

Animación espectroscópica



As estrelas: cúmulos, partos múltiples

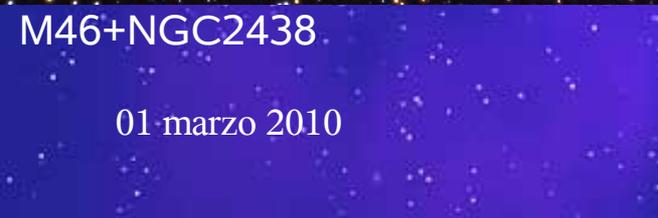
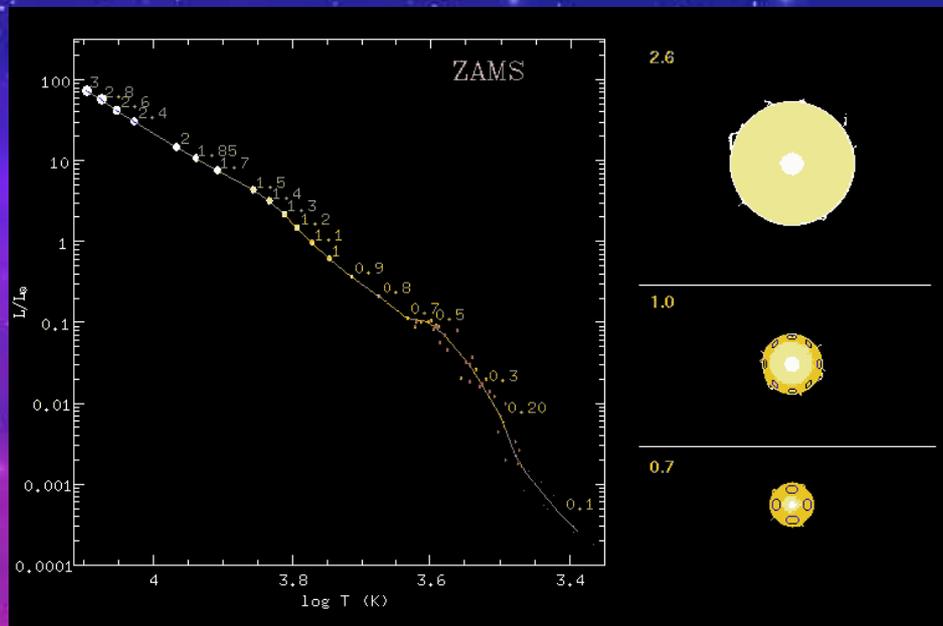
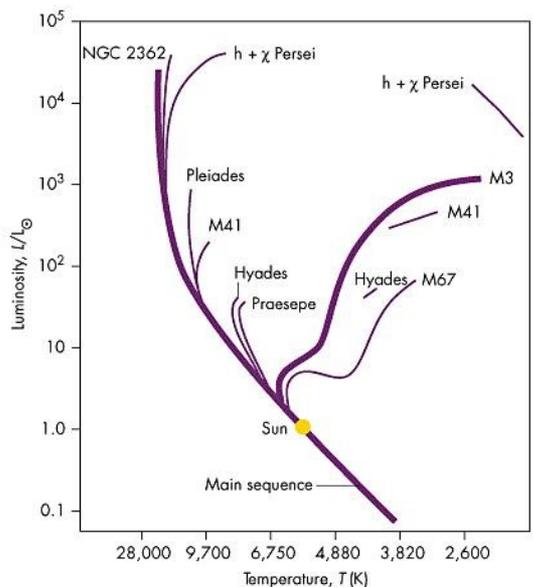
	Cúmulos abertos	Cúmulos globulares
Morfoloxía	-distribución de estrelas irregular e espallada -estrelas azúis	-distribución esférica e densa de estrelas -estrelas roxas
Nº estrelas	$\sim 10^2 +$ gas e pó	$\sim 10^5 - 10^6$, sin gas
Distribución	só no plano galáctico	distribución esférica polo halo galáctico
Diagrama HR	-todos con SP -gran variedade de puntos de xiro	-SP corta -puntos de xiro moi similares -moi antigos



01-marzo 2010

Estrelas e galaxias

As estrelas: cúmulos abertos



M46+NGC2438

01 marzo 2010

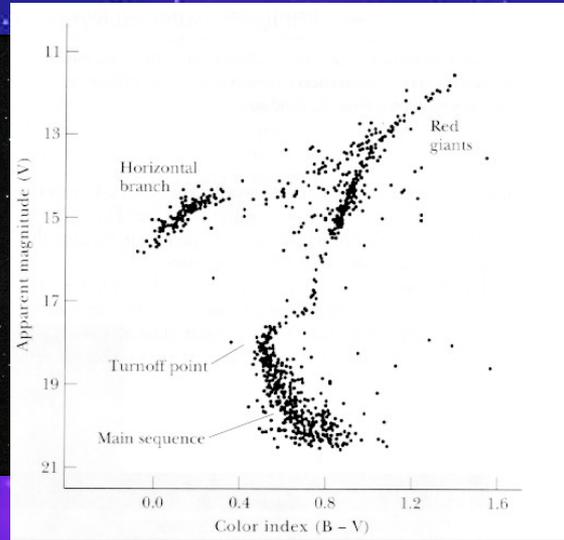
NGC4755

h+chi Per (cúmulo doble)

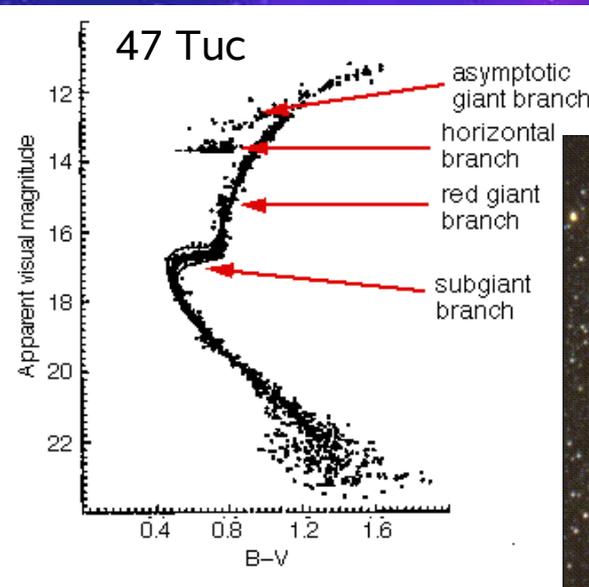
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© 1997 Jerry Lodriguss

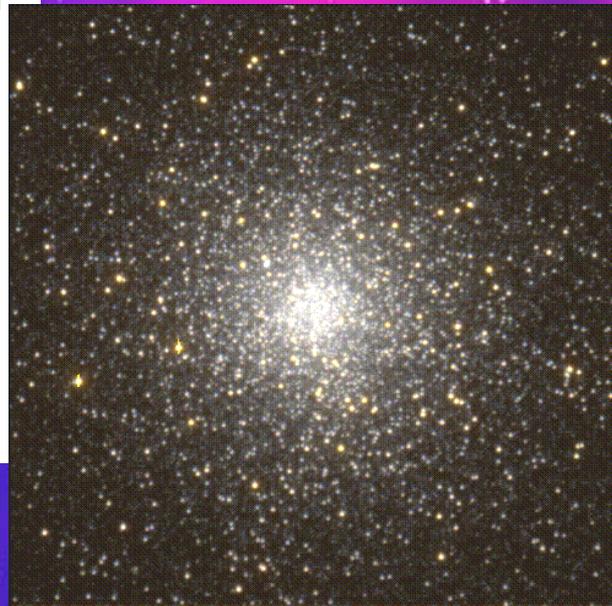
As estrelas: cúmulos globulares



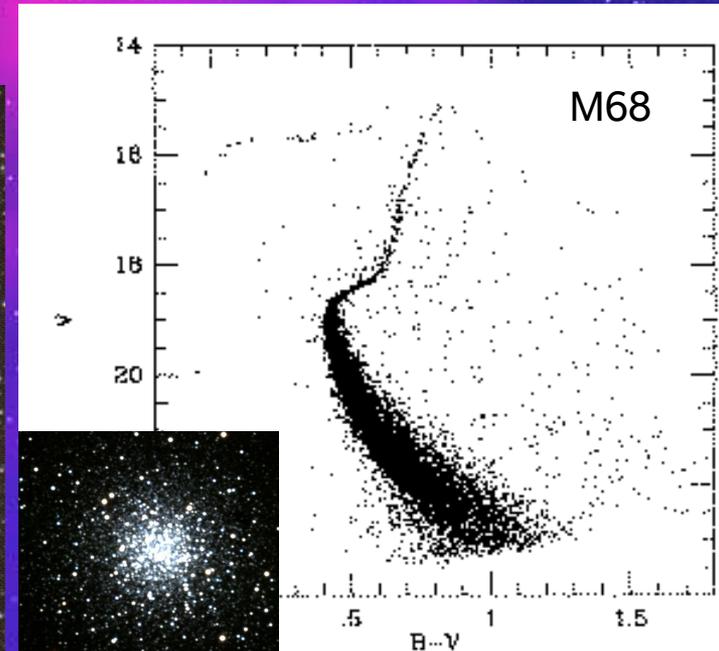
Posición de M13 na Galaxia



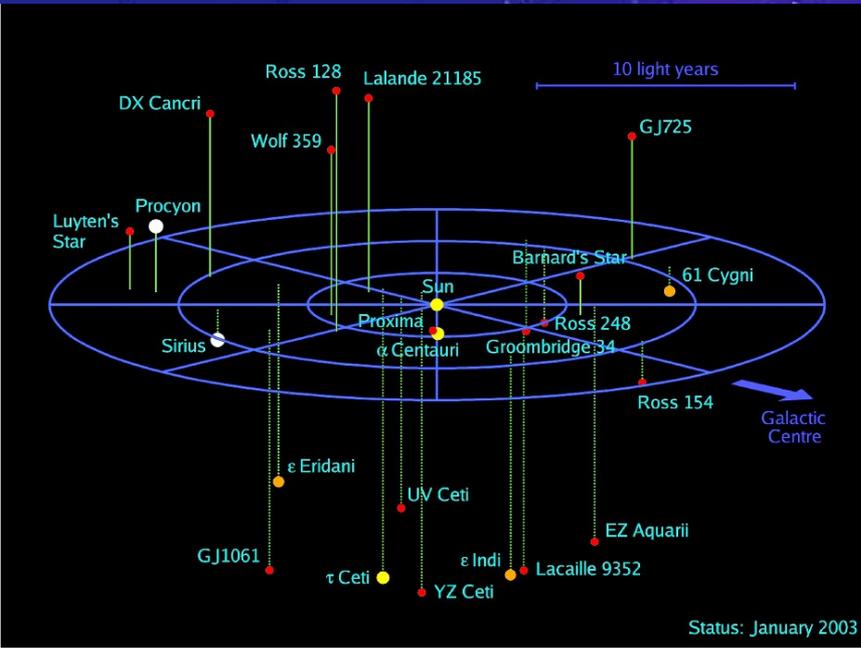
47 Tuc



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As galaxias: o Sol na Vía Láctea

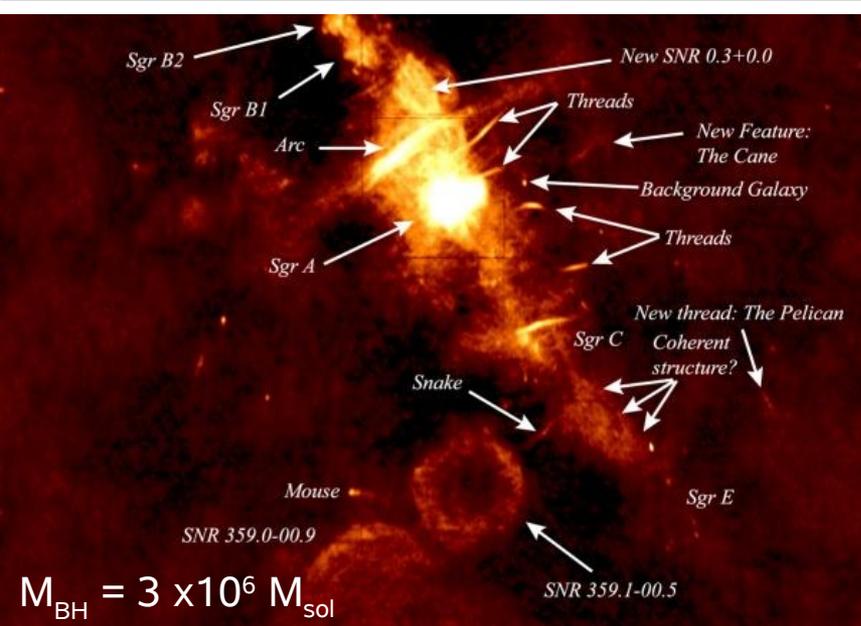
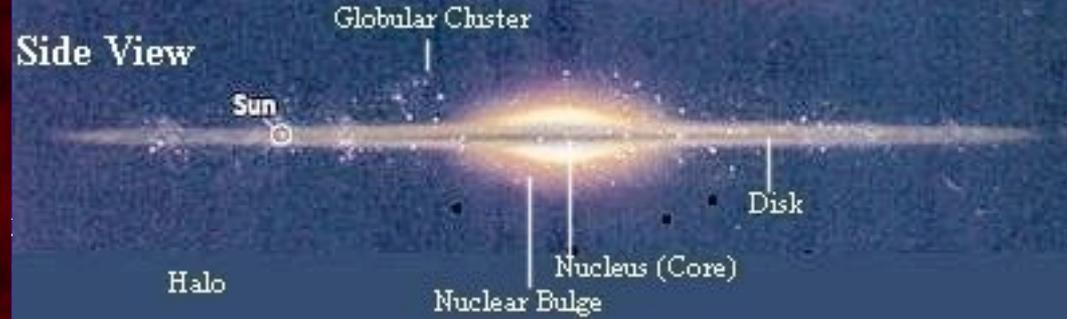


Face-on View



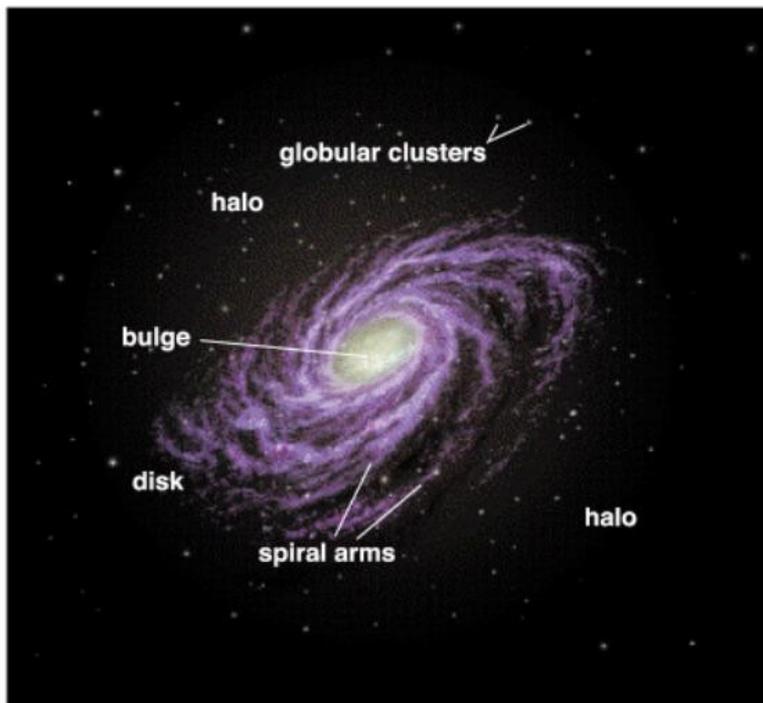
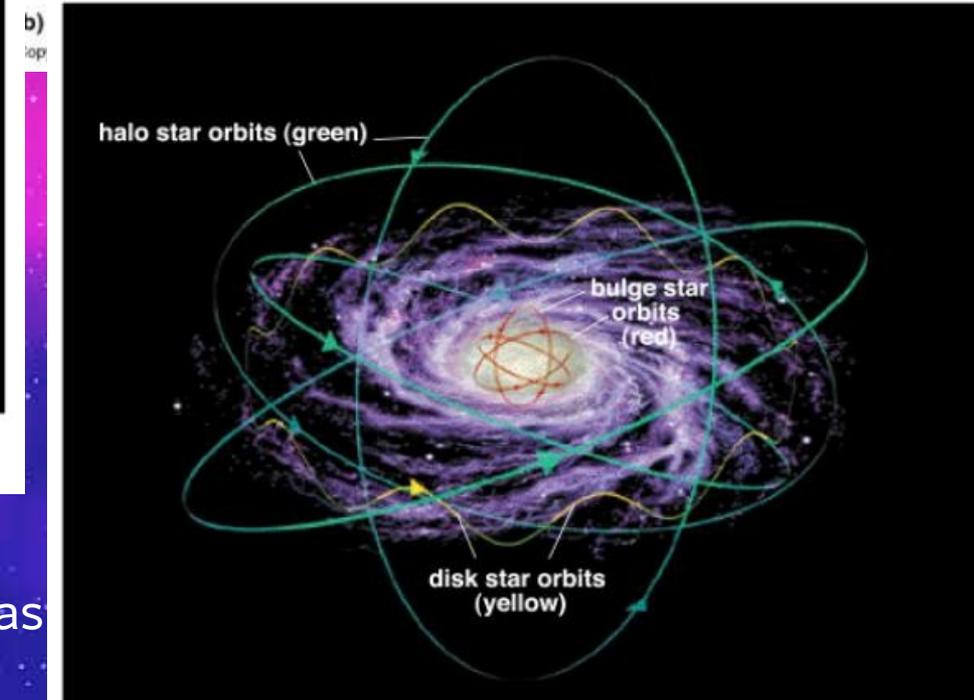
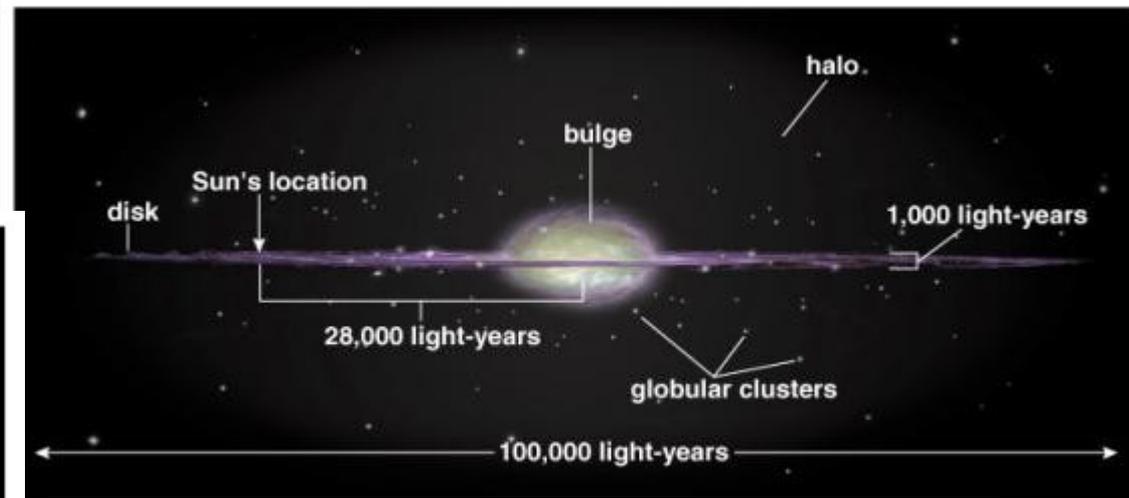
Rotation

Side View



As galaxias: estrutura

Partes das galaxias



(a)
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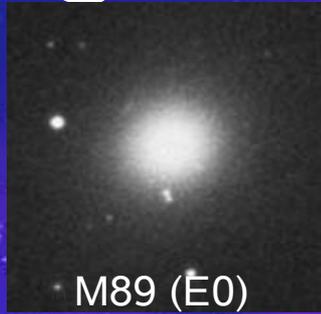
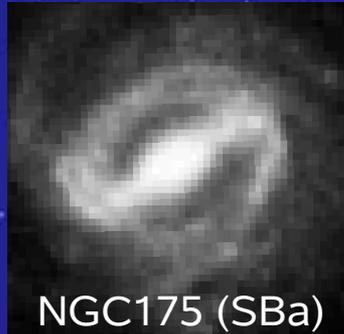
b)
top

Copyright © Addison Wesley

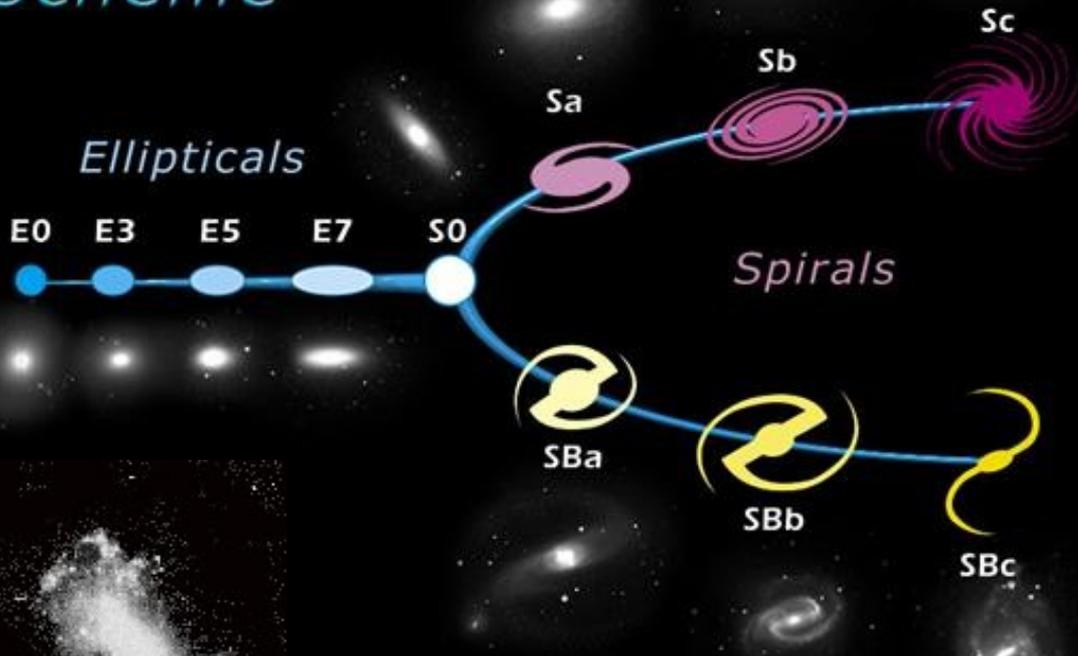
Órbitas das estrelas

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As galaxias: clasificación



*Edwin Hubble's
Classification
Scheme*



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As galaxias: elípticas

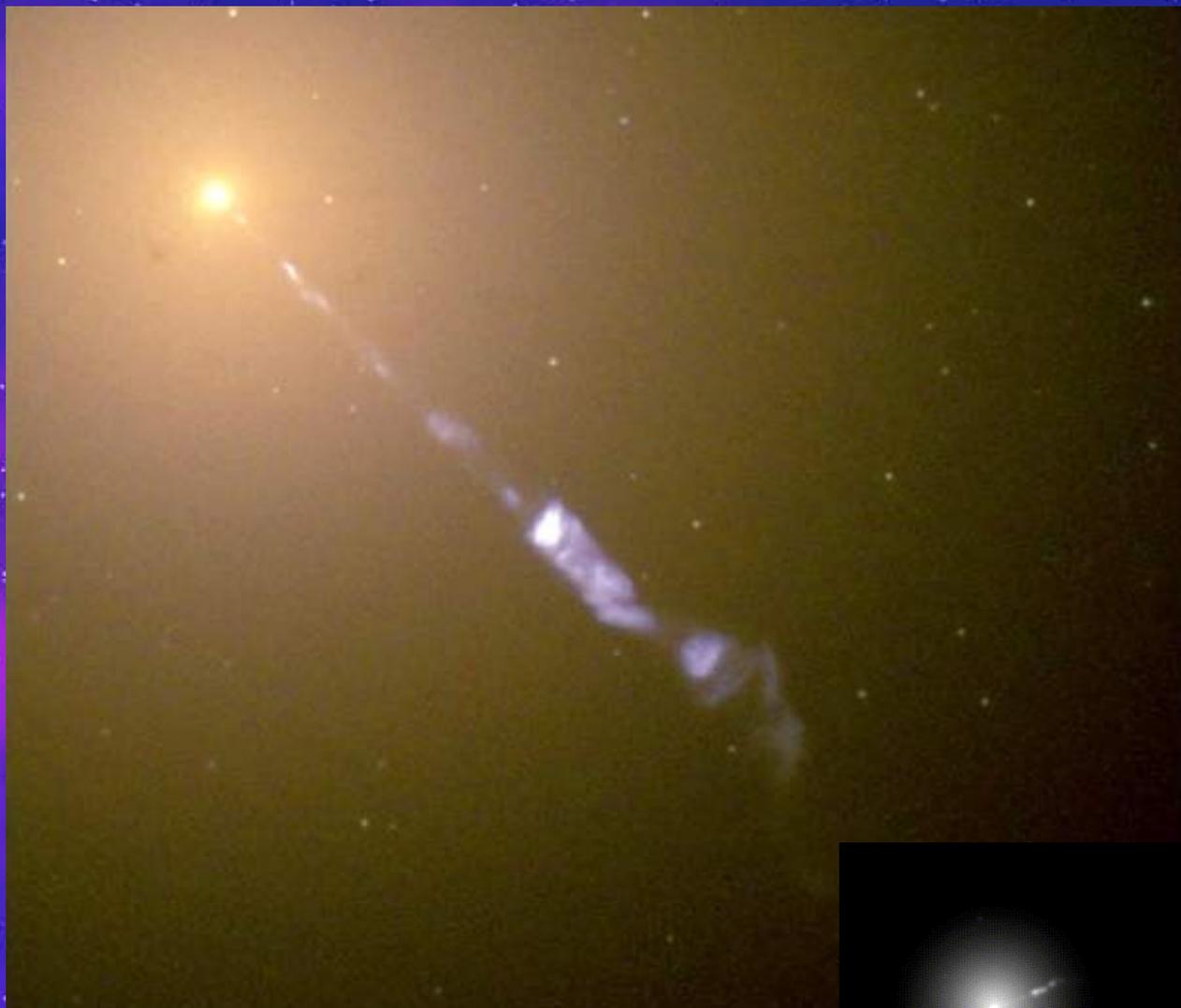


M89



M32

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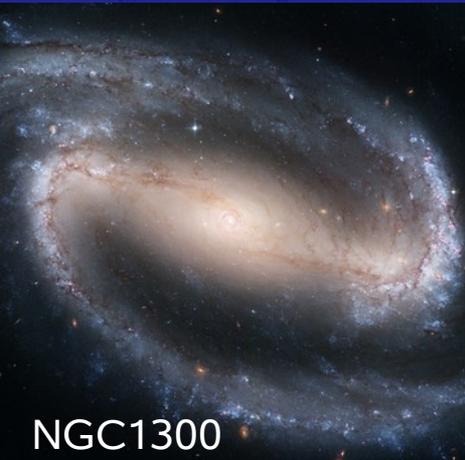


Núcleo de M87

Estrelas e galaxias



As galaxias: espirais



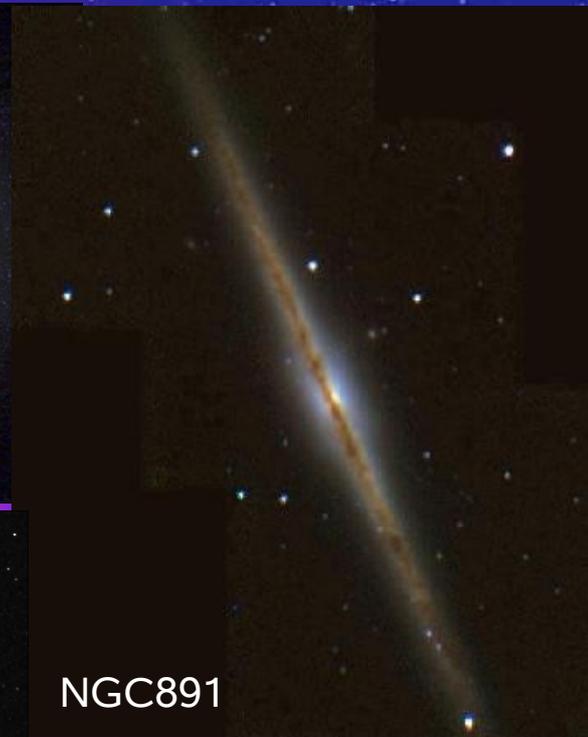
NGC1300



NGC253 (SB)



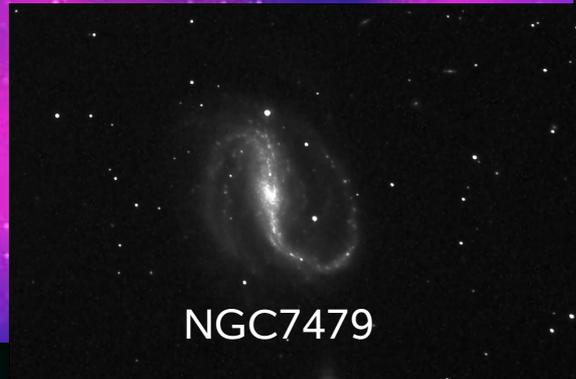
NGC7742



NGC891



M74



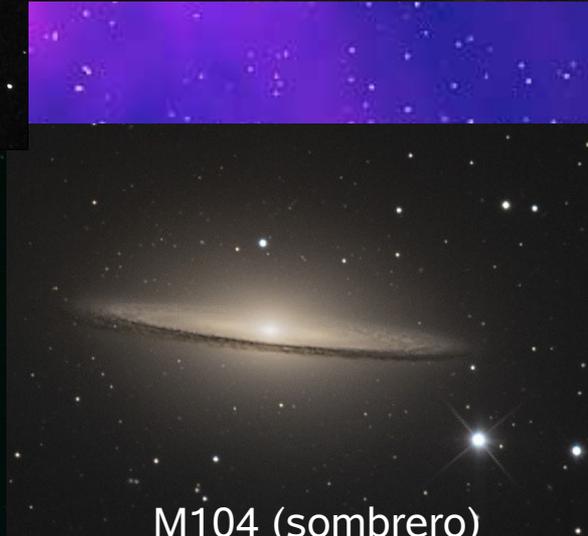
NGC7479



M51+NGC 5195

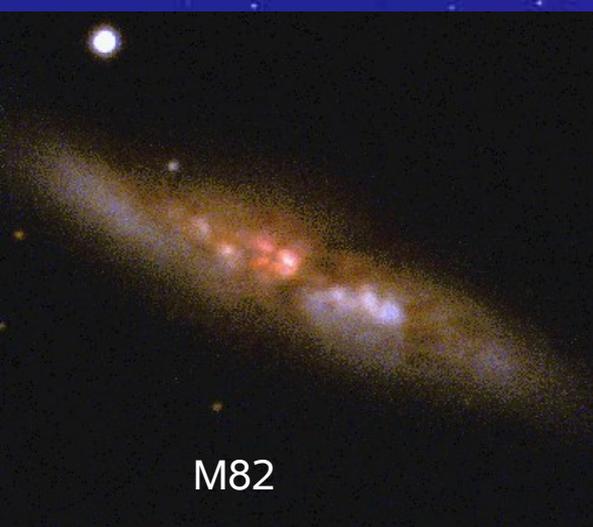


NGC4013

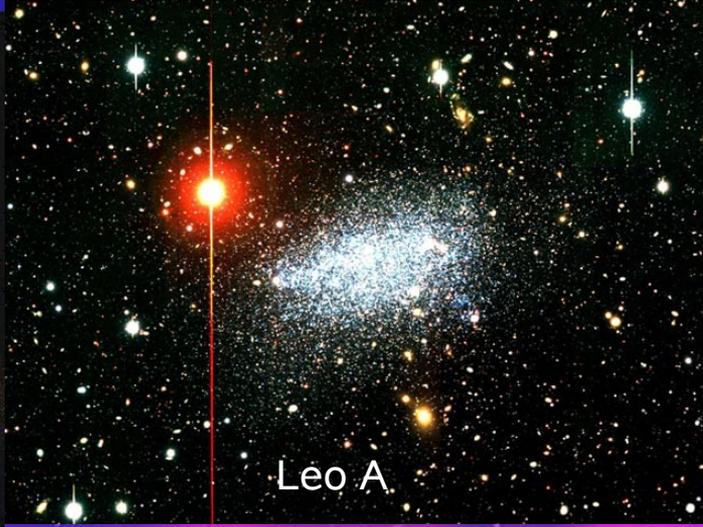


M104 (sombrero)

As galaxias: irregulares



M82



Leo A

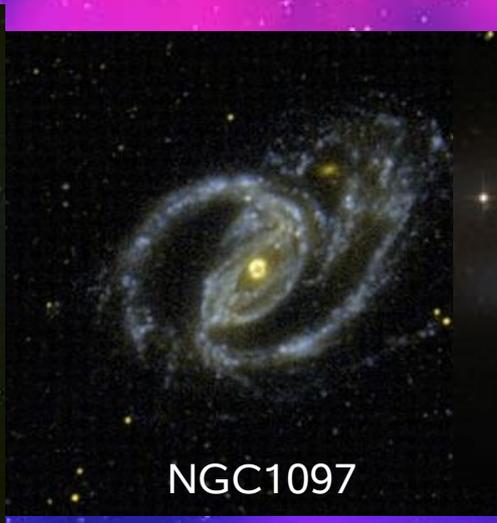


Gran Nube de Magallanes



Centaurus A

01-marzo 2010



NGC1097

Estrelas e galaxias



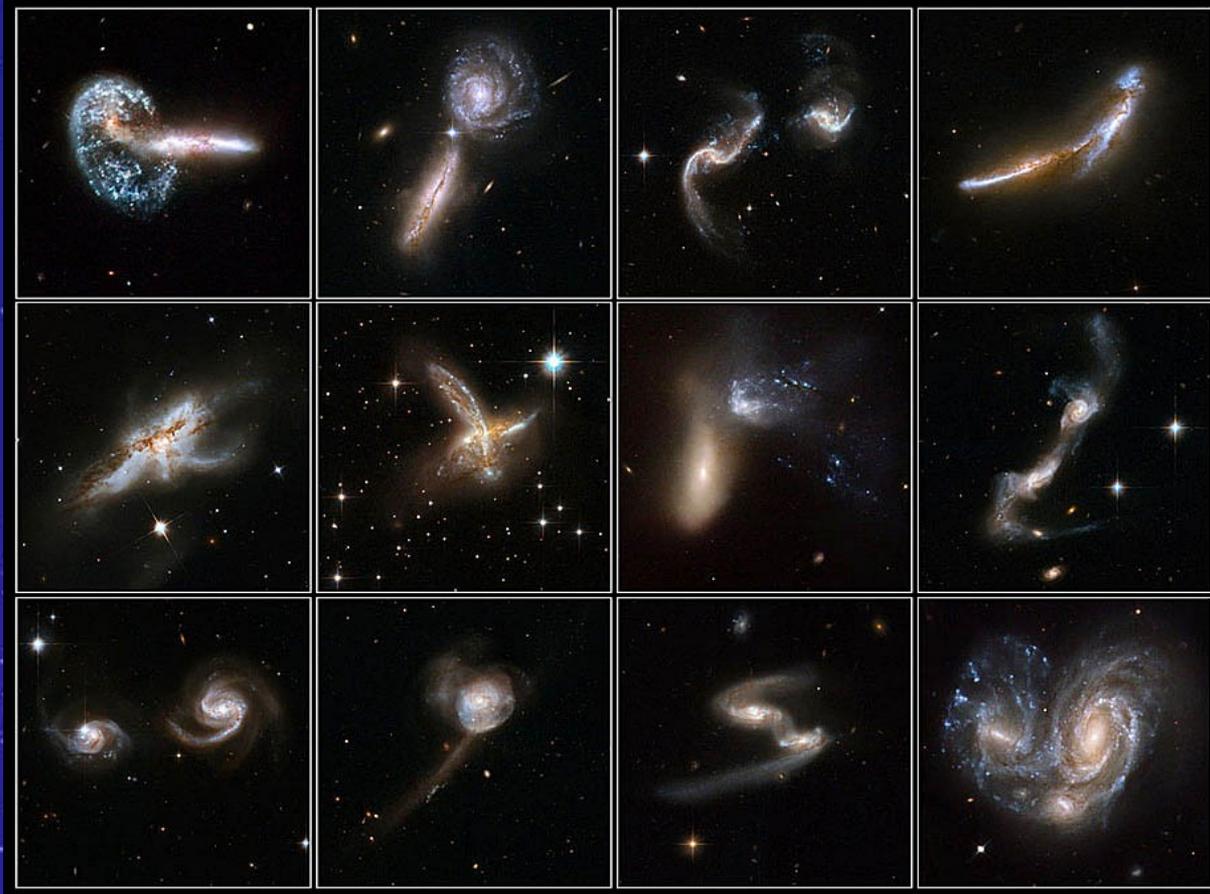
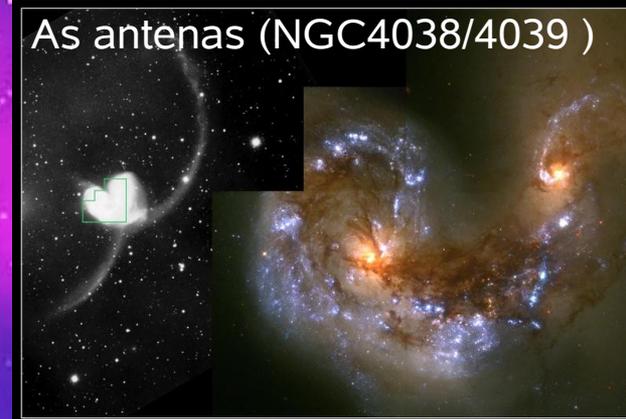
NGC520

As galaxias: interaccións

A roda da carreta (ESO 350-40)



As antenas (NGC4038/4039)



Colisión de 2 espiráis

Colisión múltiple

Colisión de 2 galaxias con buratos negros supermasivos

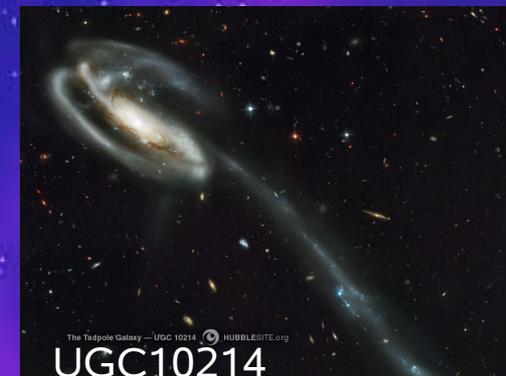
A Vía Láctea vs Galaxia de Andrómeda

01 marzo 2010

Simulación das antenas

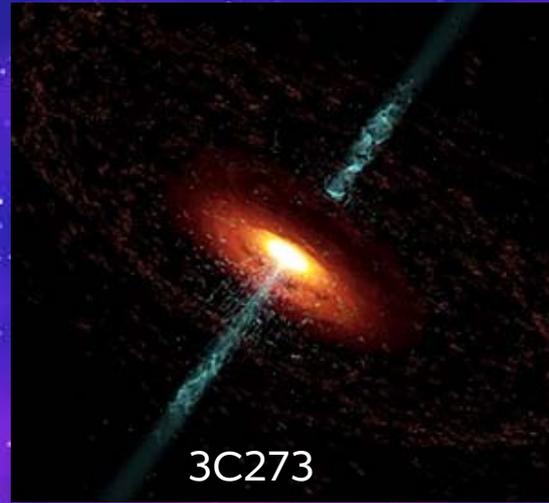
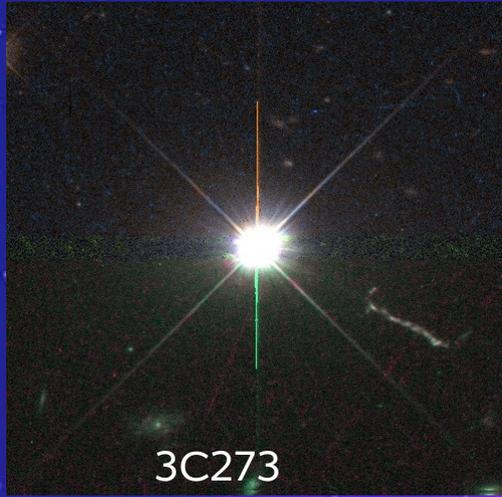
Simulación das antenas 2

Estrelas e galaxias

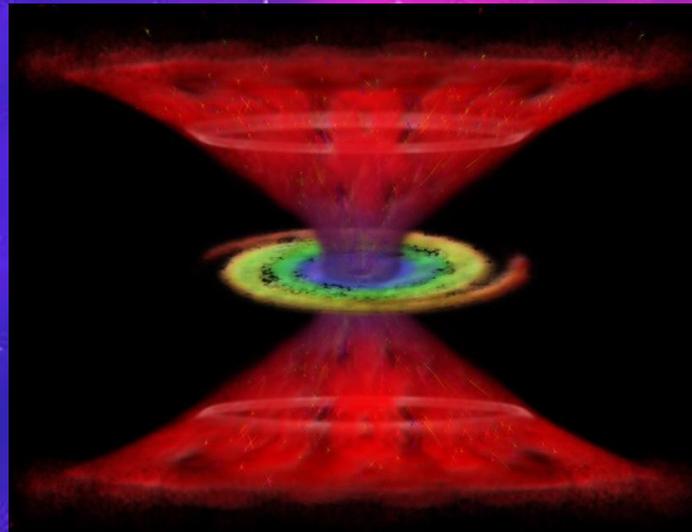


The Tadpole Galaxy — UGC 10214 — HUBBLESITE.org
UGC10214

As galaxias: galaxias activas



- Galaxias de Seyfert
- Quásares
- Objetos BL Lac (blazars)



Core of Galaxy NGC 4261
Hubble Space Telescope
Wide Field / Planetary Camera

Ground-Based Optical/Radio Image HST Image of a Gas and Dust Disk

380 Arc Seconds
88,000 LIGHTYEARS

17 Arc Seconds
400 LIGHTYEARS

01-marzo 2010

Estrelas e galaxias

As galaxias: grupos e cúmulos

Grupos:

-menos de 50 galaxias

-tamaño de 1 ou 2 Mpc

$\sim 10^{13} M_{\text{sol}}$

Ex: o Grupo Local

Cúmulos:

-50 a 1000 galaxias

-2 a 10 Mpc

$\sim 10^{15} M_{\text{sol}}$

Ex: os cúmulos de Virgo e Coma

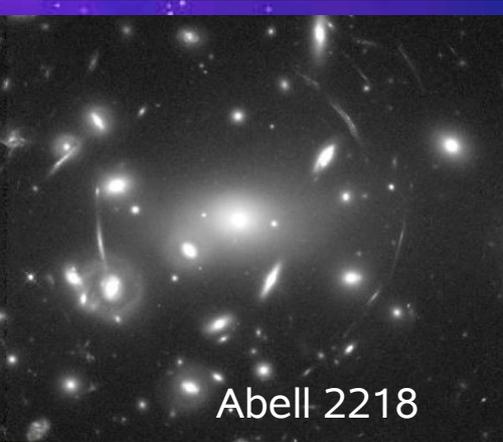
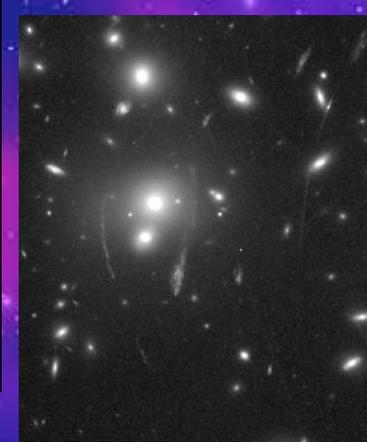
Cúmulo de Virgo



Hickson 44



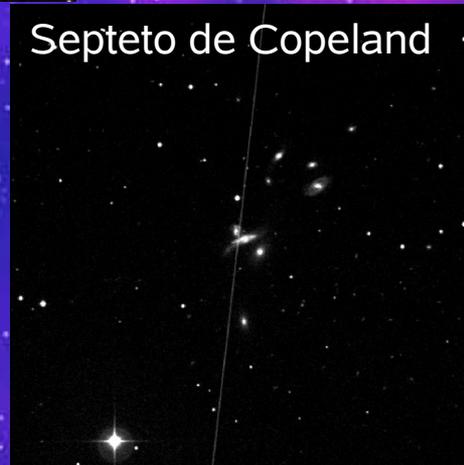
Sexteto de Seyfert



Abell 2218



Quinteto de Stefan



Septeto de Copeland

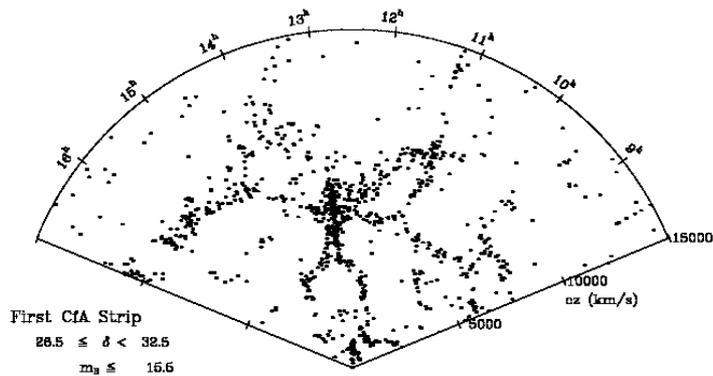


Abell 1689



Abell S0740

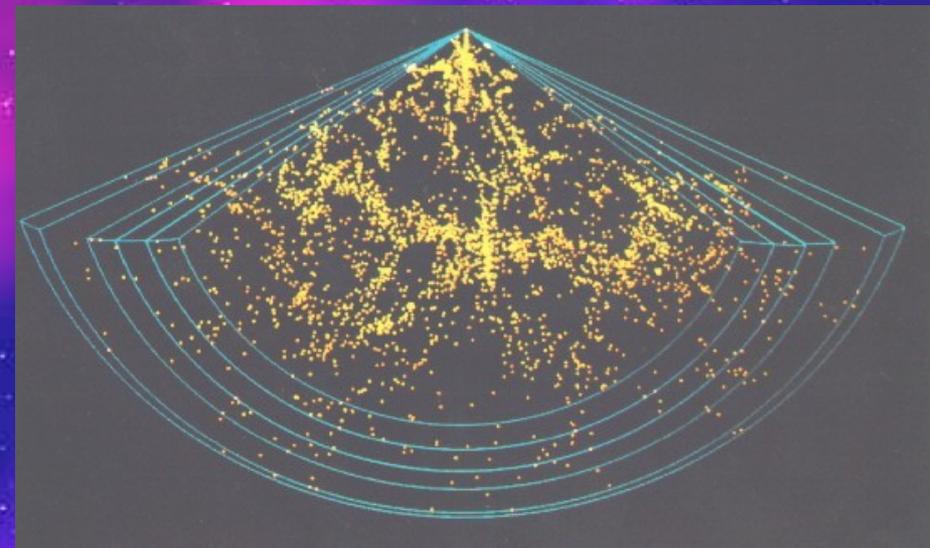
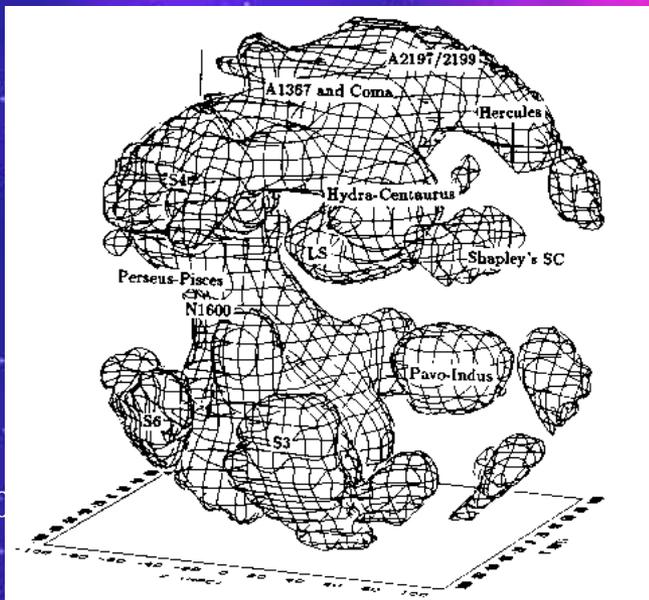
A estrutura do Universo



1 CfA survey



2 CfA survey (4000 galaxias)



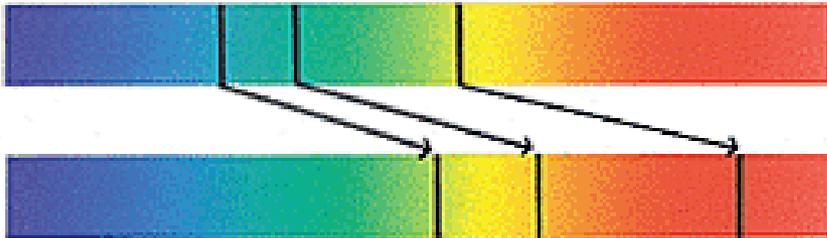
Geller and Huchra 1989, Science 246, 897

Estrelas e galaxias

Distribución suavizada de galaxias en 3D

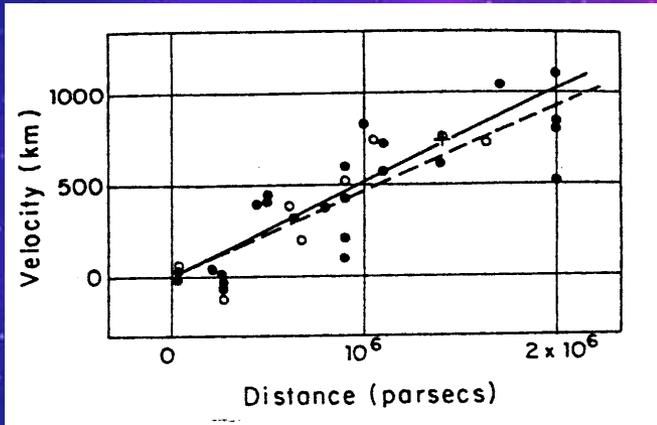
A expansão do Universo

Spectrum of motionless light source



Spectrum of receding galaxy

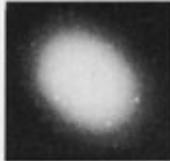
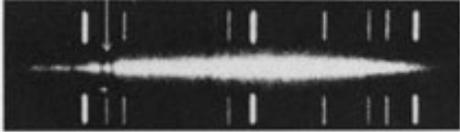
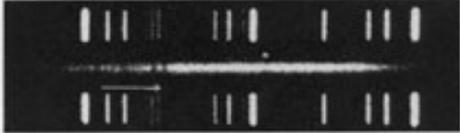
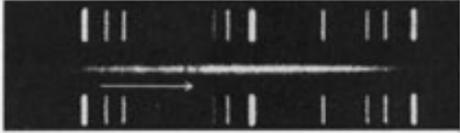
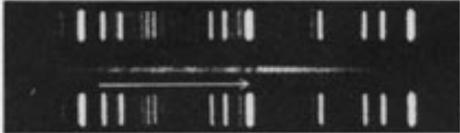
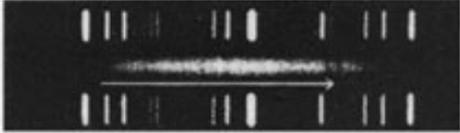
$$z = (\lambda_0 - \lambda_e) / \lambda_e = \Delta\lambda / \lambda_e = v/c$$



Lei de Hubble:

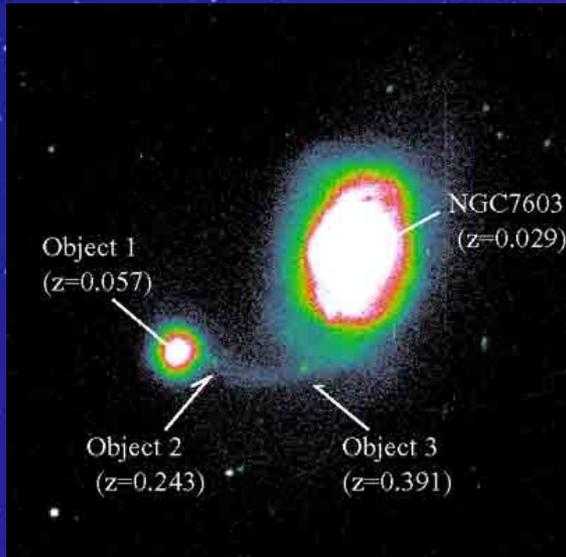
$$v = H_0 d, \quad H_0 = 72 \pm 8 \text{ km/s/Mpc}$$

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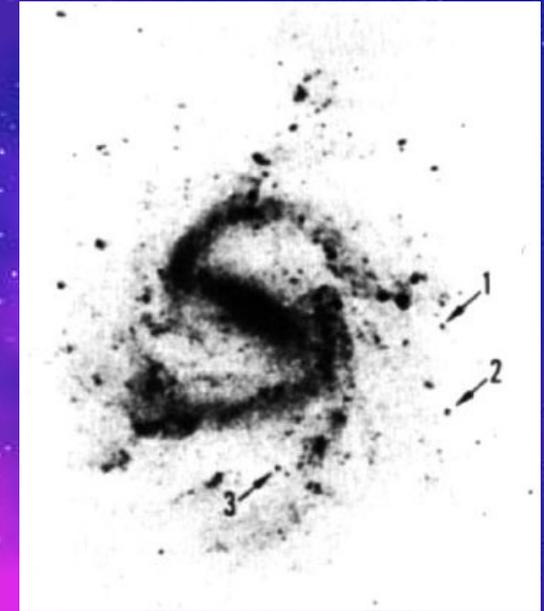
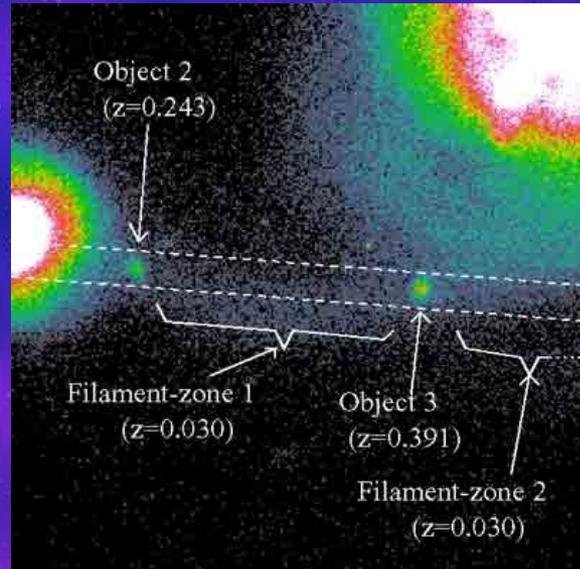
Cluster nebula in	Distance in light-years	Redshifts
 Virgo	78,000,000	 H + K 1,200 km s ⁻¹
 Ursa Major	1,000,000,000	 15,000 km s ⁻¹
 Corona Borealis	1,400,000,000	 22,000 km s ⁻¹
 Bootes	2,500,000,000	 39,000 km s ⁻¹
 Hydra	3,960,000,000	 61,000 km s ⁻¹

As galaxias: controversia

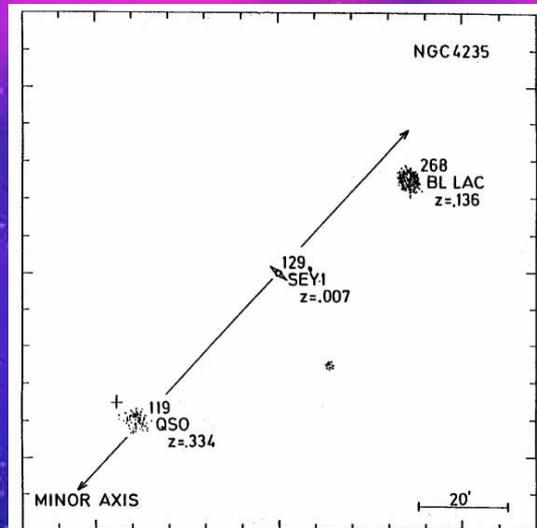
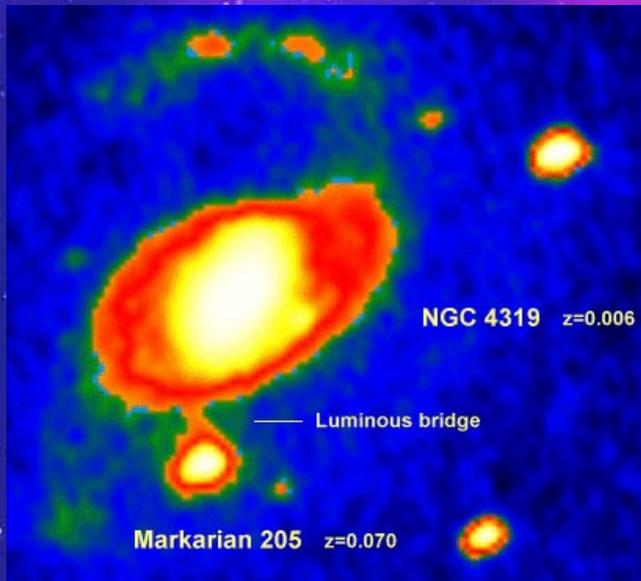
Algúns non creen nada do que vos acabo de contar



NGC7603 + quasar (López-Corredoira & Gutiérrez 2002)



NGC1073 con 3 quasares



1997 - X-RAY SOURCES ASSOCIATED WITH SEYFERTS AT 7.5σ LEVEL. BRIGHTEST TEND TO BE QUASARS ALONG THE MINOR AXIS. THESE TWO SOURCES ARE 268 AND 119 COUNTS PER KILOSEC!

¿Astrónomos proscritos?
Halton Arp
G. Burbidge & M. Burbidge
J. Narlikar

Actividades:

Identificar pares de estrelas de diferentes cores.

Obter a curva de luz dunha estrela variable (por exemplo delta Cep).

Localizar con prismáticos a galaxia de Andrómeda (M31).

Localizar con prismáticos a nebulosa de Orión.

Referencias e recursos:

Libros e unidades didácticas:

“Extreme stars”. James Kaler. Cambridge University Press, 2001

“An introduction to modern astrophysics”. BW Carroll, DA Ostlie. Addison-Wesley, 1996
 (“o ladrillo roxo”)

“Cosmos”. Carl Sagan. Planeta.

“Unidades didácticas del IAC”: <http://www.iac.es/divulgacion.php?op1=18&op2=51>

“Observing variable stars”. David H. Levy. Cambridge University Press, 1989
 (excelente).

Webs:

Artigo da wikipedia sobre constelacións:

<http://es.wikipedia.org/wiki/Constelaci%C3%B3n>

Programa para simular binarias eclipsantes: <http://www.midnightkite.com/binstar.html>

Ducias de simulacións científicas (varias astronómicas):

<http://www.ba.infn.it/~zito/museo/leonardoen.html>

Máis animacións: <http://www.astro.ubc.ca/~scharein/applets/#Sim>

Web dos primeiros mapas da distribución de galaxias:

<http://cfa-www.harvard.edu/~huchra/zcat/>

Controversia no corremento ó roxo:

<http://www.haltonarp.com/>

<https://eee.uci.edu/clients/bjbecker/ExploringtheCosmos/week10e.html>

<http://www.astr.ua.edu/keel/galaxies/arp.html>