



Universidad Nacional de Río Negro

Int Partículas, Astrofísica & Cosmología - 2020

- **Unidad** 03-Astrofísica: escalas
- **Clase** UO3C01 - 11/16
- **Fecha** 13 Oct 2020
- **Cont** Galaxias
- **Cátedra** Asorey
- **Web** <https://gitlab.com/asoreyh/unrn-ipac/>



Contenidos: un viaje en el tiempo y el espacio

HOW DID OUR UNIVERSE BEGIN?

In the first second of the universe's life, it grew exponentially larger than it had in all previous time since the Big Bang. This period of rapid expansion, called inflation, occurred about 10⁻³⁴ seconds after the Big Bang. It stretched the fabric of space-time by a factor of at least 10²⁶. The universe expanded, cooled, and eventually filled with a soup of subatomic particles called quarks.

Infation
Age: 10⁻³⁴ seconds
Size: Infinitesimal to golf ball

Early building blocks
The universe expands, cools. Quarks clump into protons and neutrons, creating the first building blocks of atomic nuclei. Perhaps dark matter forms.

First nucleci
As the universe continues to cool, the light of hydrogen atoms arise. A thick block of particles forms at .01 milliseconds.

First atoms, first light
Quarks begin orbiting nuclei, creating atoms. The glow from their inflection points is unveiled. This light is as far back as our instruments can see.

The "dark ages"
For 300 million years this continues. Light is the only light. Clumps of matter that will become galaxies glow brightest.

Gravity wins: first stars
Dense gas clouds collapse under their own gravity. As they grow, they form galaxies and stars. Fusion lights up the stars.

Antigravity wins
After being slowed for billions of years, cosmic expansion accelerates again. The culprit: dark energy. Its nature: unclear.

Today
The universe continues to expand, becoming ever less dense. As a result, fewer new stars and galaxies are forming.

COSMIC QUESTIONS

In the 20th century the universe became a story—a scientific one. It had always been seen as static and eternal. Then astronomers observed other galaxies flying away from ours, and Einstein's general relativity theory implied space itself was expanding—which meant the universe had once been denser. What had seemed eternal now had a beginning and an end. But what beginning? What end? Those questions are still open.

WHAT IS OUR UNIVERSE MADE OF?

Stars, dust and gas—the stuff we can discern—make up less than 5 percent of the universe. Their gravity can't account for how galaxies hold together. Scientists figure about 24 percent of the universe is a mysterious dark matter—perhaps exotic particles formed right after inflation. The rest is dark energy, an unknown energy field or property of space that counters gravity, providing an explanation for observations that the expansion of space is accelerating.

The Universe
71.5% Dark energy
24% Dark matter
4% Gas
0.5% Planets and stars

WHAT IS THE SHAPE OF OUR UNIVERSE?

Einstein discovered that a star's gravity curves space around it. But is the whole universe curved? Might space close up on itself like a sphere or curve the other way, opening out like a saddle? By studying cosmic background radiation, scientists have found that the universe is poised between the two: just dense enough with just enough gravity to be almost perfectly flat, at least the part we can see. What lies beyond we can't know.

Observable Universe
The universe began 13.8 billion years ago. Because it has been expanding ever since, the farthest observable edge is now 47 billion light-years away.

The Unknown Edge
For what we can't see, the possible shapes are many.

Flat
Saddle
Sphere

Unidad 3 Astrofísica, escalas grandes

Unidad 2 Astrofísica, escalas medias

DO WE LIVE IN A MULTIVERSE?

What came before the big bang? Maybe other big bangs. The uncertainty principle holds that even the vacuum of space has density fluctuations. Inflation theory says our universe exploded from such a fluctuation—a random event that, odds are, had happened many times before. Our cosmos may be one in a sea of others just like ours—or nothing like ours. These other cosmos will very likely remain forever inaccessible to observation, their possibilities limited only by our imagination.

HOW WILL IT END?

Which will win in the end, gravity or antigravity? Is the density of matter enough for gravity to halt or even reverse cosmic expansion, leading to a big crunch? It seems unlikely—especially given the power of dark energy, a kind of antigravity. Perhaps the acceleration in expansion caused by dark energy will trigger a big rip that shreds everything, from galaxies to atoms. If not, the universe may expand for hundreds of billions of years, long after all stars have died.

Big crunch
Big rip
Infinite expansion
Galaxies ripped apart by rapid expansion

Unidad 1 Partículas, lo más pequeño

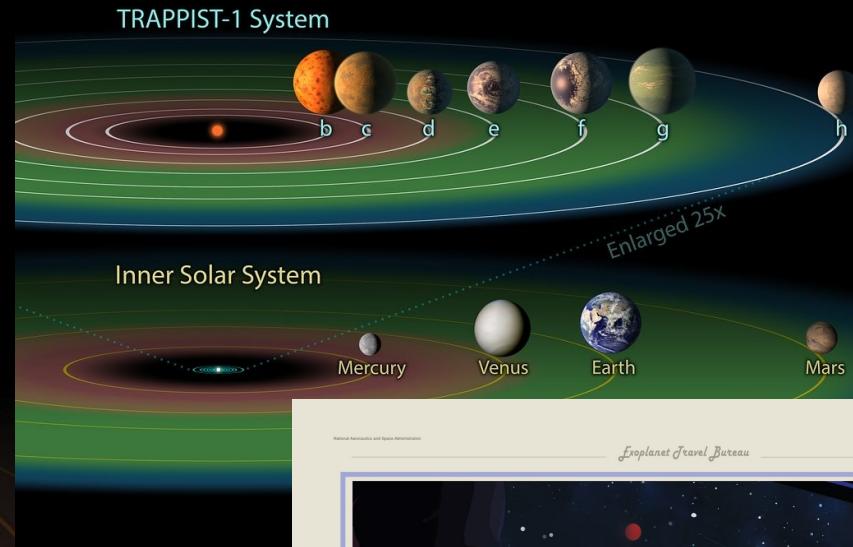
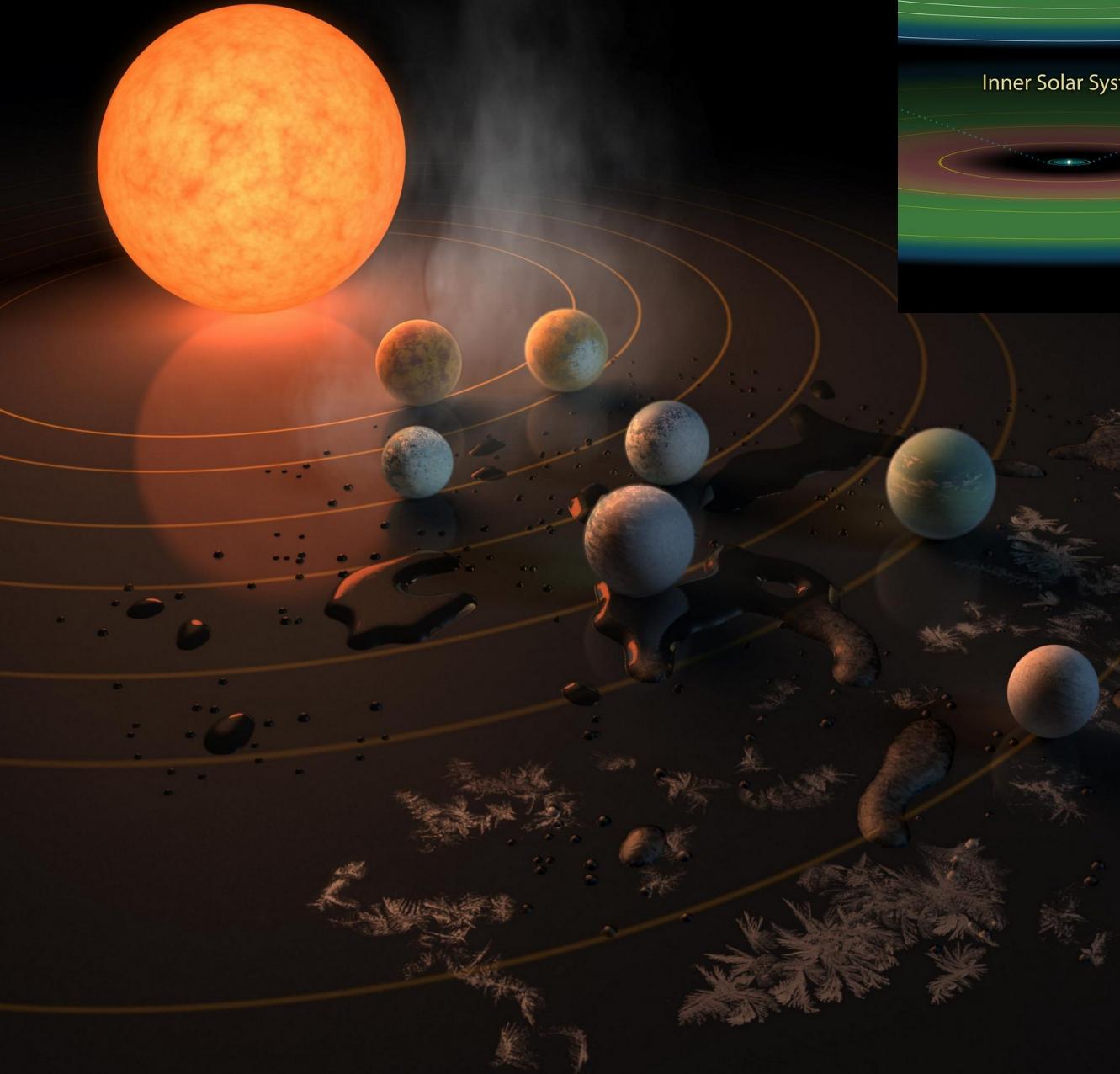


U3: Astrofísica, escalas grandes

3 encuentros, del 13/Oct al 27/Oct

- Relatividad General.
 - Introducción y conceptos básicos.
 - Solución de Schwarzschild.
 - Objetos compactos: enanas blancas, estrellas de neutrones y agujeros negros.
- Formación de estructuras
 - Galaxias: Modelos y formación. **GalaxyZoo**.
 - Galaxias de Núcleos activos. **Clasificación**.
 - Formación de estructuras. Corrimiento al rojo y el universo en expansión.
- Trabajo de la unidad: **Midiendo distancias en el Universo.**
Entrega Viernes 30/Oct/2020

Sistema Trappist 1



Some 40 light-years from Earth, a planet called TRAPPIST-1 offers a heart-stopping view: brilliant objects in a red sky, looming like larger and smaller versions of our own moon. But these are no moons. They are other Earth-sized planets in a spectacular planetary system outside our own. These seven rocky worlds huddle around their small, dim, red star, like a family around a campfire. Any of them could harbor liquid water, but the planet shown here, fourth from the TRAPPIST-1 star, is in the habitable zone, the area around the star where liquid water is most likely to be detected. This system was revealed by the TRAnsiting Planets and Planetesimals Small Telescope (TRAPPIST) and NASA's Spitzer Space Telescope. Take a planet-hopping excursion through the TRAPPIST-1 system.

<https://exoplanets.nasa.gov/>

The screenshot shows the homepage of the NASA Exoplanet Exploration website. The header features the NASA logo and the text "EXOPLANET EXPLORATION Planets Beyond Our Solar System". To the right are links for "What is an Exoplanet?", "Explore", "News", "Multimedia", "More", and "For Scientists". A search bar is also present. The main visual is a large, detailed illustration of a green, rocky exoplanet against a dark, star-filled background. Below the illustration, the text "Search for New Worlds at Home With NASA's Planet Patrol Project" is displayed, followed by a dropdown menu icon. At the bottom, there is a summary of current findings: "Exoplanets 4,284 CONFIRMED", "NASA CANDIDATES 5,573", "PLANETARY SYSTEMS 3,179", and links to "Glossary" and "FAQ". A note indicates the data was last updated on October 4, 2020.

click to expand

Exoplanets	4,284 CONFIRMED	NASA CANDIDATES	3,179 PLANETARY SYSTEMS	Glossary ›	FAQ ›
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Last update: October 4, 2020

<https://exoplanets.nasa.gov/eyes-on-exoplanets>

The screenshot shows a 3D visualization of the Milky Way Galaxy. The Sun is located at the center of the visible disk of stars. A bright yellow and white starburst surrounds the Sun, representing the galactic plane. Numerous smaller stars of various colors (yellow, orange, white) are scattered throughout the dark background, representing other stars and stellar systems. In the bottom left corner, there is a text overlay: "Milky Way Galaxy" with a small icon, "3,179 solar systems | 4,284 confirmed planets". On the left side, a message says "You are 8,774 light-years from Earth". The top navigation bar includes the NASA logo, the title "EYES ON EXOPLANETS beta", and links for "HOME", "BROWSE PLANETS", "MISSIONS", and a search icon. A "FILTER" button is located in the bottom right corner, with options for "Planet Type", "Missions", and "Observatory". The status "Current filter: All Planet Types" is displayed below the filter button.



Vida, por Wikipedia

<https://es.wikipedia.org/wiki/Vida>

- “puede definirse como la capacidad de administrar los recursos internos de un ser físico de forma adaptada a los cambios producidos en su medio, sin que exista una correspondencia directa de causa y efecto entre el ser que administra los recursos y el cambio introducido en el medio por ese ser, sino una asymptota de aproximación al ideal establecido por dicho ser, ideal que nunca llega a su consecución completa por la dinámica del medio”

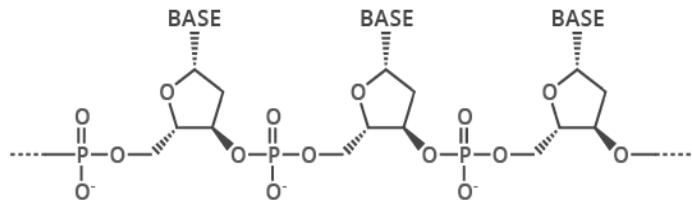


Para la biología, si está vivo tiene que...

- (auto)organización
- crecimiento
- reproducción
- evolución
- homeostasis
- Movimiento
- Si falta algo de esto → no está vivo (**virus, viroides, células cancerosas**)

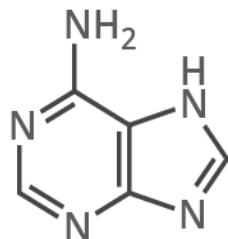
THE CHEMICAL STRUCTURE OF DNA

THE SUGAR PHOSPHATE 'BACKBONE'

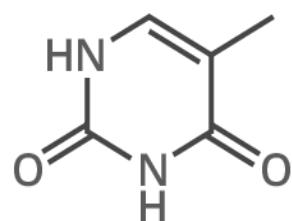


DNA is a polymer made up of units called nucleotides. The nucleotides are made of three different components: a sugar group, a phosphate group, and a base. There are four different bases: adenine, thymine, guanine and cytosine.

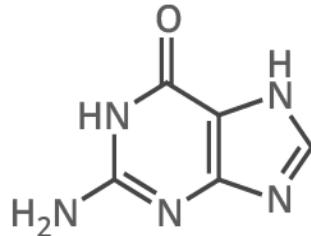
A ADENINE



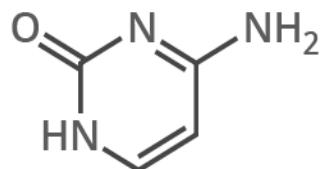
T THYMINE



G GUANINE

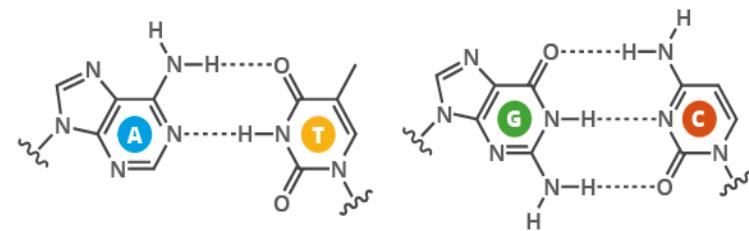


C CYTOSINE



WHAT HOLDS DNA STRANDS TOGETHER?

DNA strands are held together by hydrogen bonds between bases on adjacent strands. Adenine (A) always pairs with thymine (T), while guanine (G) always pairs with cytosine (C). Adenine pairs with uracil (U) in RNA.



FROM DNA TO PROTEINS

The bases on a single strand of DNA act as a code. The letters form three letter codons, which code for amino acids - the building blocks of proteins.



An enzyme, RNA polymerase, transcribes DNA into mRNA (messenger ribonucleic acid). It splits apart the two strands that form the double helix, then reads a strand and copies the sequence of nucleotides. The only difference between the RNA and the original DNA is that in the place of thymine (T), another base with a similar structure is used: uracil (U).

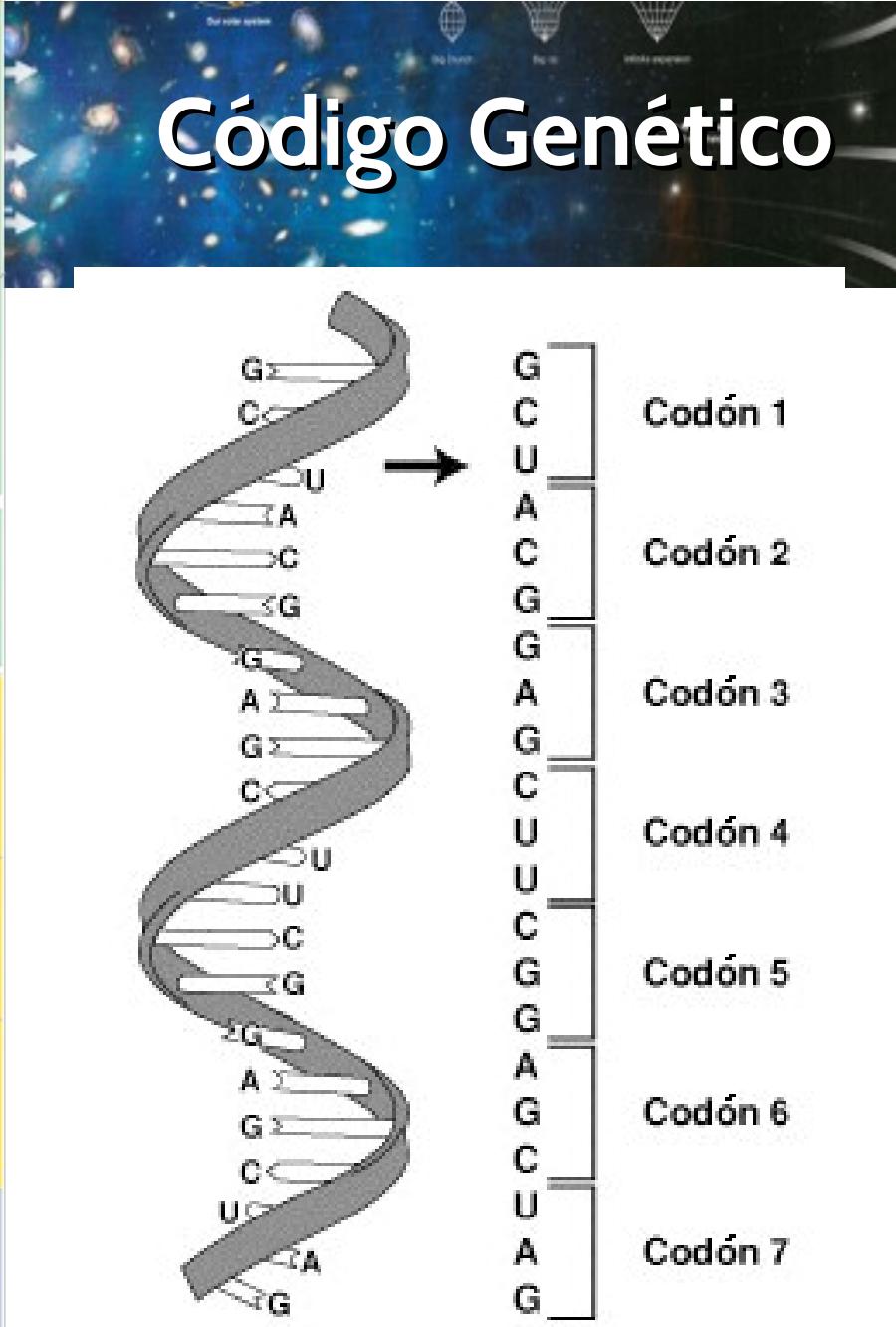
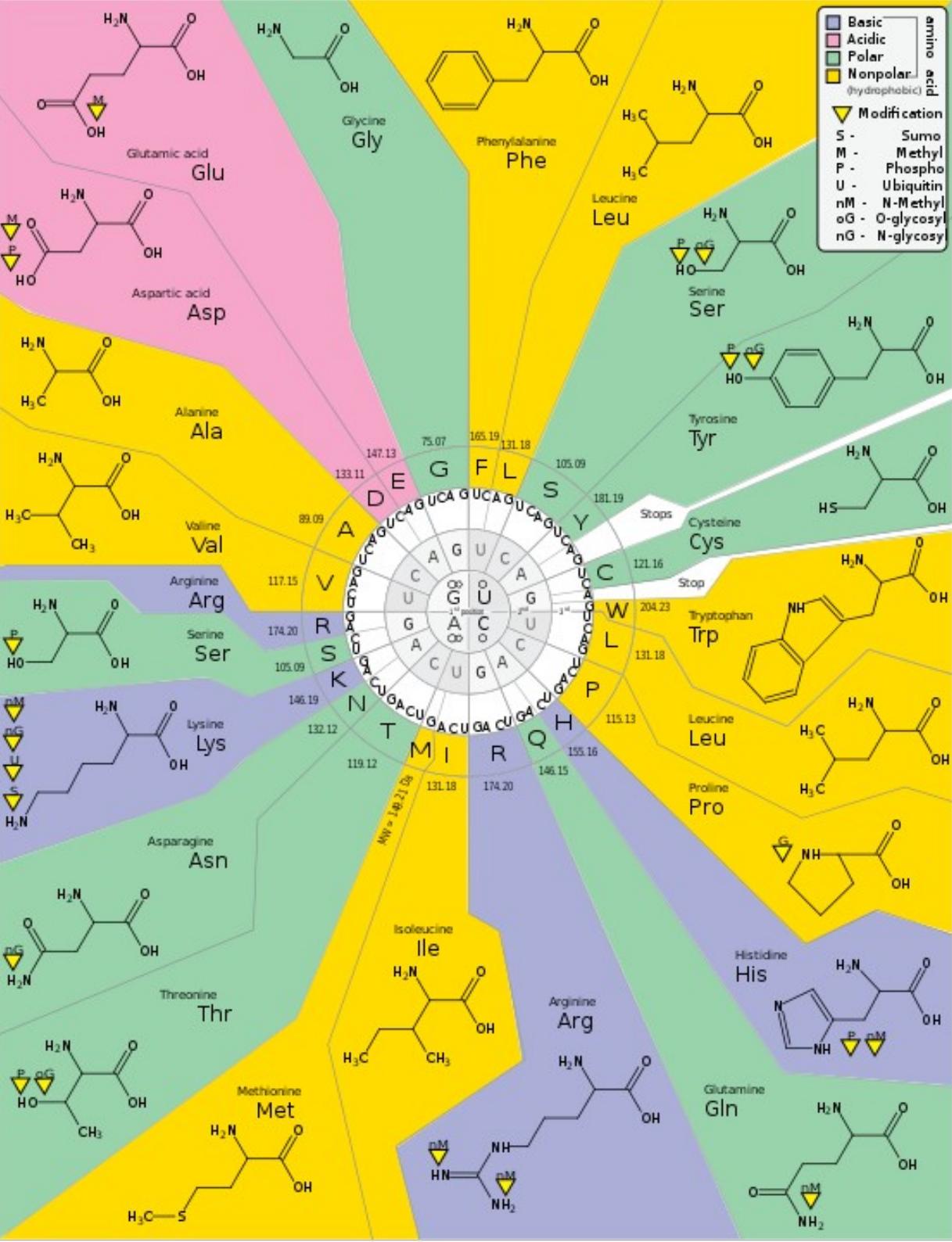
DNA SEQUENCE T T C C T G A A C C C G T T A

mRNA SEQUENCE U U C C U G A A C C C G U U A

AMINO ACID Phenylalanine Leucine Asparagine Proline Leucine

In multicellular organisms, the mRNA carries genetic code out of the cell nucleus, to the cytoplasm. Here, protein synthesis takes place. 'Translation' is the process of turning the mRNA's 'code' into proteins. Molecules called ribosomes carry out this process, building up proteins from the amino acids coded for.

Código Genético

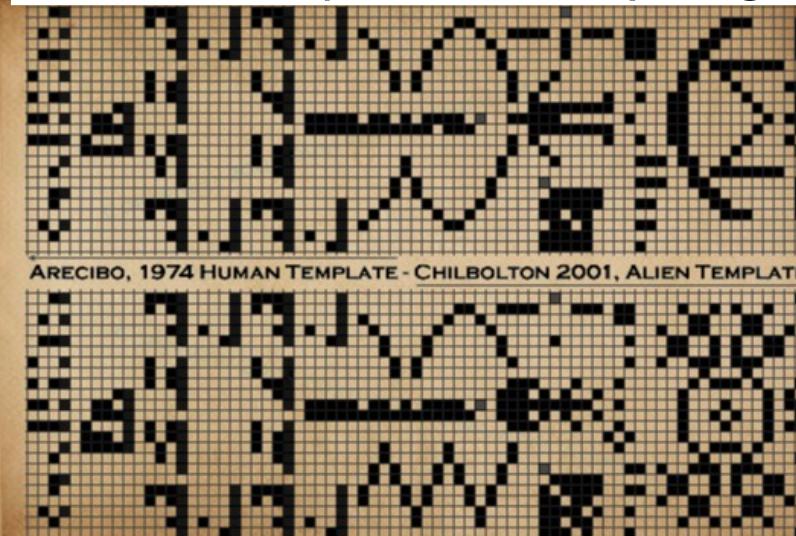


ARN
Ácido ribonucleico

B

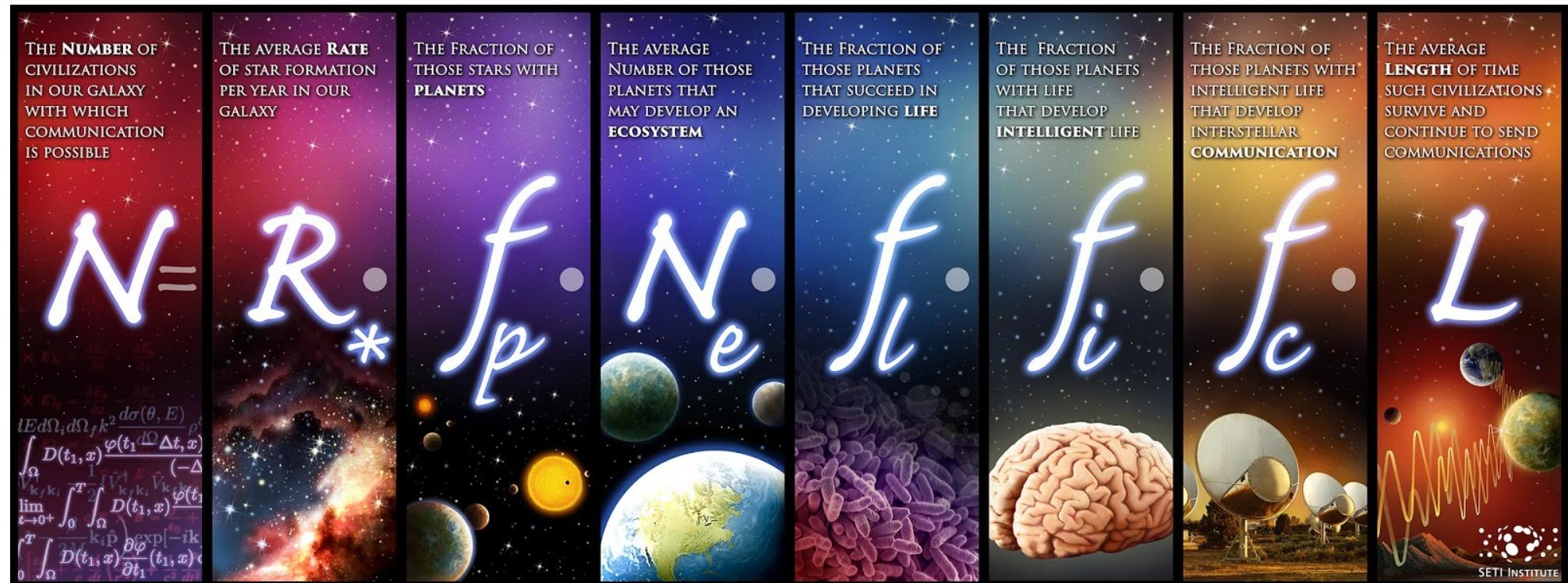
Mensaje de Arecibo

- 1679 bits enviados a M13 (8 kpc) (16/Nov/1974)
 - Diseñado por Carl Sagan y Frank Drake
 - Números 0 al 9 en binario
 - Componentes del ADN (HCNOP)
 - Nucleótidos y doble hélice
 - Humanidad, altura y población humana 1974
 - Sistema Solar (Sol y Planetas → Tamaño)
 - Telescopio, medidas y longitud de onda



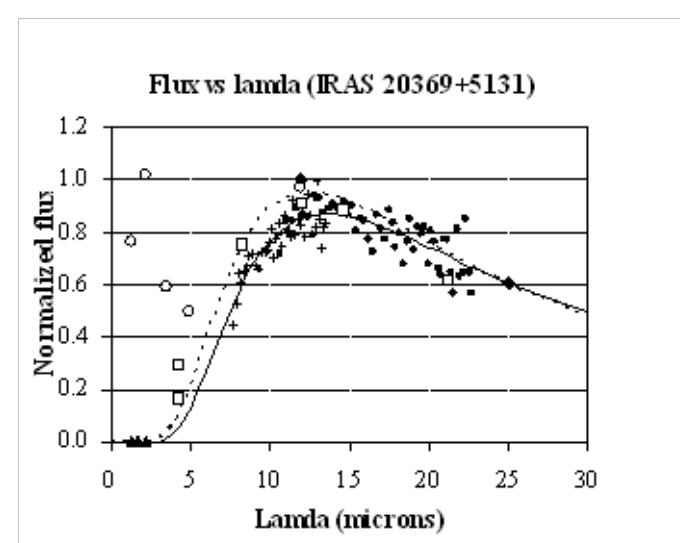
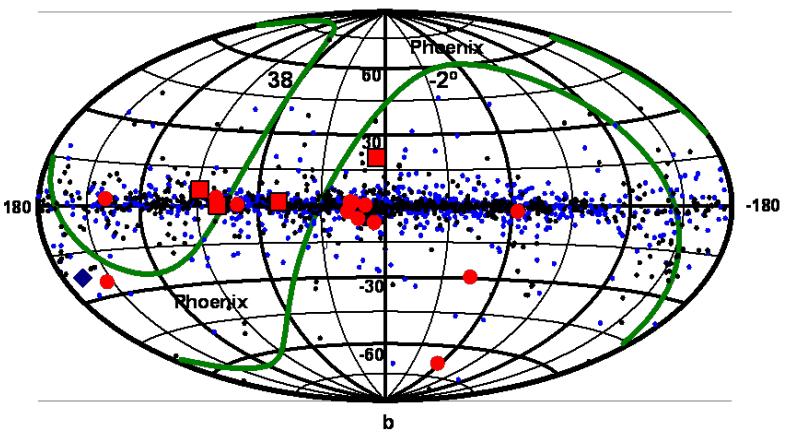
La ecuación de Drake

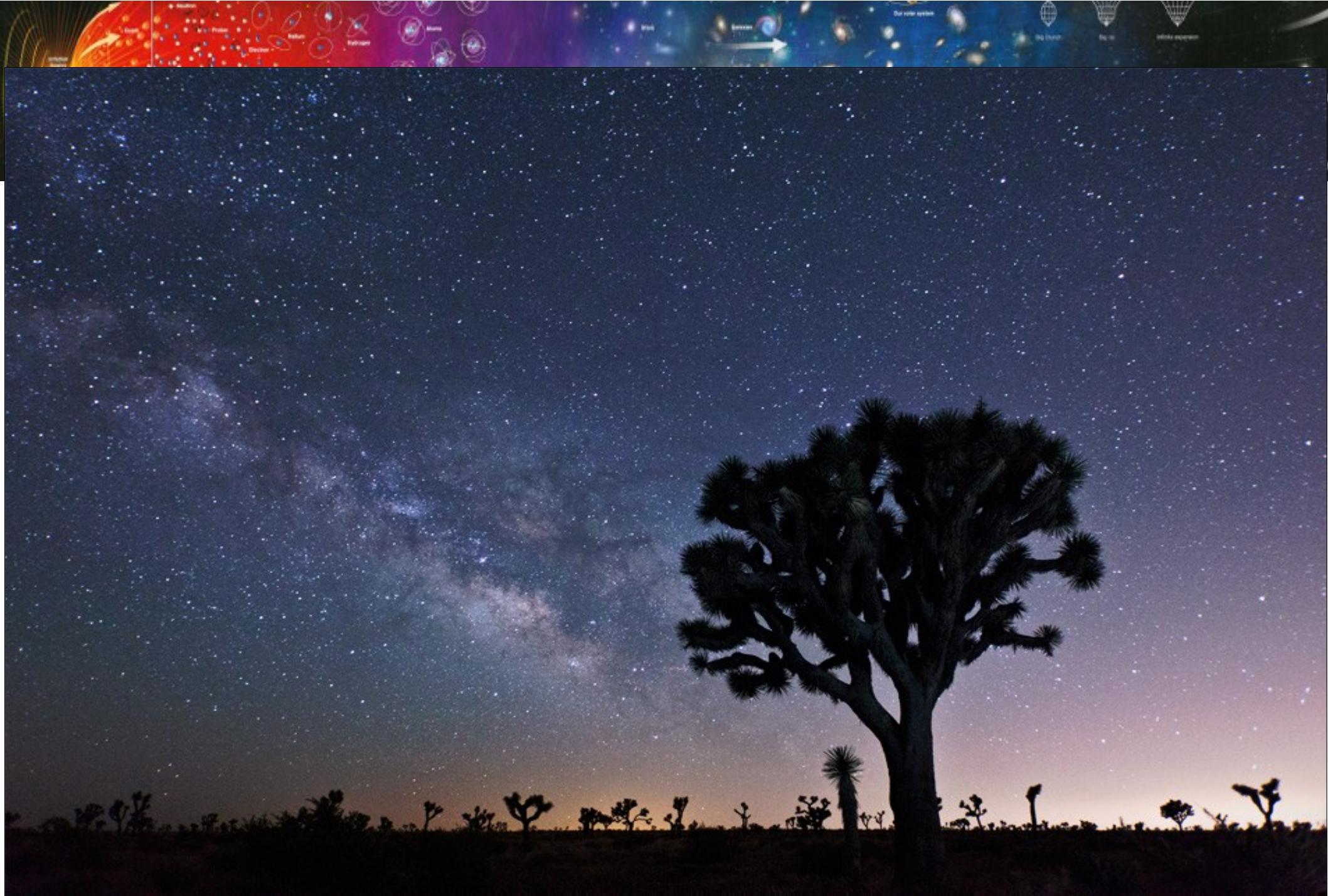
<https://steemit.com/cervantes/@simonmaz/planetas-extrasolares-x--1526399175-5431302>



IRAS (InfraRed Astronomical Satellite)

http://home.fnal.gov/~carrigan/infrared_astronomy/Termilab_search.htm



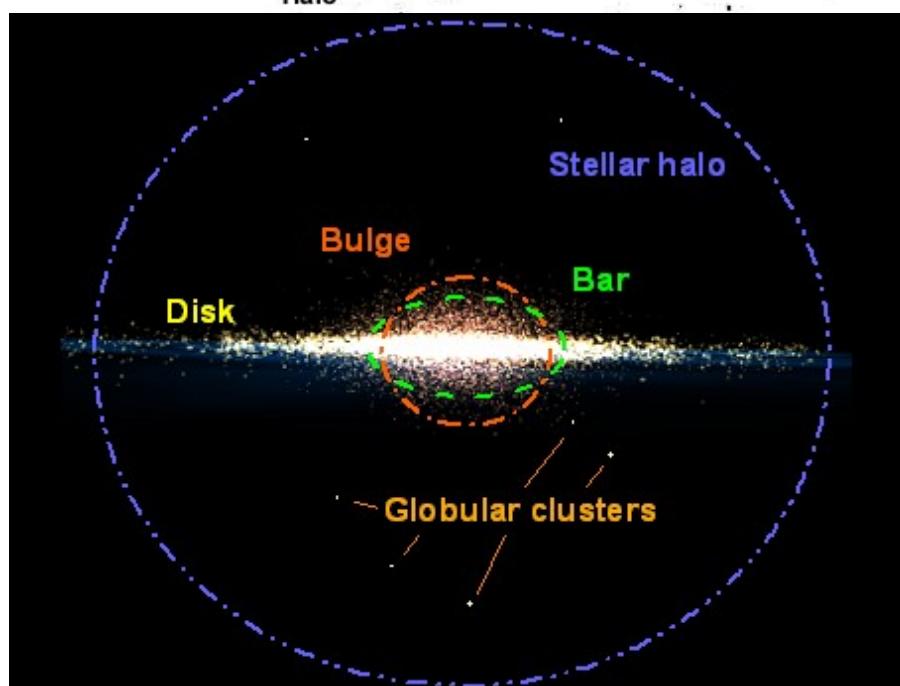
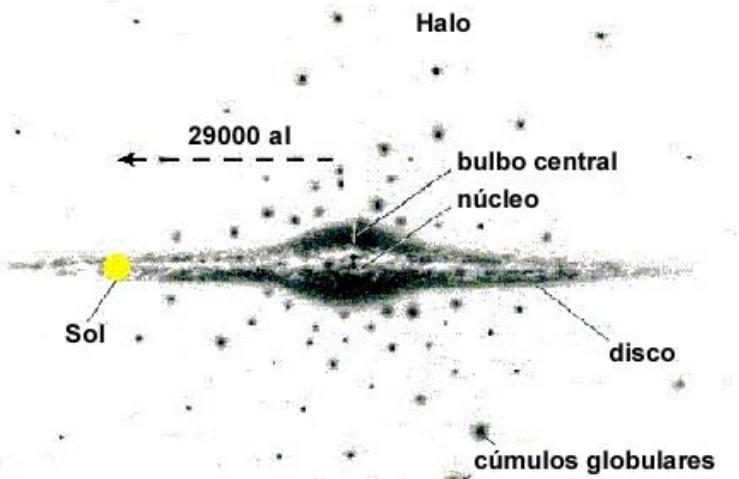


Galaxias



- Una **galaxia** es un sistema autogravitante compuesto por:
 - Estrellas (Vía Láctea: 10^{11} estrellas)
 - Remanentes estelares
 - Un medio interestelar formado por gas y polvo...
 - Un agujero negro central (no en todas, pero...)
 - Materia oscura (no está confirmada, pero...)
- **Tamaños:**
 - Enanas (~1000 estrellas, 1000 pc)
 - Gigantes (100000 pc, 10^{14} estrellas)
- Están separadas por distancias ~Mpc (1 Mpc ~ $3,1 \times 10^{22}$ m)

Componentes de una galaxia



- **Disco**

- Estrellas (solas o en cúmulos abiertos), polvo y gas distribuidos en forma de un disco delgado

- **Bulbo**

- Distribución esférica de estrellas viejas y rojizas cerca del centro.

- **Núcleo**

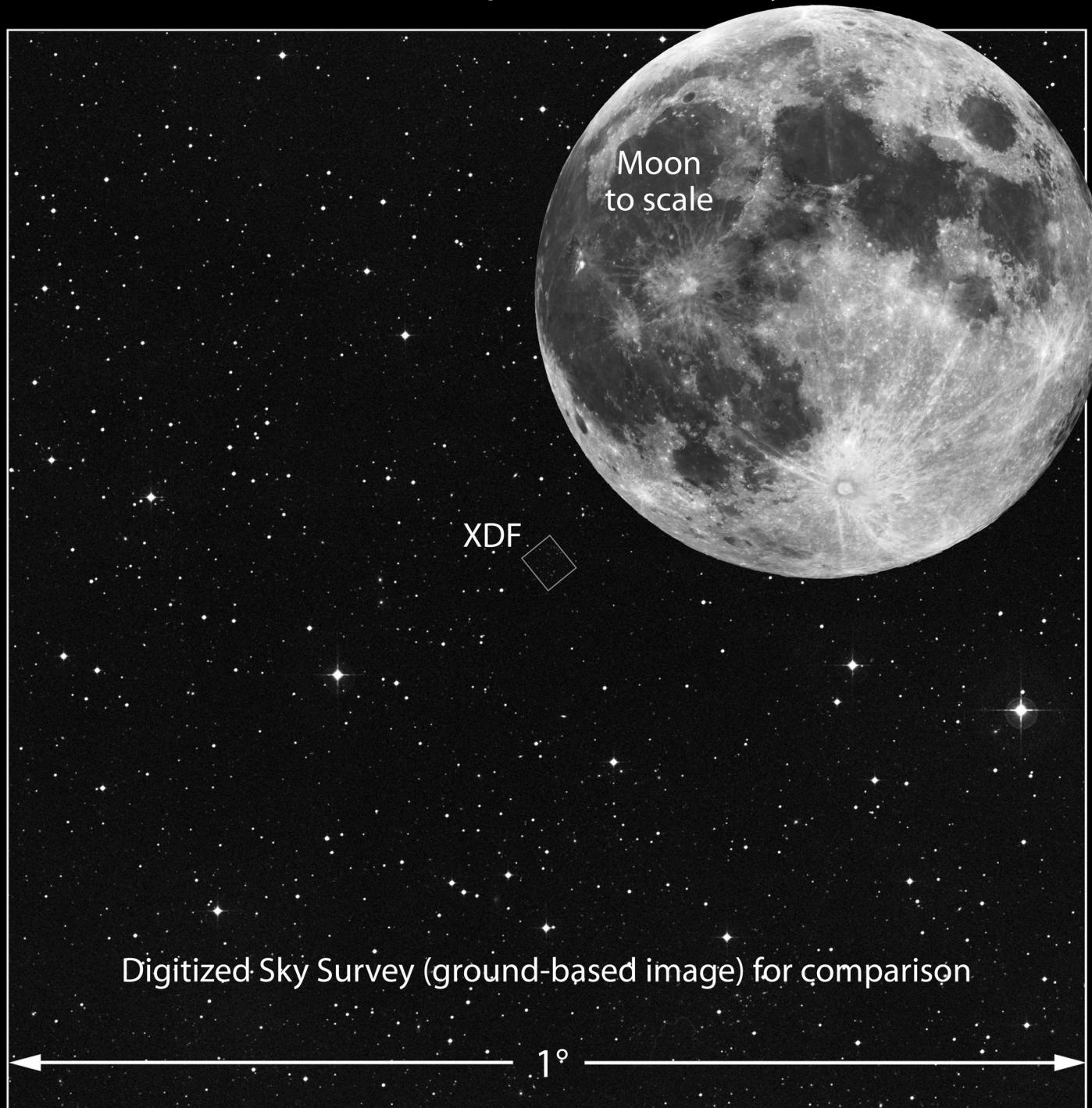
- Acumulación de estrellas en el centro de la galaxia. Usualmente hay un agujero negro muy masivo en el centro

- **Halo**

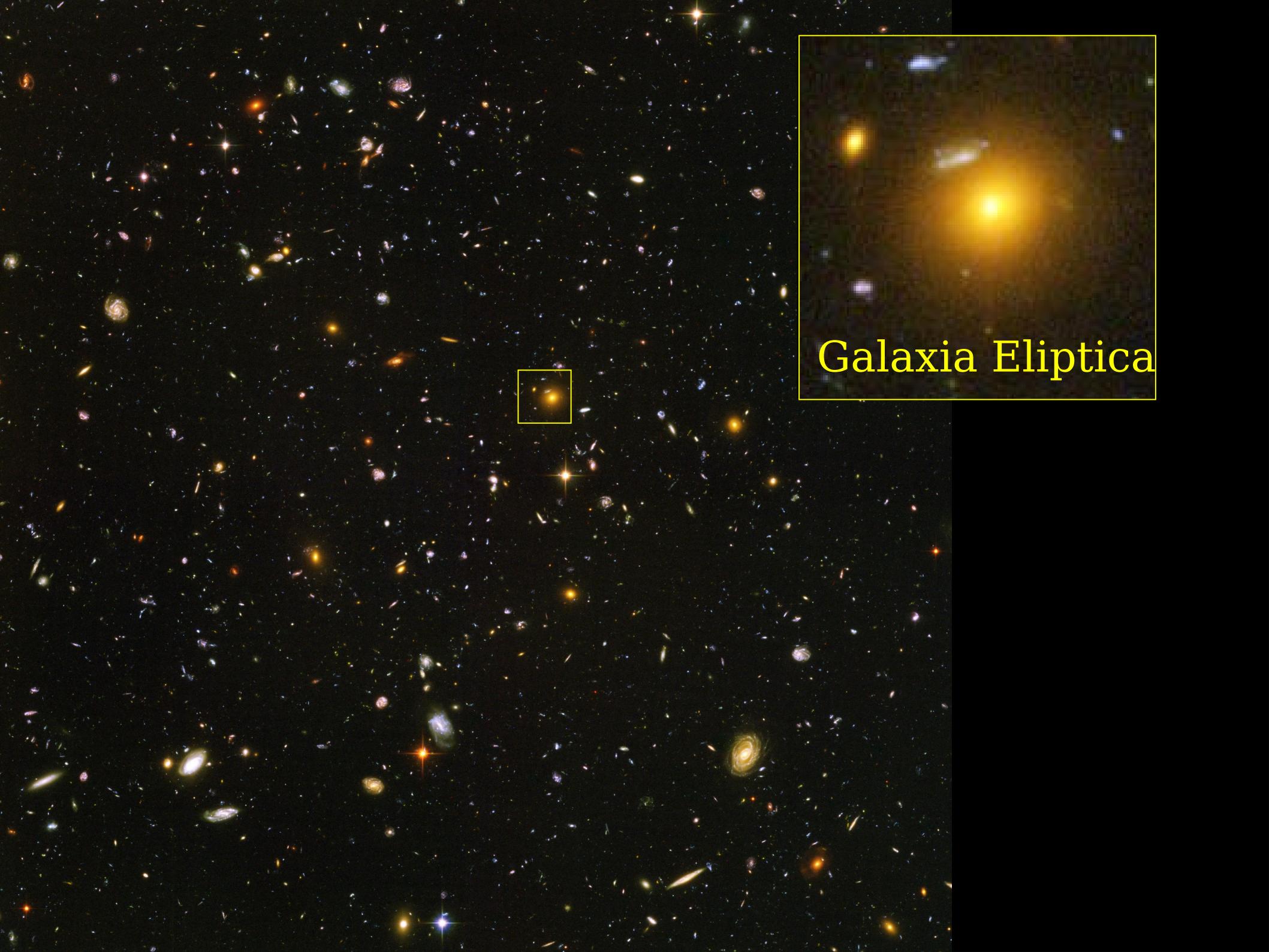
- Distribución esférica de estrellas y cúmulos globulares (cúmulos de millones de estrellas viejas (gigantes rojas))



Size of Hubble eXtreme Deep Field on the Sky





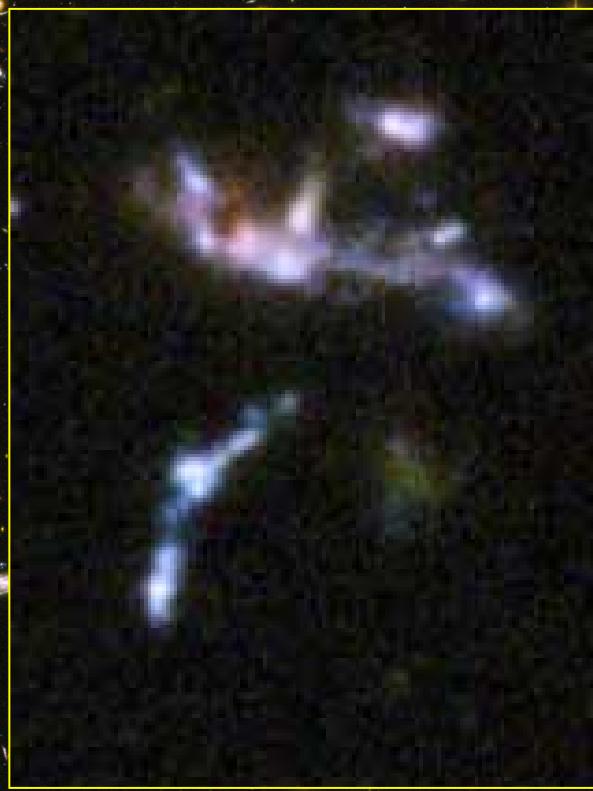
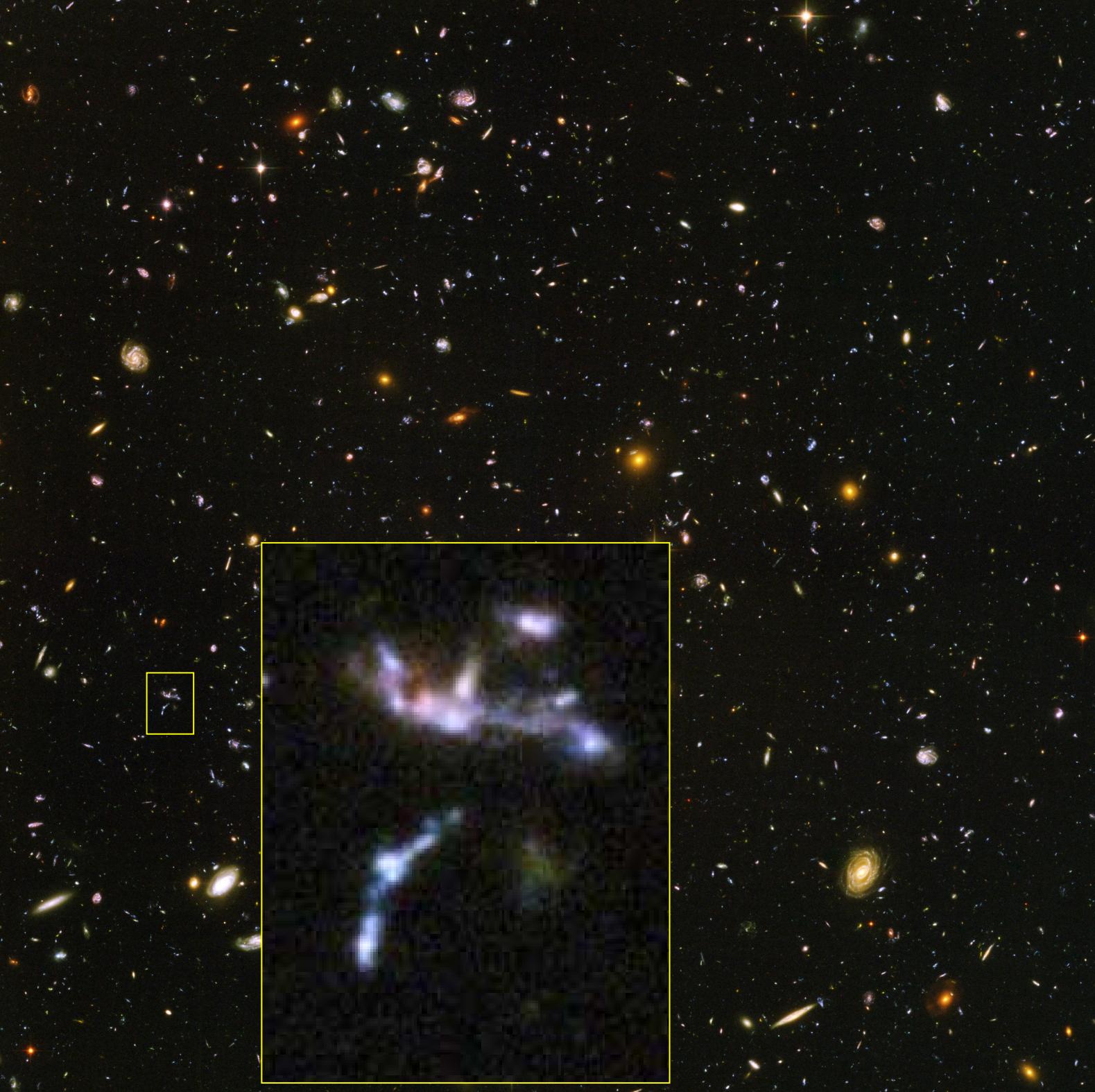


Galaxia Eliptica



en Galáctica





Clasificación Galáctica



Clasificación Galáctica



Clasificación Galáctica



The Sombrero Galaxy — M104  HUBBLESITE.org

Clasificación Galáctica



Clasificación Galáctica (Antennae NGC4038/9)



Colisión de Galaxias



Galaxia de Anillo (Hoag)



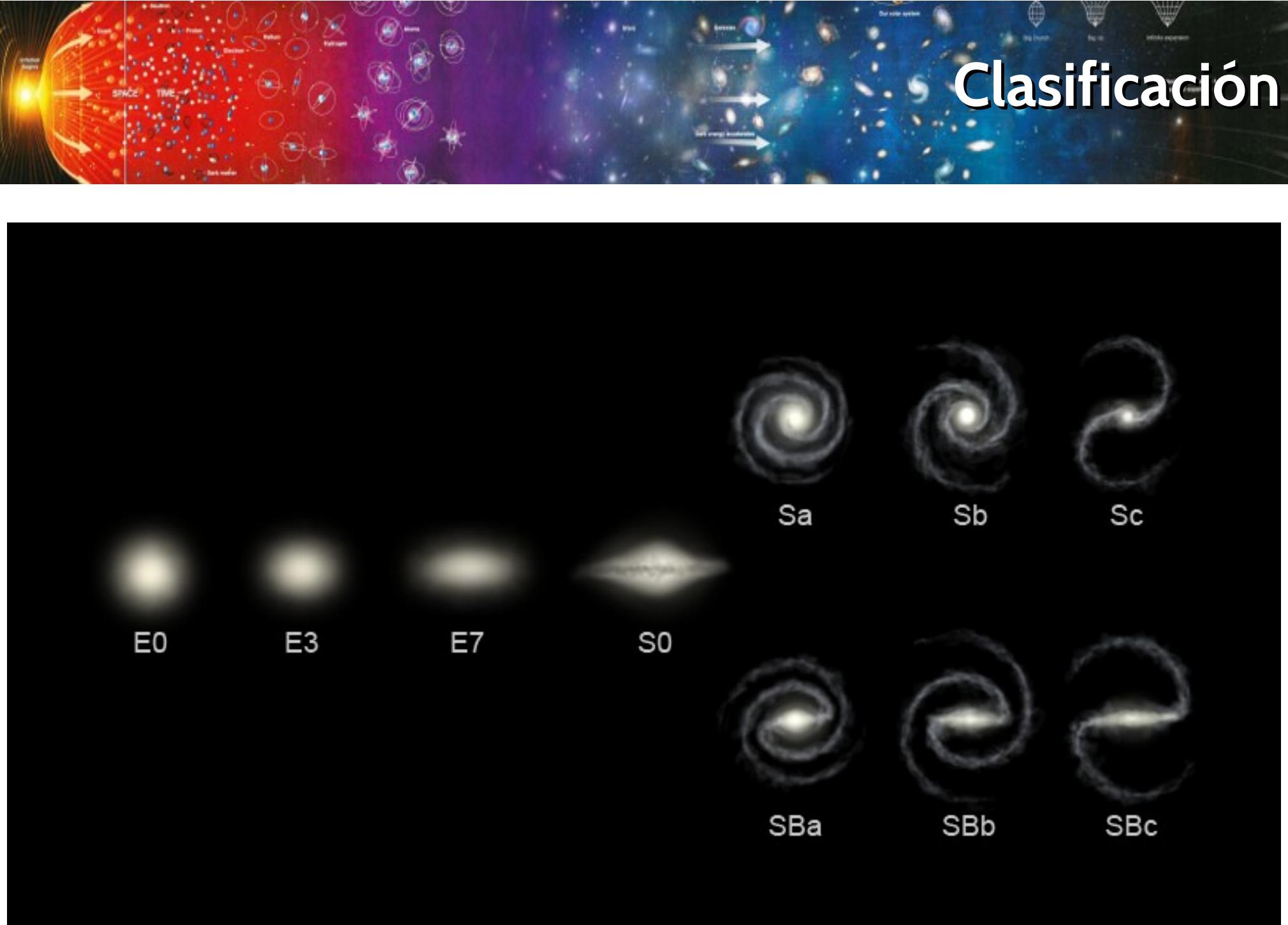
Colisión galáctica (NGC4676 - Mice galaxies)



Colisión galáctica: ARP 273

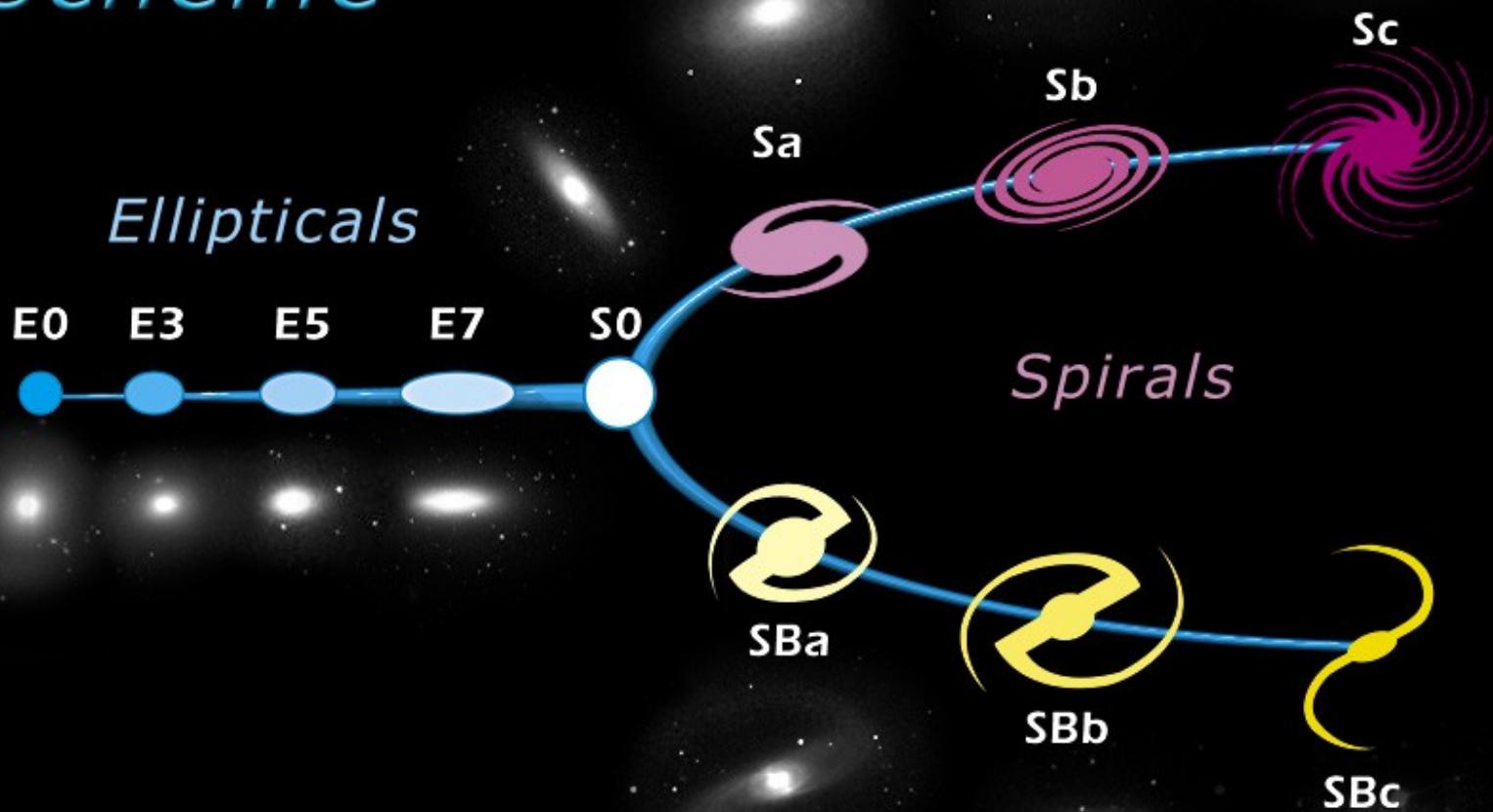


Clasificación

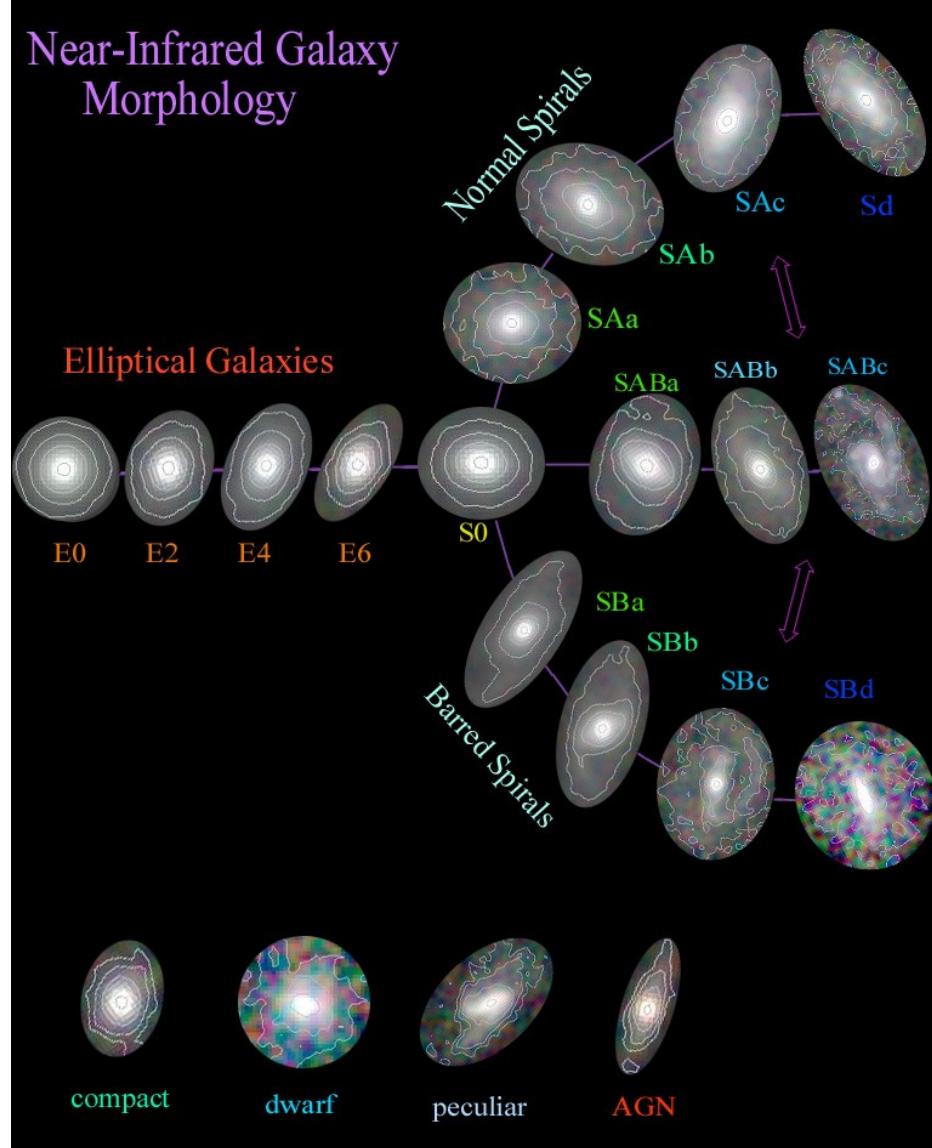


Clasificación galáctica, Hubble

Edwin Hubble's Classification Scheme



Clasificación galáctica



Tipo	Fracción
Espirales	60%
Elípticas	13%
Lenticulares	22%
Irregulares	3%
Peculiares	1%

- **Ley de De Vaucouleurs**
Variación de la intensidad luminosa como función del radio

$$I(r) = I_0 e^{-\sqrt[4]{r/r_0}}$$

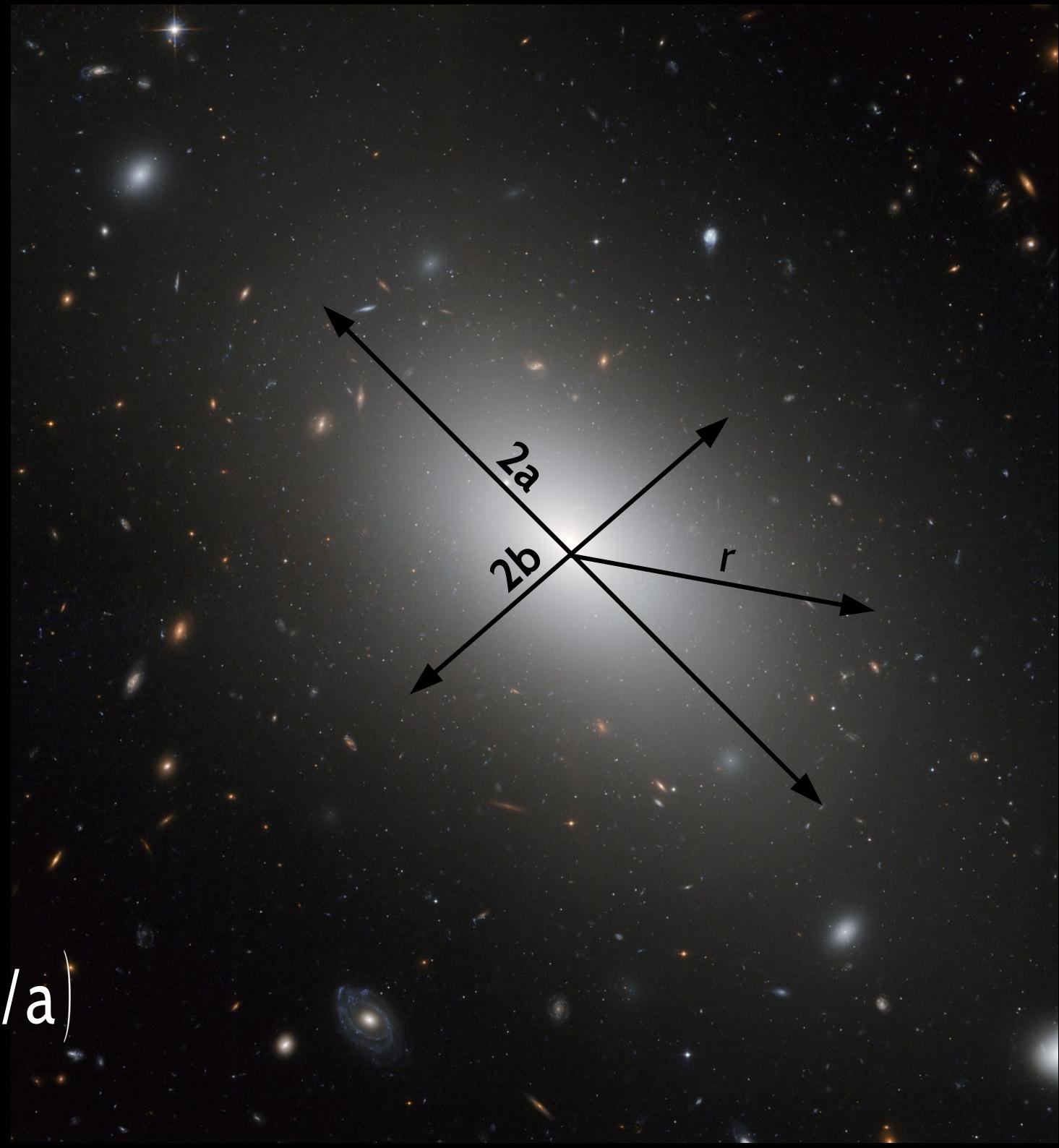
A dense field of galaxies of various shapes and colors against a dark background.

Galaxy Zoo

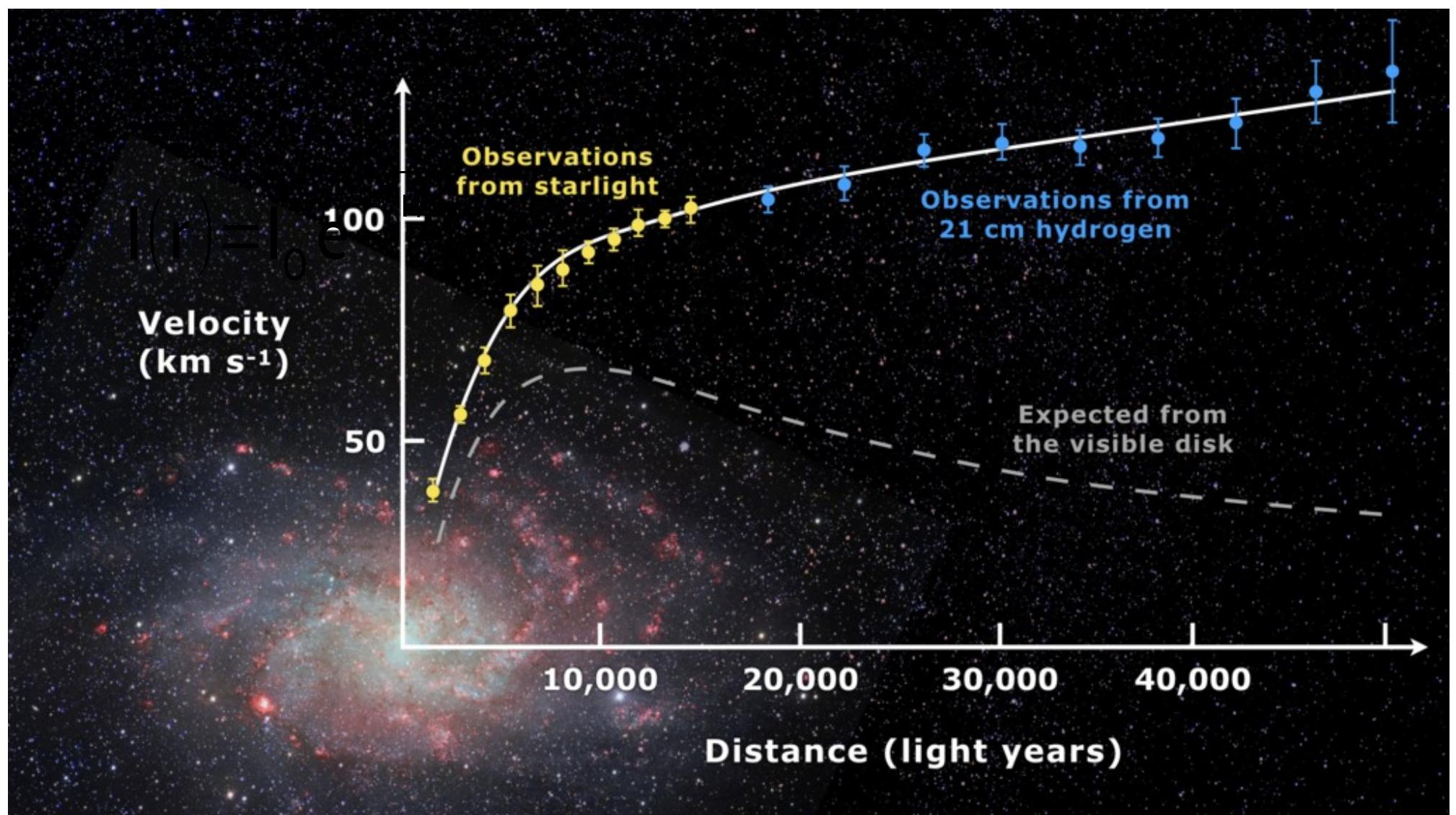
<http://www.galaxyzoo.org>

$$I(r) = I_0 e^{-\sqrt[4]{r/r_0}}$$

$$E_q \rightarrow E_q = 10(1 - b/a)$$



Curvas de rotación





- Igualando la fuerza centrífuga y la fuerza gravitatoria:

$$v_\omega(r) = \sqrt{\frac{GM}{r}} \rightarrow M(r) = \frac{v_\omega^2}{G} r$$

- Pero en una galaxia típica

$$v_\omega(r) \approx \alpha \rightarrow M(r) = \frac{\alpha^2}{G} r \propto r (!!)$$

- Relación de Tully-Fisher

$$\omega \propto \sqrt[4]{L}$$



Materia oscura (no visible)

- Consideremos, p. ej, $\alpha \sim 250 \text{ km/s}$ y $r \sim 50 \text{ kpc}$

$$M = \frac{(250 \text{ km/s})^2 50 \text{ kpc}}{G} \simeq 8 \times 10^{11} M_{\odot}$$

- Pero según Tully-Fisher, $M_{\text{vis}} \simeq 10^{10} M_{\odot}$



Materia oscura (no visible)

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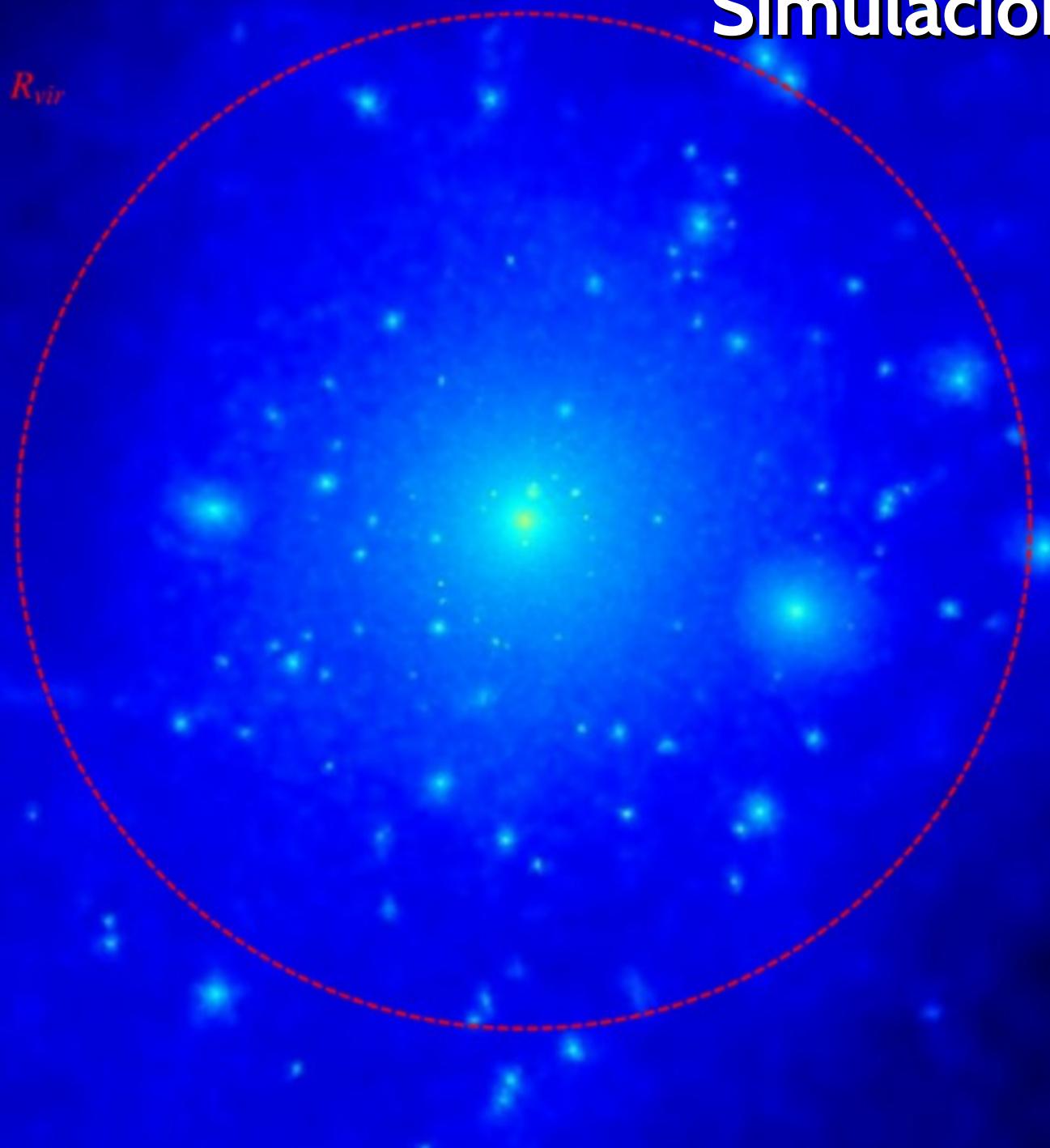
La masa galáctica es ~10-100 veces la masa observada

El tamaño galáctico es ~10-100 veces el radio observado

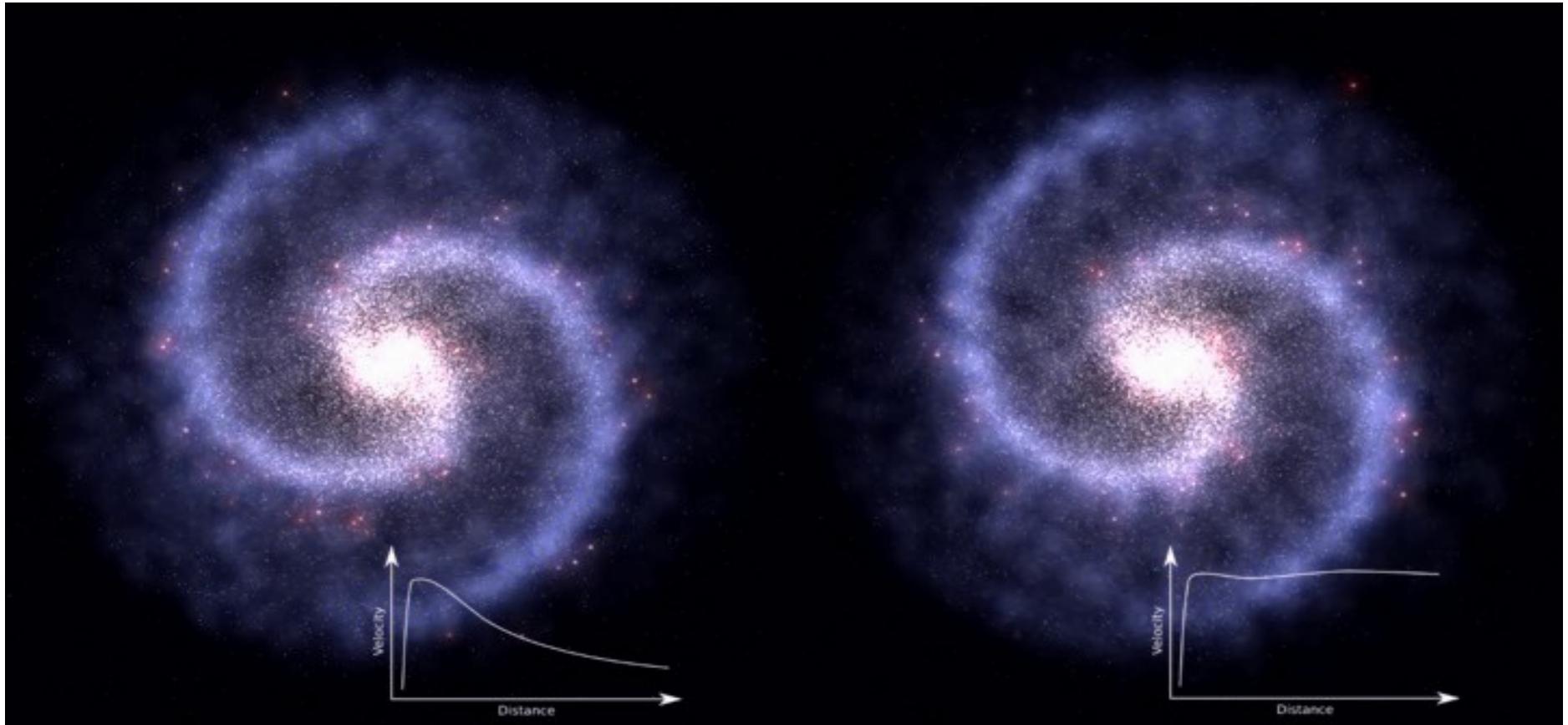
El “halo” de materia oscura



Simulaciones n-cuerpos



Curvas de rotación con y sin materia oscura



Otras explicaciones para explicar estos comportamientos:
distribución de masa en el disco galáctico (Newton)
MOND (MO Newtonian Dynamics)