

Discovering the mysteries of the Universe

CESAR Scientific Challenge

(Observing visible and invisible light)



Beatriz González García on behalf of the CESAR Science Cases Team

Not only are superheroes able to see the invisible, but also the state-of-the-art technology on board the European Space Agency scientific missions, that fly over the Earth's atmosphere to reveal the invisible and bring this information back home. Are you ready to discover the hidden Universe?

Guess which is the superpower and the name of the ESA mission that uses it.

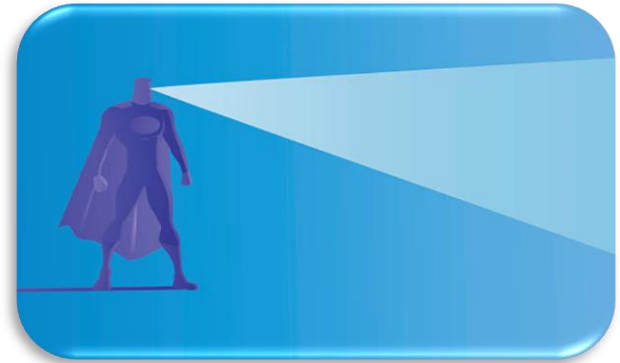


Figure 1: X-ray vision



Figure 2: IR vision

Didactics



Figure I: The considered top 10 skills in the 2020. (Credits: Rethinking).

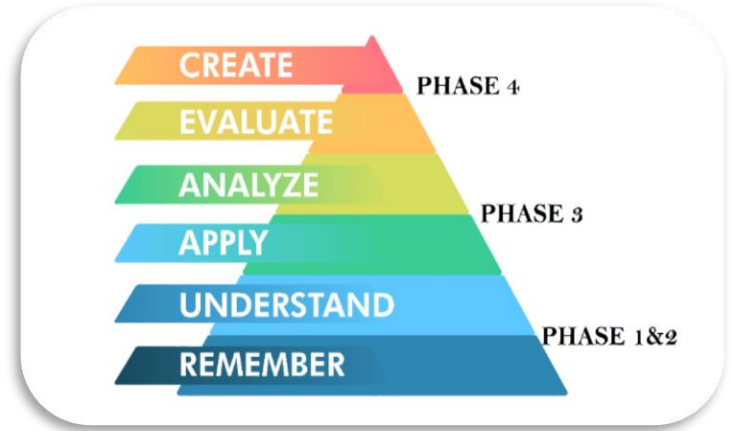







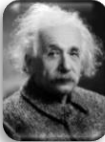


Figure II: Bloom's Taxonomy diagram. (Credits: <https://medium.com/@ryan.ubc.edtech/>)

Challenge ID	Team Number (1-6):			
Members				
Professions	Mathematics Software Engineer	Astrophysicists	Engineers	Biologists/ physicist
Roles	Leads the correct execution of the calculations	She/he guides the solar virtual telescope (ESASky)	She/he is in charge of finding agreements and leading the team.	She/he addresses the need for further research.
References	<u>Katherine Johnso</u> 	<u>Vera Rubin</u> 	<u>Samantha Cristoforetti</u> 	<u>Marie Curie</u> 
(female)				
	<u>Steve Wozniak</u> 	<u>Matt Taylor</u> 	<u>Pedro Duque</u> 	<u>Albert Einstein</u> 
(male)				



Fast Facts

Age range: 14-18

Type: Scientific challenge for students

Complexity: Medium

Teacher preparation time: (1 -2) hours

Lesson time required: (1 -3) hours, depending on the activities selected by the teacher to be executed.

Location: Indoors

Includes use of: Computers, internet

The students should already know...

- The concept and basic properties of waves.
- The concept of light as an electromagnetic wave.
- The concept of blackbody radiation.

Curriculum relevance

General

- Working scientifically.
- Use of ICT.

Physics

- Waves.
- Light waves. The electromagnetic spectrum.
- Temperature. Blackbody radiation.

Space/Astronomy

- Research and exploration of the Universe.
- The evolution of stars.
- Stars, star clusters, interstellar medium, galaxies.

Students will learn ...

- The different phenomena responsible for the emission of light by astronomical objects.
- How astronomers use different types of light to study different objects or phenomena in the Universe.
- The reasons for sending telescopes to space.
- What information can be seen and extracted from an astronomical image.
- Some basic ideas about a variety of astronomical objects.

Students will improve ...

- Their understanding of scientific thinking.
- Their strategies of working scientifically.
- Their teamwork and communication skills.
- Their evaluation skills.
- Their ability to apply theoretical knowledge to real-life situations.
- Their skills in the use of ICT.

What did you know?

What do you know about the Light & Universe?



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Light



Astronomical
objects



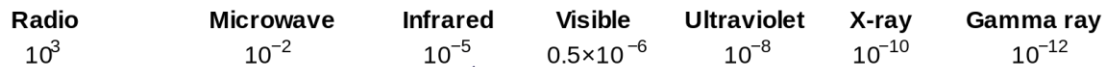
Multi-wavelength Astronomy



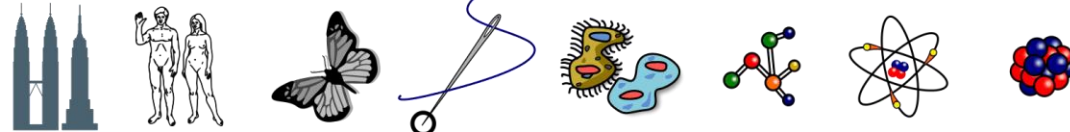
Penetrates Earth's Atmosphere?



Radiation Type
Wavelength (m)



Approximate Scale of Wavelength

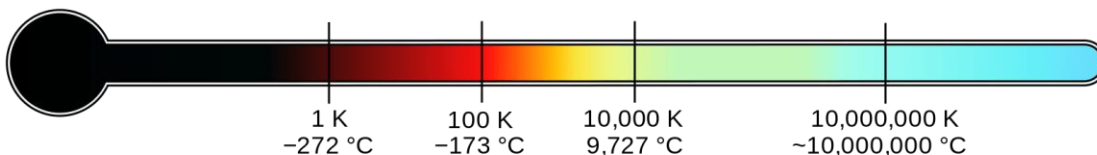


Buildings Humans Butterflies Needle Point Protozoans Molecules Atoms Atomic Nuclei

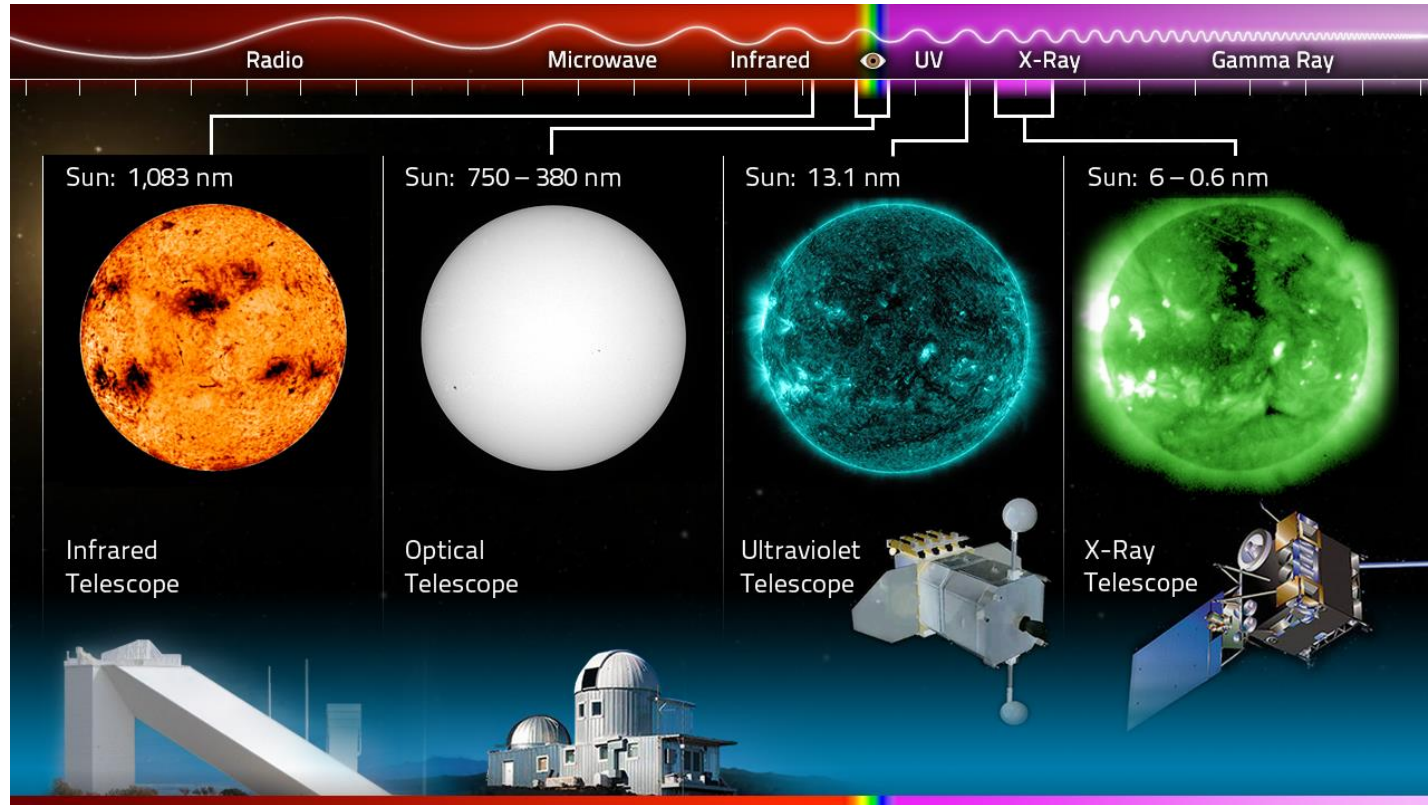
Frequency (Hz)



Temperature of objects at which this radiation is the most intense wavelength emitted



Sun as a black-body emitter

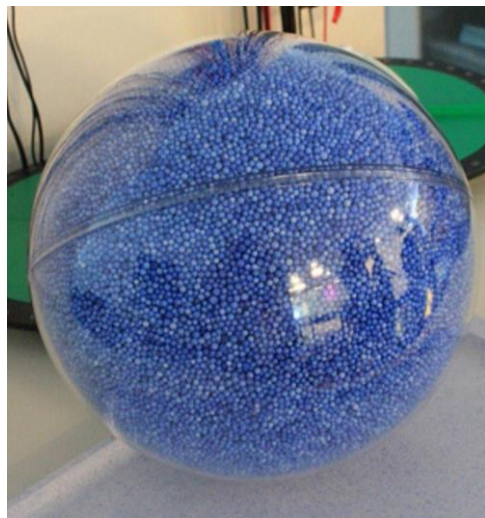


Let's get to know the stars – The Sun



1.3 million Earths fitting
into the Sun

Let's get to know the stars – The Sun



1.3 million Earths fitting into the Sun

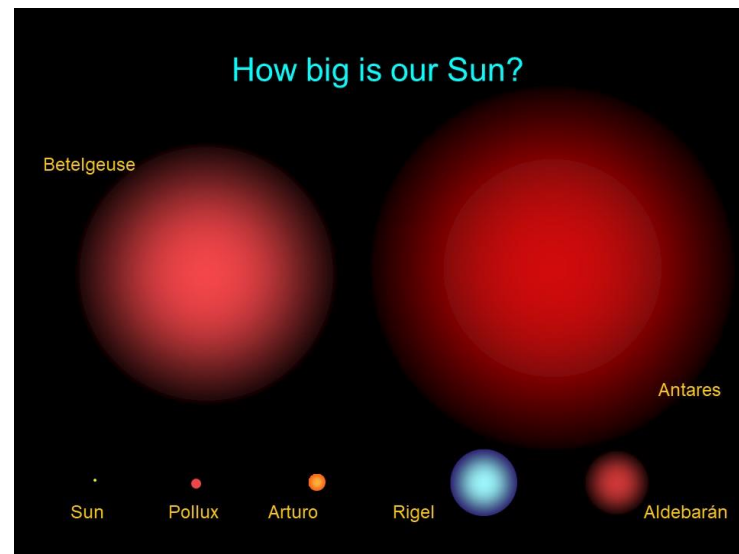


Figure: Adapted from a presentation of Benjamín Montesinos-Comino for the June 2018 CESAR Teacher workshop

Let's get to know the stars – The Sun

Mass

1.9×10^{30} kg



about 333 060 Earths

Let's get to know the stars – The Sun

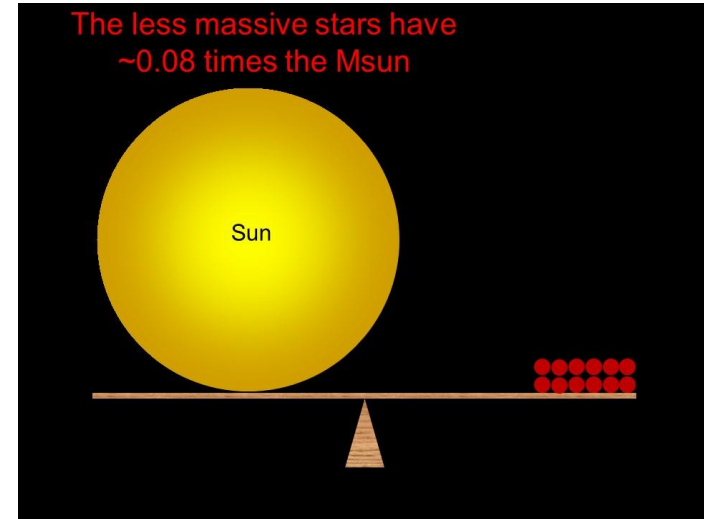
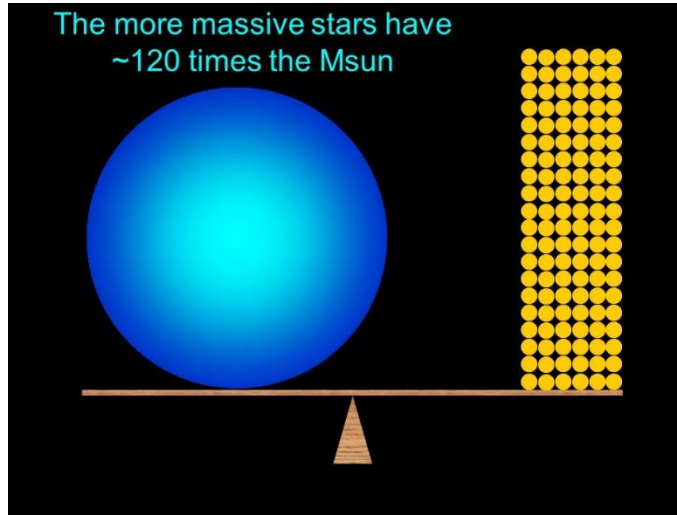
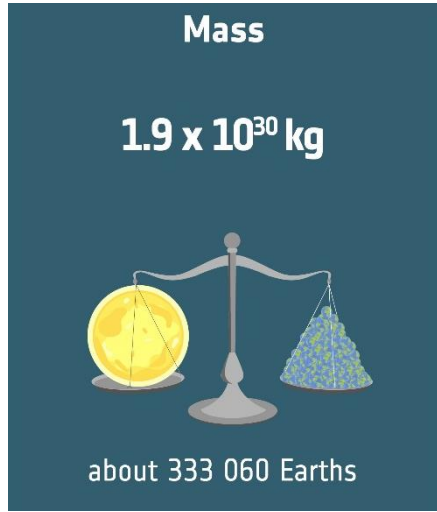
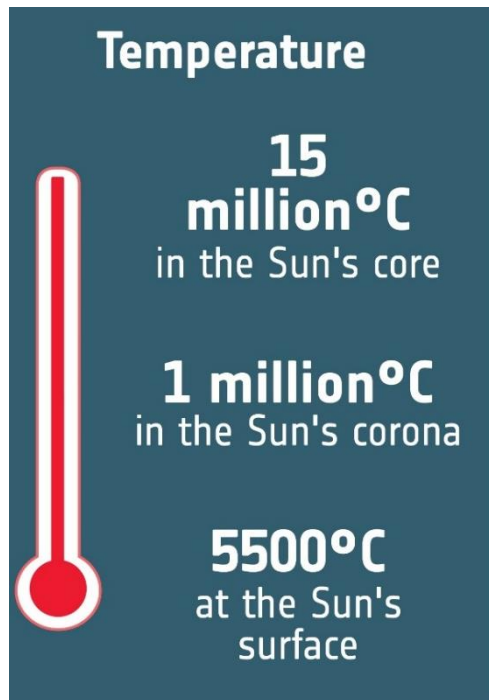


Figure: Adapted from a presentation of Benjamín Montesinos-Comino for the June 2018 CESAR Teacher workshop

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Let's get to know the stars – The Sun



Let's get to know the stars – The Sun

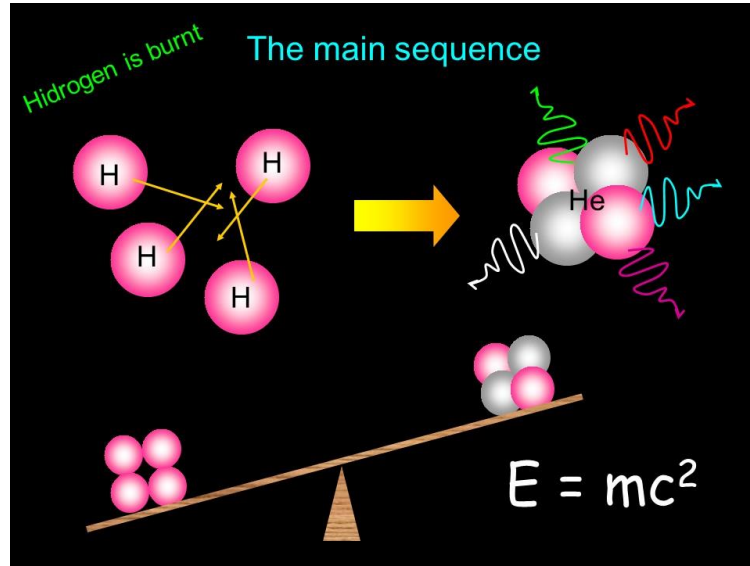
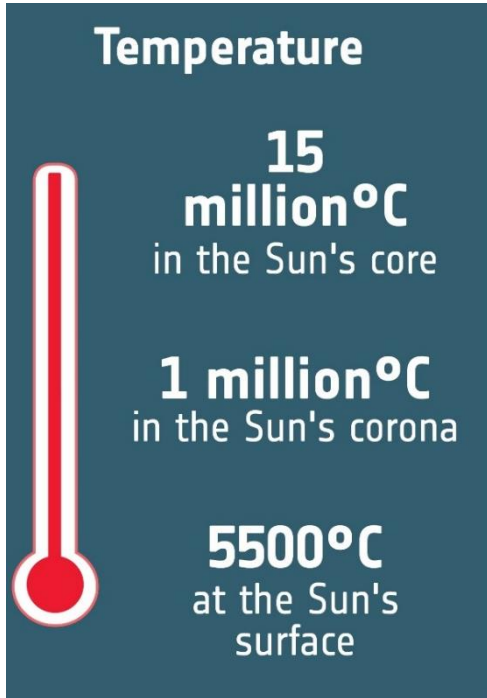


Figure: Adapted from a presentation of Benjamín Montesinos-Comino for the June 2018 CESAR Teacher workshop

Let's get to know the stars – The Sun

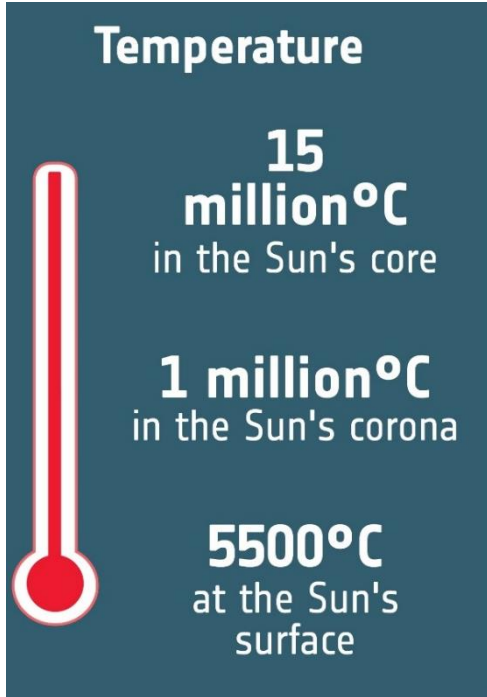
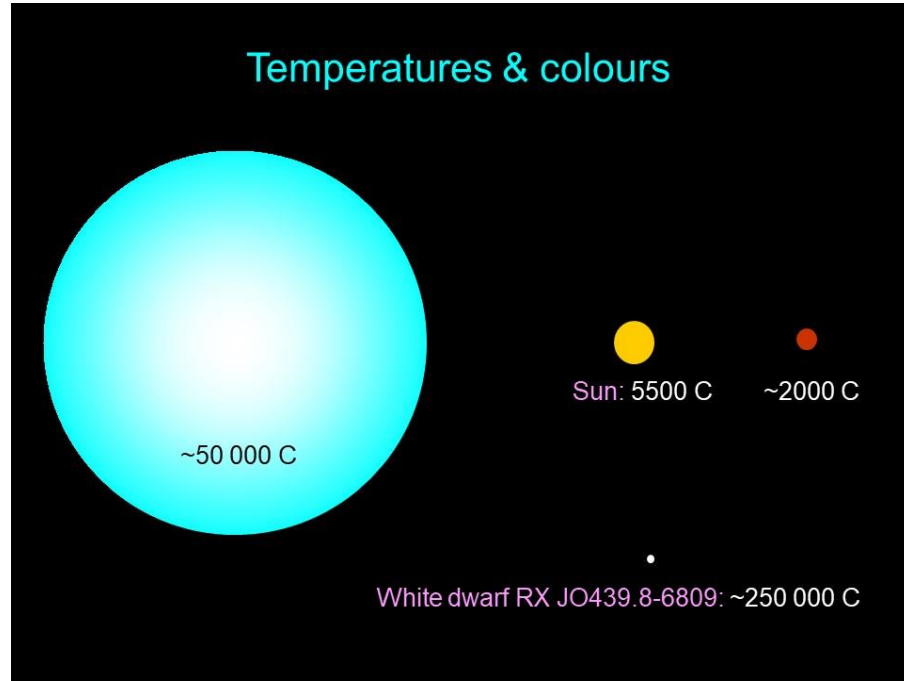
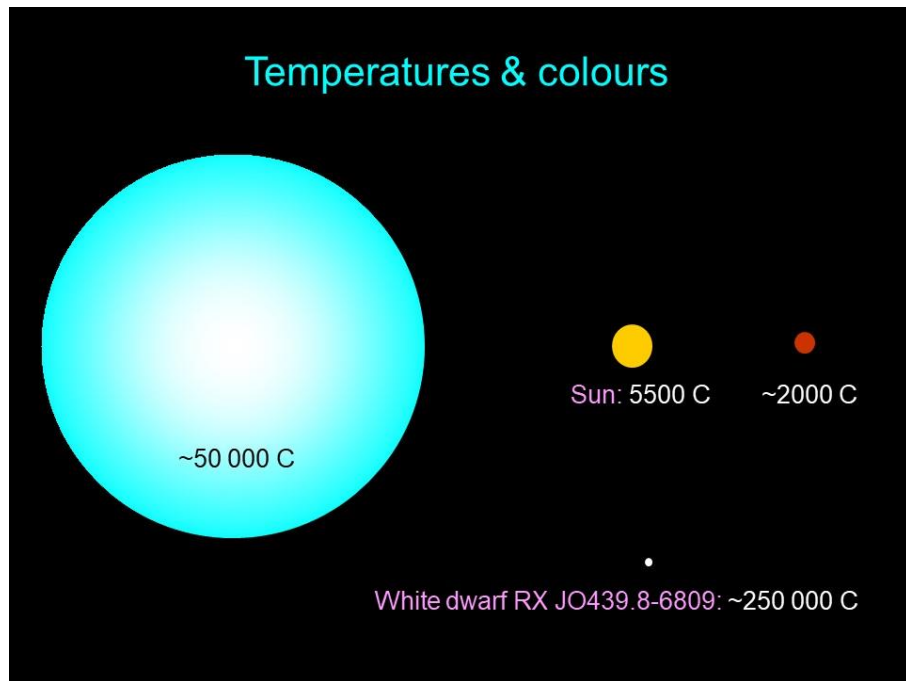


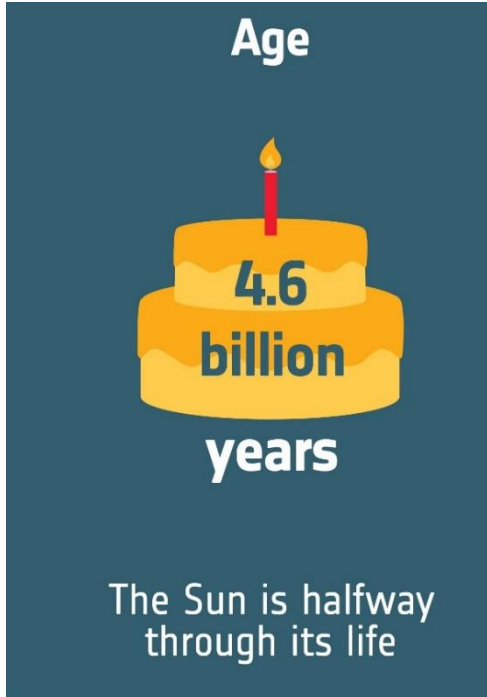
Figure: Adapted from a presentation of Benjamin Montesinos-Comino for the June 2018 CESAR Teacher workshop



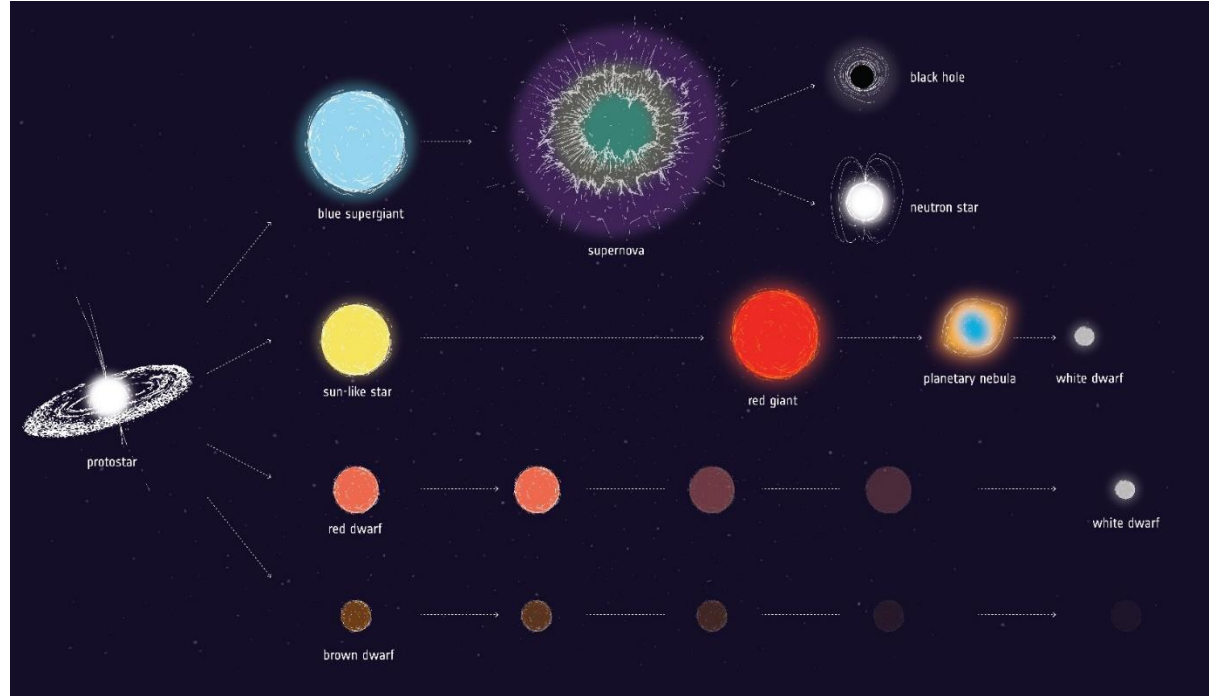
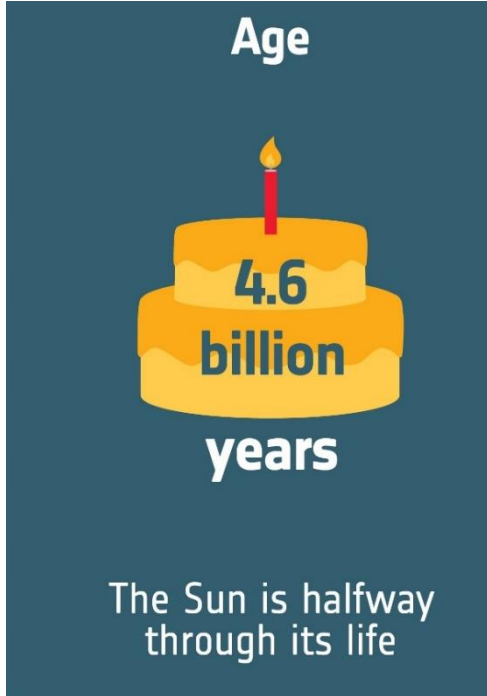
Let's get to know the stars – The Sun



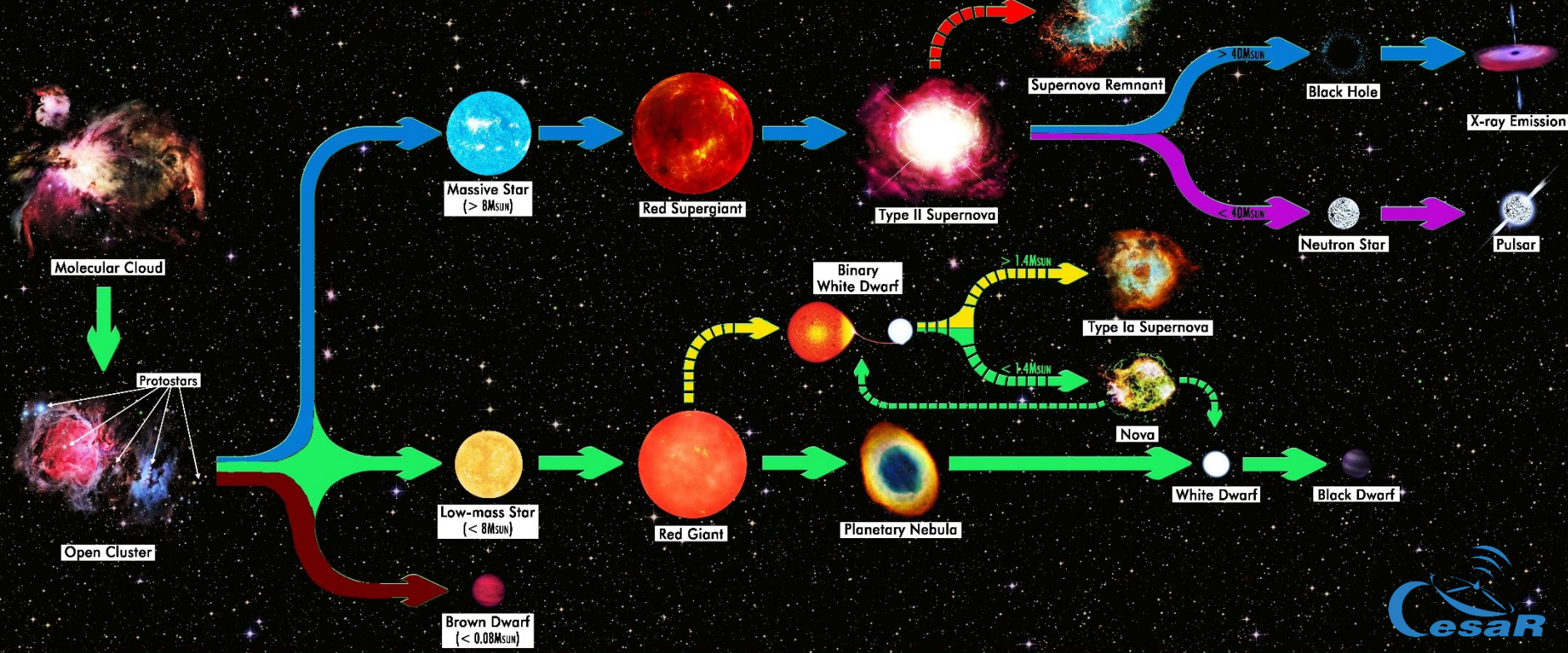
Let's get to know the stars – The Sun



Let's get to know the stars – The Sun



STELLAR LIFE CYCLE



Birth

Main Sequence

Old Age

Death

Remnant



- Emission Spectrum

EMISSION SPECTRUM OF HYDROGEN



EMISSION SPECTRUM OF HELIUM



Radiation emitted due to the energetic transition of an electron (from higher to lower energetic levels)

- Emission Spectrum



EMISSION SPECTRUM OF HYDROGEN



EMISSION SPECTRUM OF HELIUM



OVERLAPPED SPECTRUM



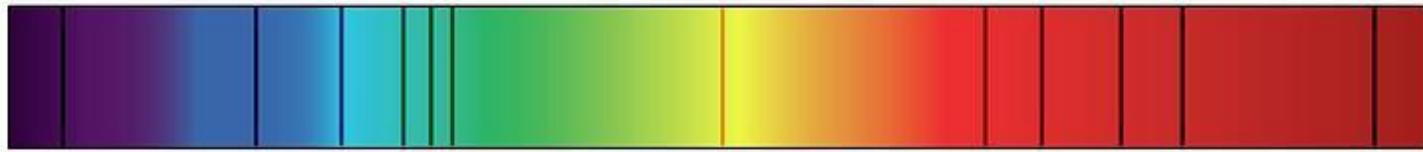
- Absorption Spectrum



ABSORPTION SPECTRUM OF HYDROGEN



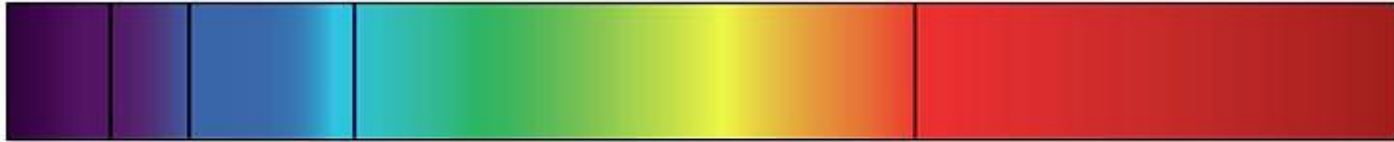
ABSORPTION SPECTRUM OF HELIUM



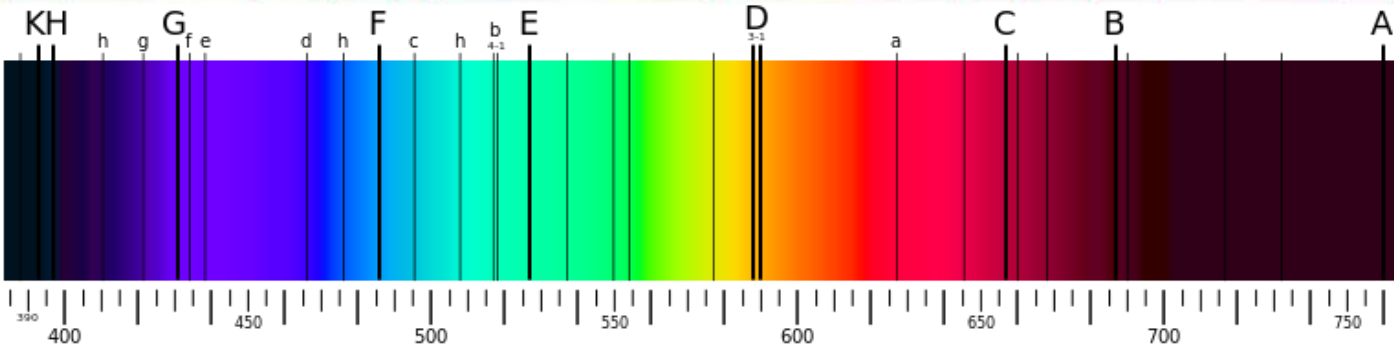
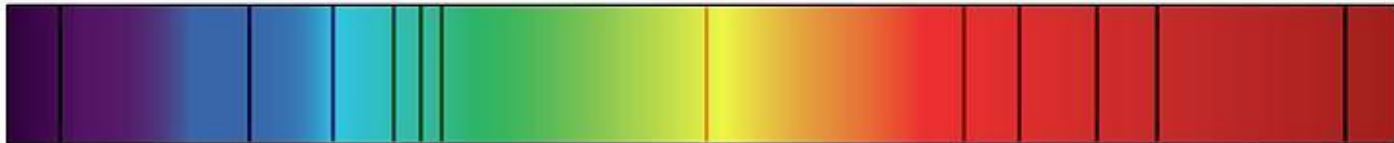
- Absorption Spectrum



ABSORPTION SPECTRUM OF HYDROGEN



ABSORPTION SPECTRUM OF HELIUM



ABSORPTION SPECTRUM OF THE SUN

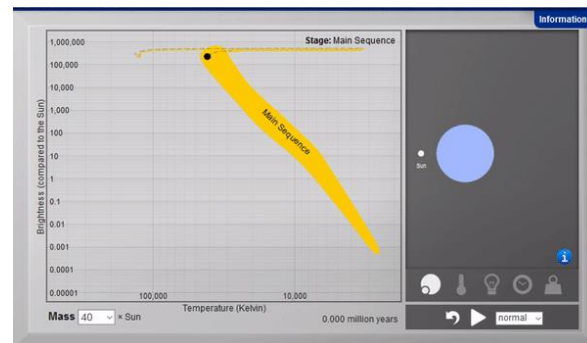
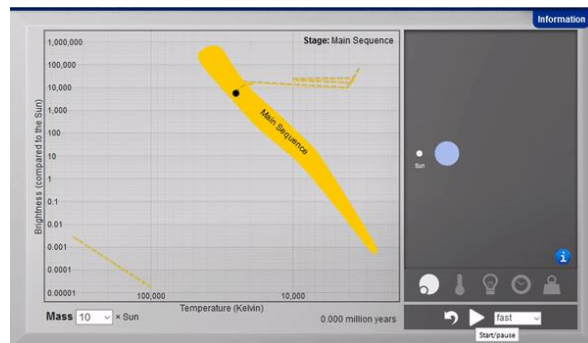
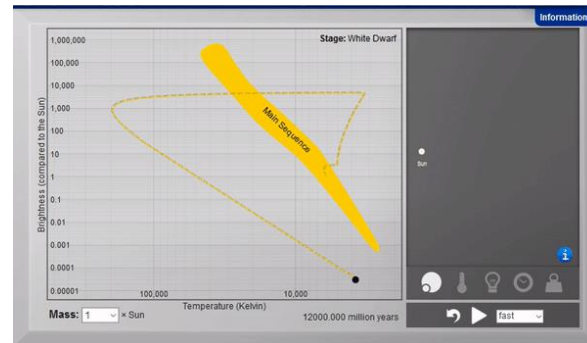
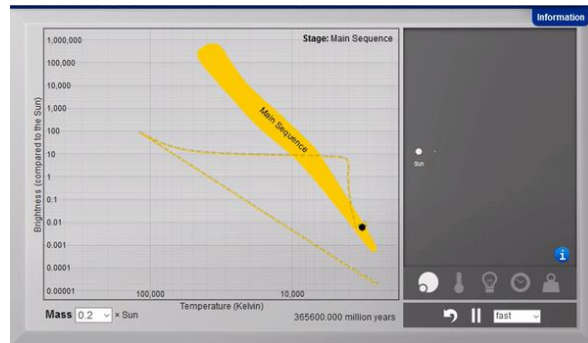
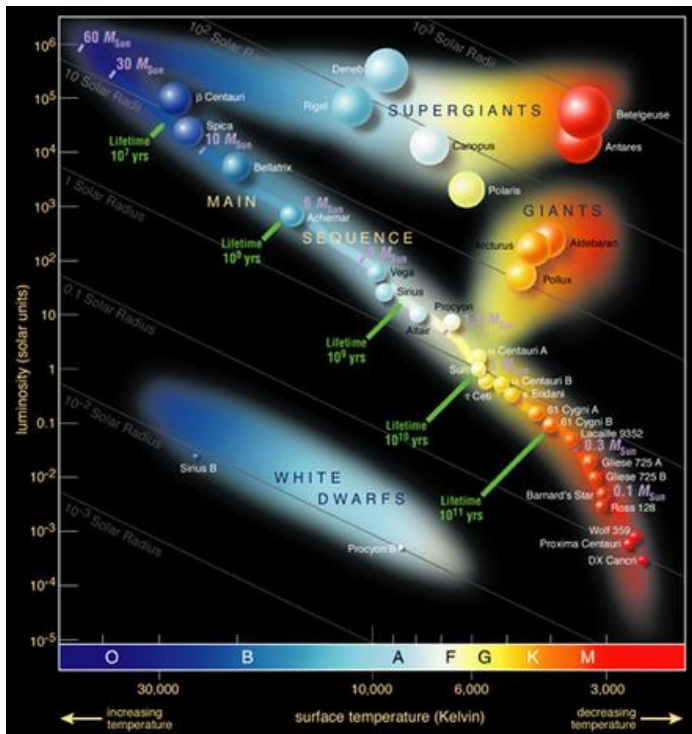


wavelength in nm

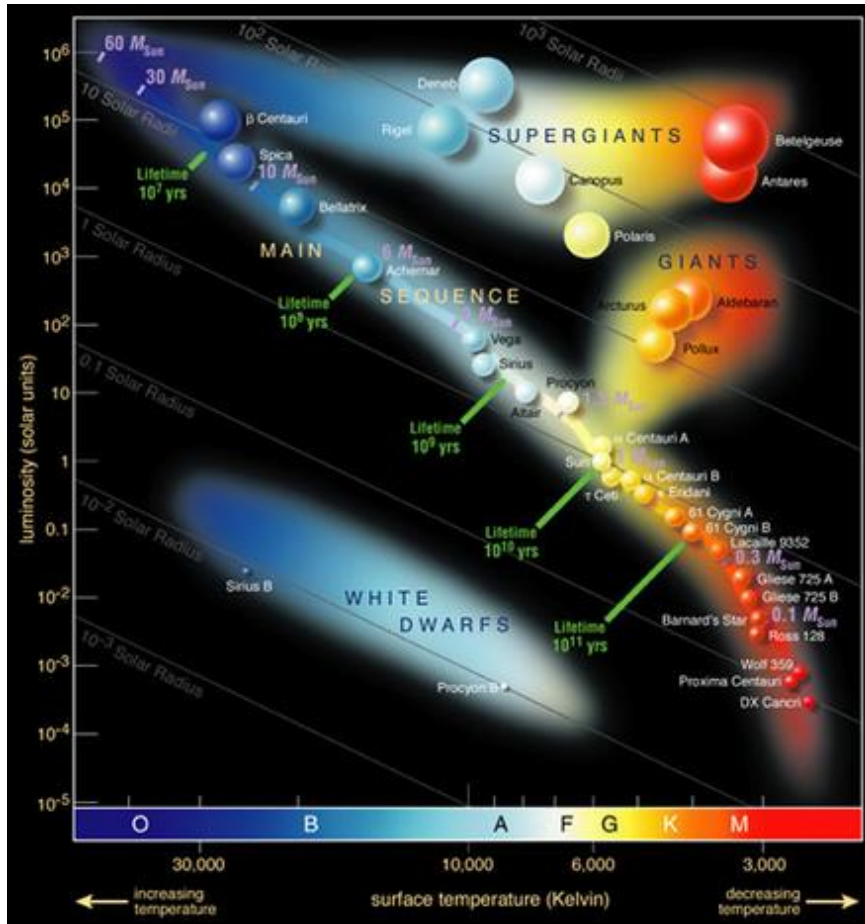


Classification of the stars

HR diagram



<https://starinbox.lco.global/>

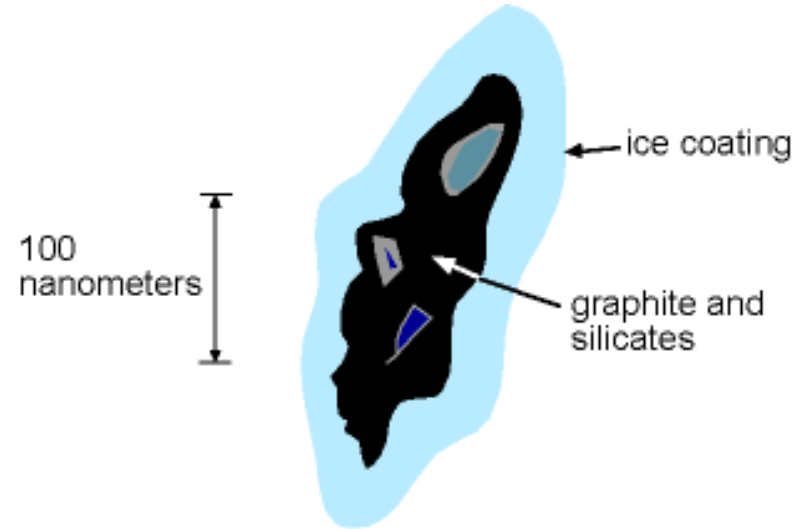
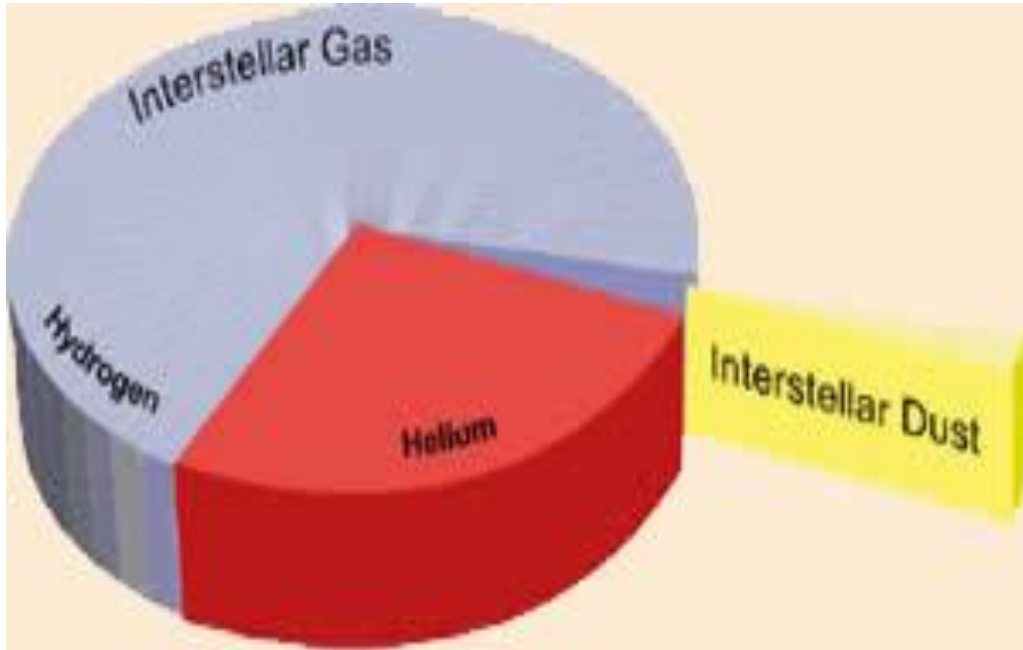


Hertzsprung-Russel
Diagram

Let's get to know about the star clusters

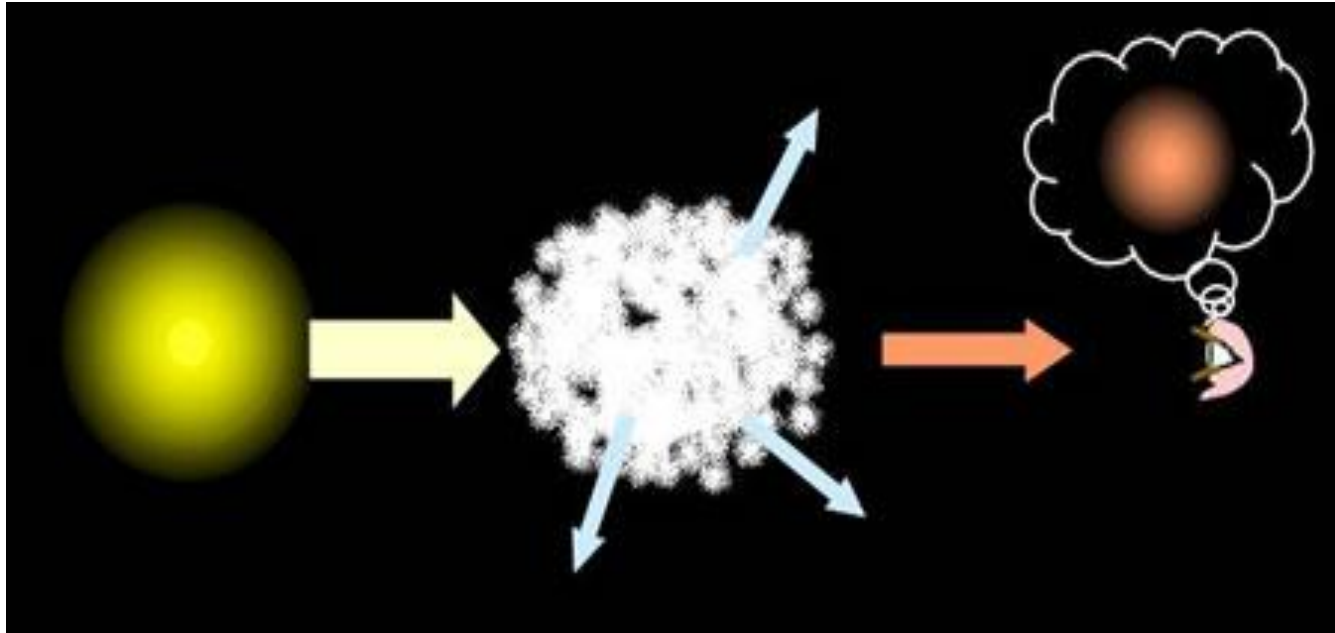


Let's get to know about the ISM



A typical dust grain (note the tiny scale!).

Let's get to know about the ISM

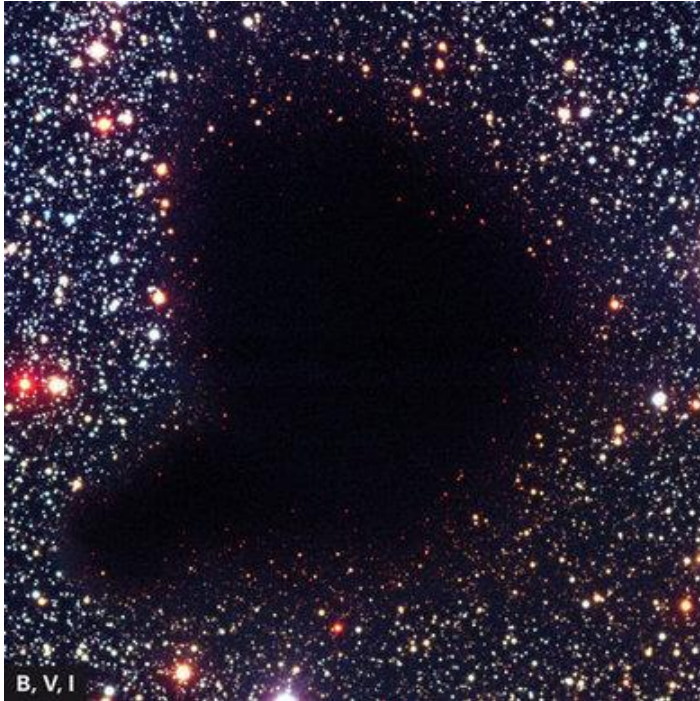


Interstellar reddening = The star appear **redder** than what it should be

Optical extinction = the star may appear less bright than expected

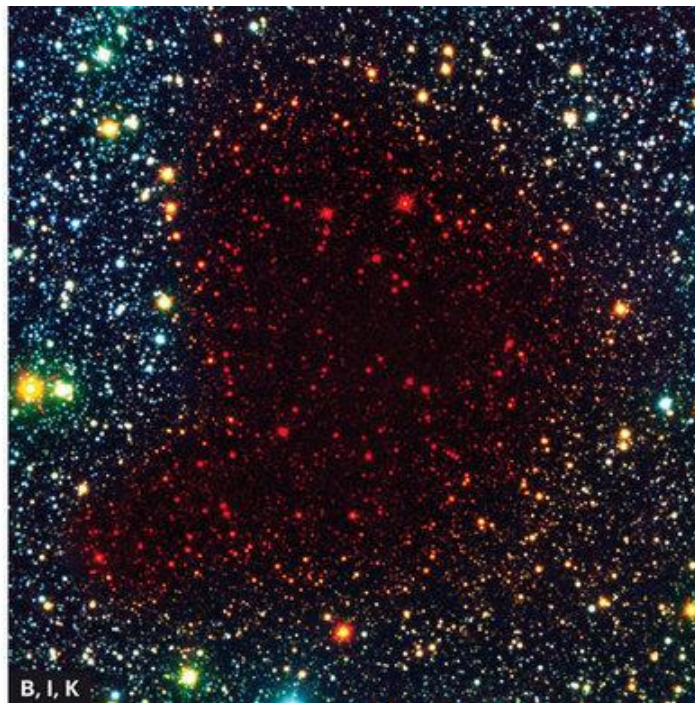
Let's get to know about the ISM

Empty spaces?

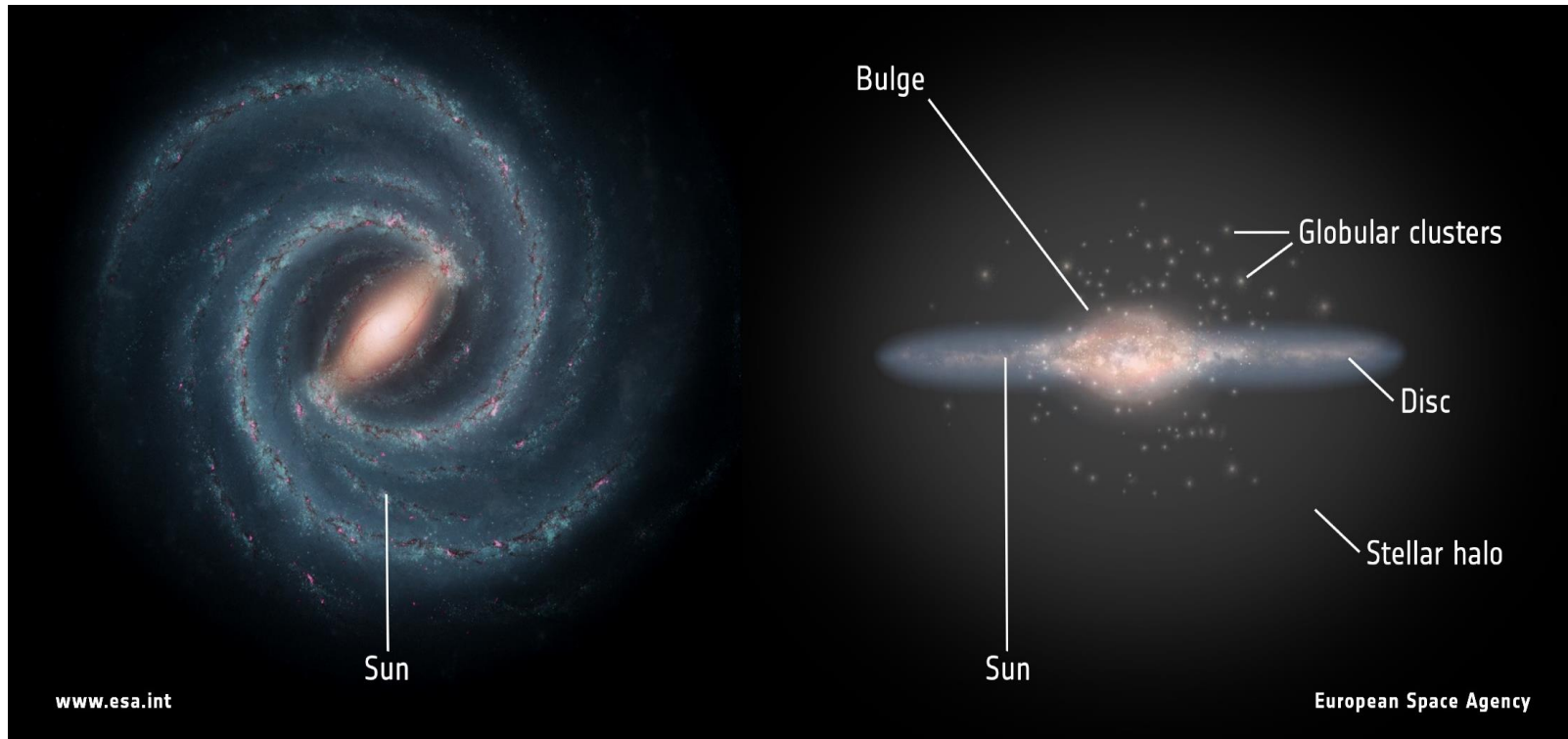


The Instestellar medium

Empty spaces?



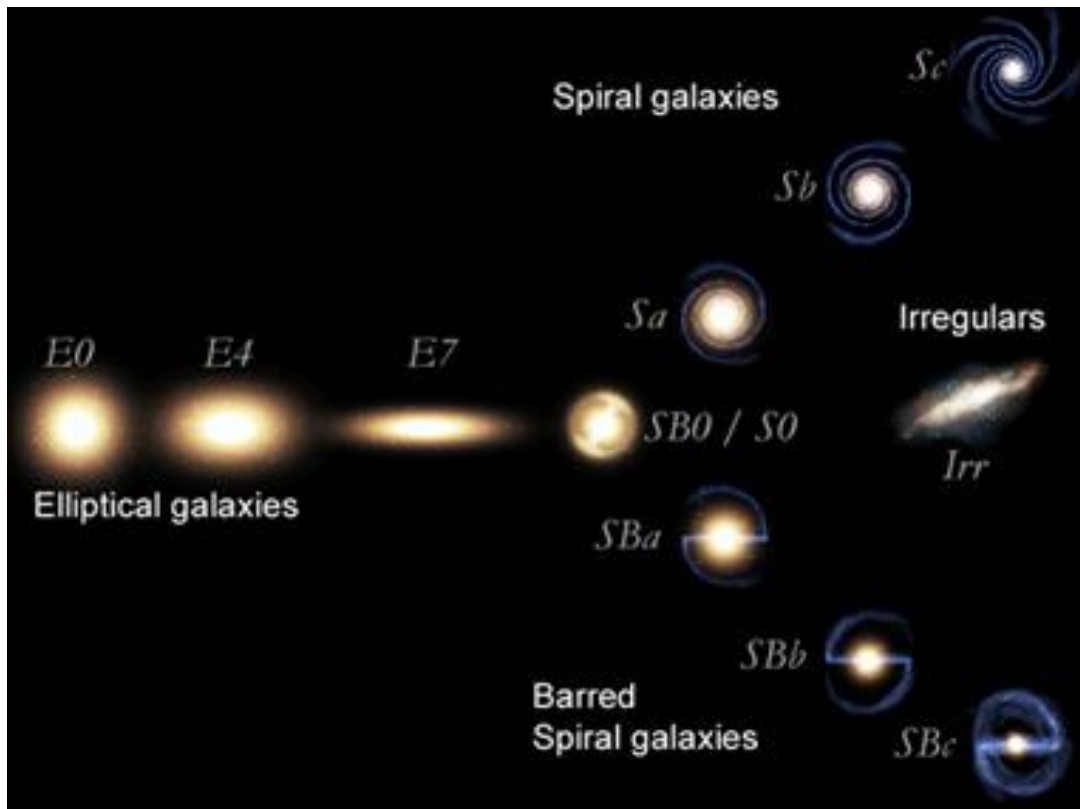
Let's get to know about galaxies



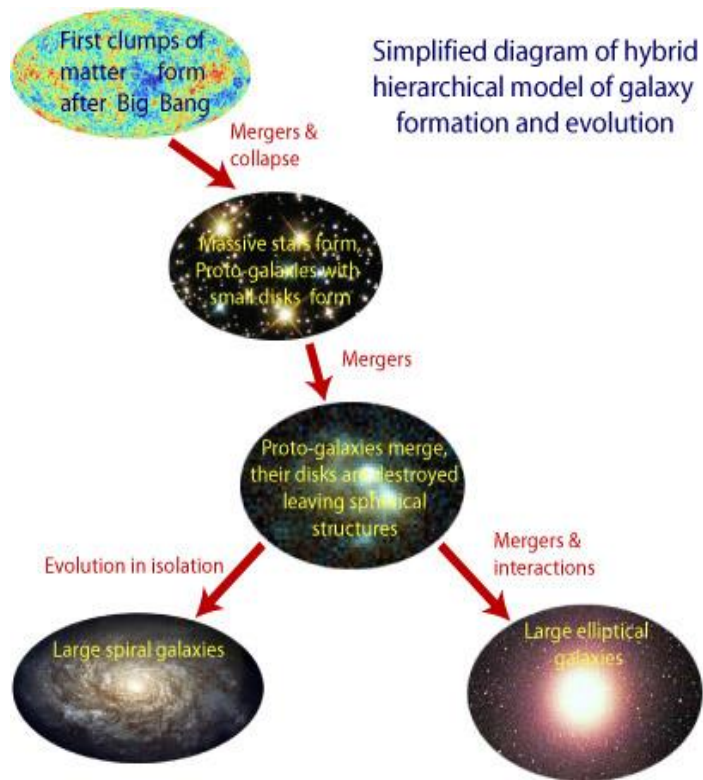
Let's get to know about galaxies



Let's get to know about galaxies



Let's get to know about galaxies



Galaxy evolution

Let's start with the Challenge

Let's get familiar with ESASky !!

<http://sky.esa.int/>

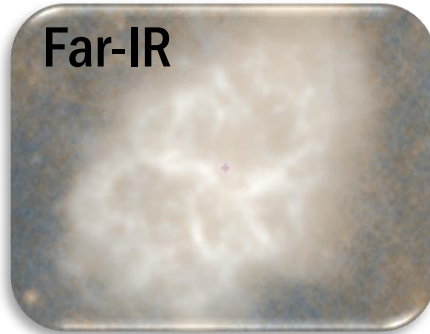
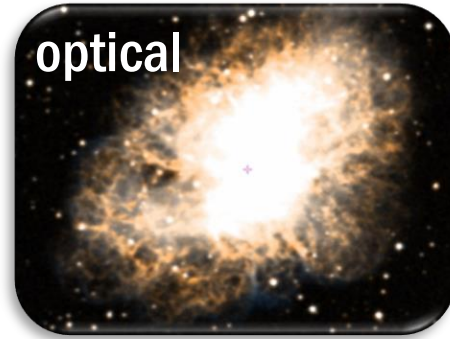
The Colours of Astronomy



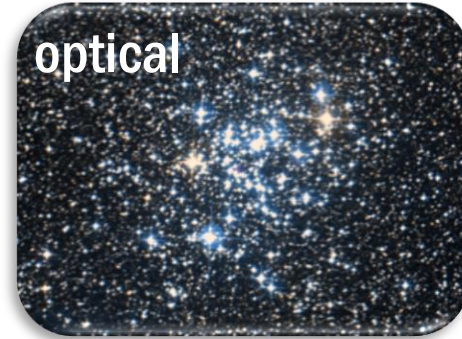
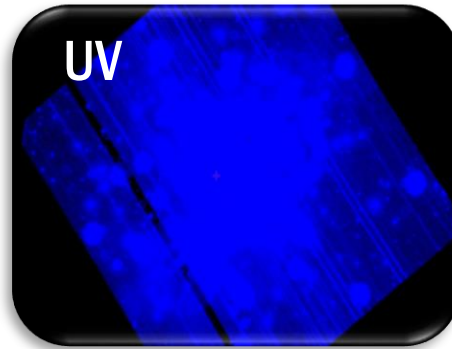
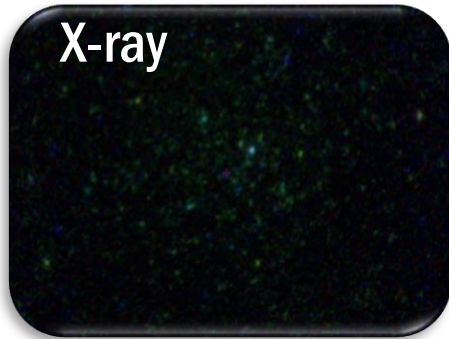
Type of radiation	Temperature	Energy	Typical sources
Gamma-rays	$>10^8$ K	$> 2 \times 10^{-14}$ J	Matter falling into black holes
X-rays	$10^6 - 10^8$ K	$2 \times 10^{-17} - 2 \times 10^{-14}$ J	Gas in clusters of galaxies Hot gas clouds in supernova remnants Stellar coronae Neutron stars
Ultraviolet	$10^4 - 10^6$ K	$5 \times 10^{-19} - 2 \times 10^{-17}$ J	Hot gas clouds in supernova remnants Very hot stars
Visible	$10^3 - 10^4$ K	$3 \times 10^{-19} - 5 \times 10^{-19}$ J	Stars Hot clouds of gas
Infrared	$10 - 10^3$ K	$2 \times 10^{-22} - 3 \times 10^{-19}$ J	Very cool stars Planets
Infrared	$10 - 10^3$ K	$2 \times 10^{-22} - 3 \times 10^{-19}$ J	Cool clouds of dust
Microwave and radio	<10 K	$< 2 \times 10^{-22}$ J	Cool clouds of gas The Cosmic Microwave Background (CMB) Electrons moving in magnetic fields



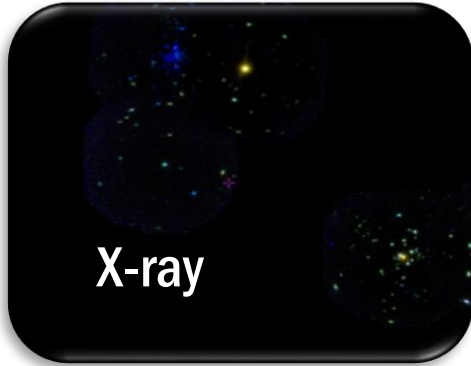
Look for M1 (The Crab) in ESASky



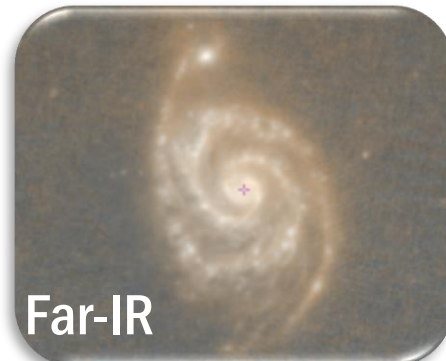
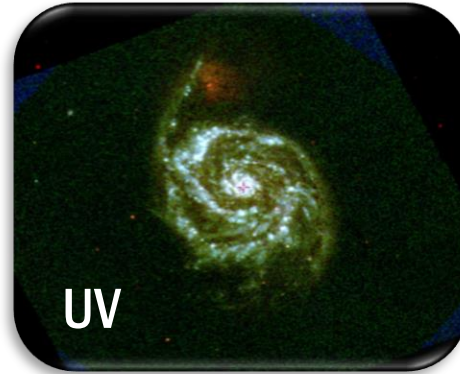
Look for NGC 3766 (a star cluster)



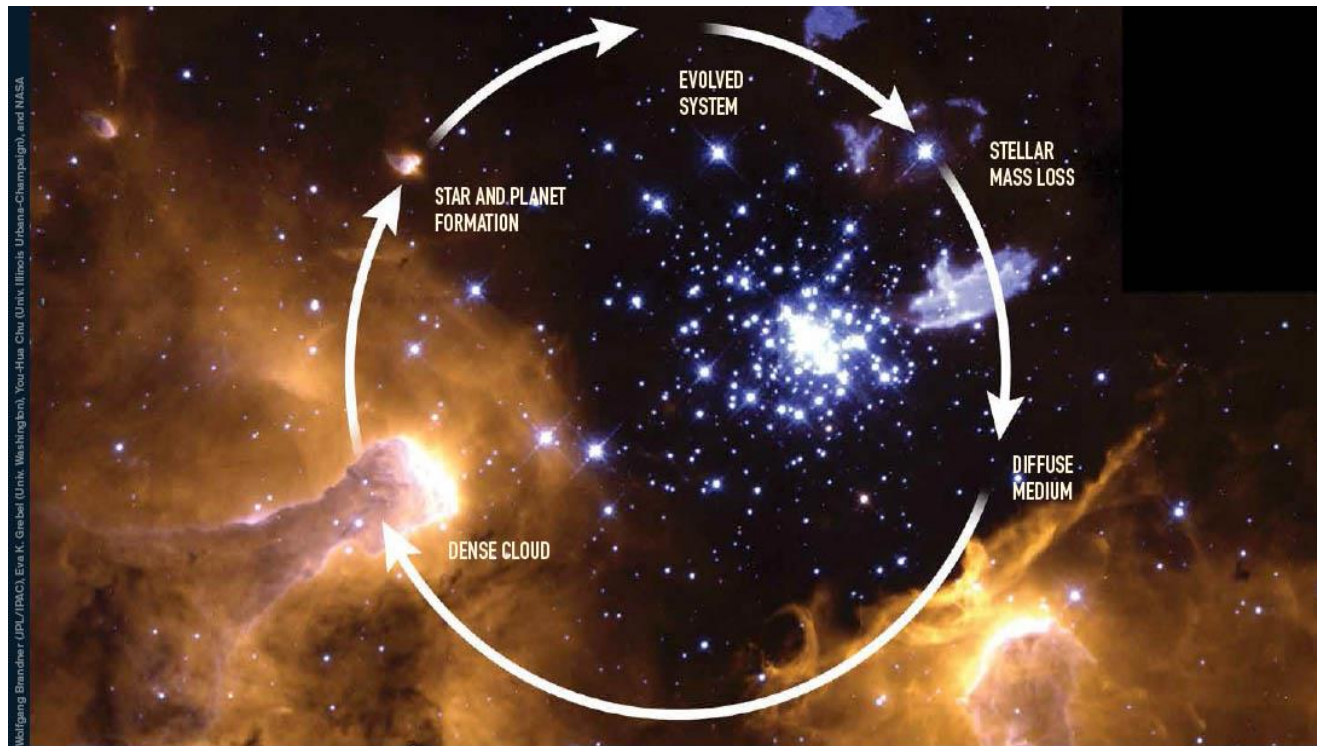
Look for The Horsehead Nebula (ISM)



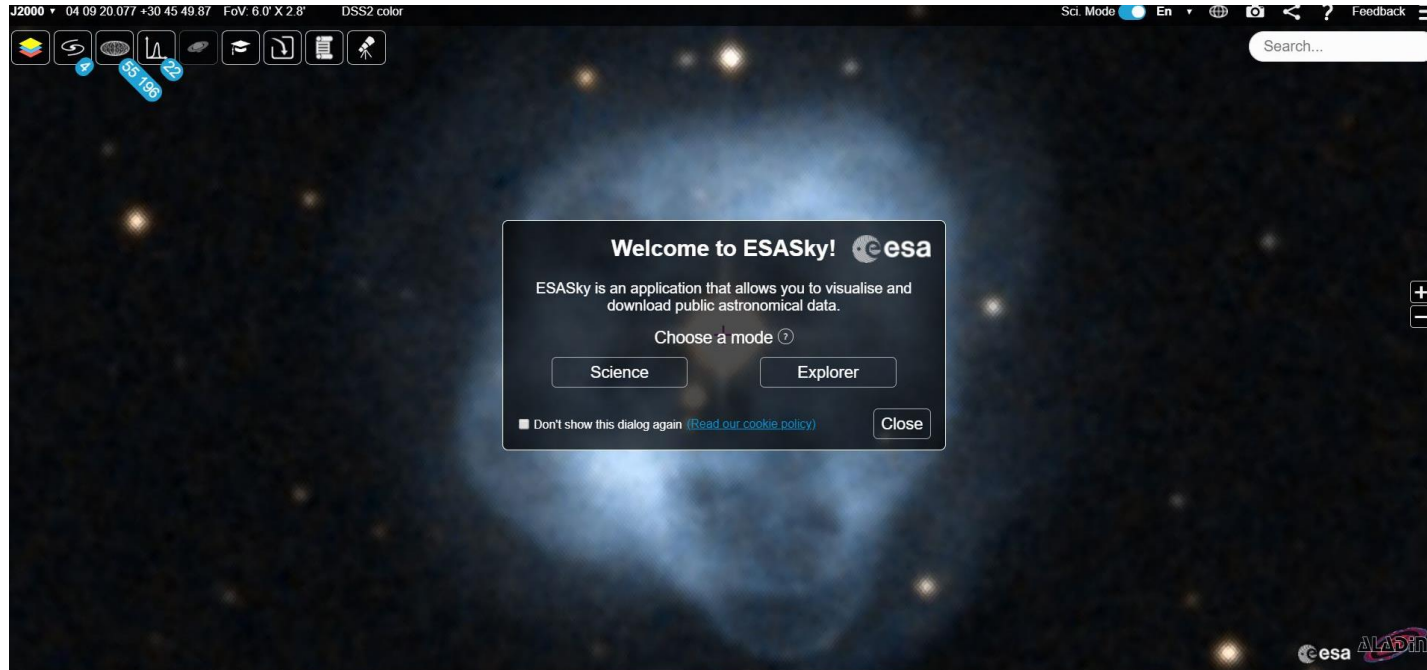
Look for The Whirlpool galaxy (M51 or NGC 5194)



Interstellar medium



Let's get familiar with ESASky (<http://sky.esa.int/>)



What is ESASky?

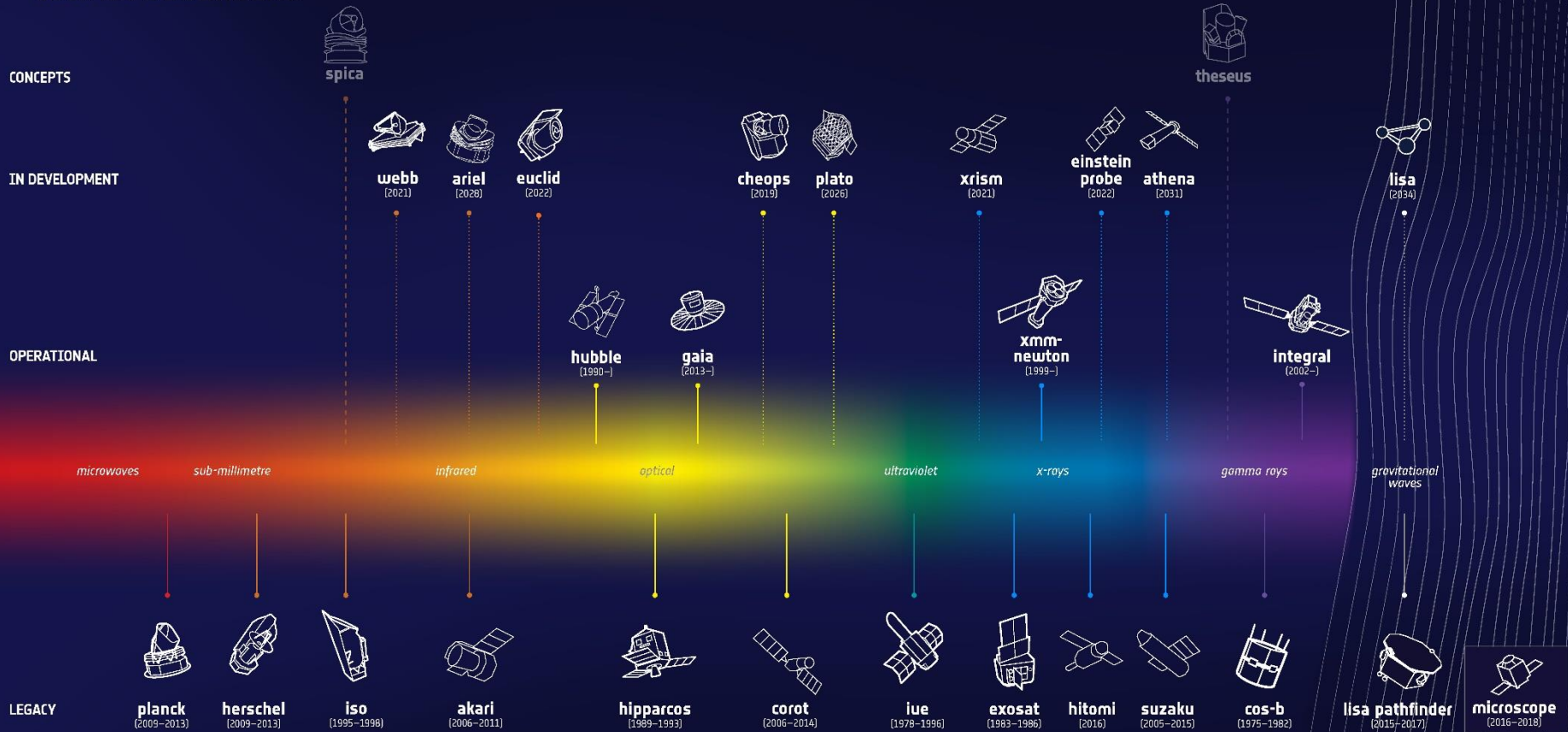
ESASky is an interactive tool which gathers tons of astronomical data taken by space missions

- Fancy user interface
- Multiwavelength images/spectra
- No previous knowledge is required
- Publications of the selected option displayed
- Access to astronomical DBs and catalogues



AIM  *Being accessible to everyone*

→ COSMIC OBSERVERS



What's new in ESASky in 2020?

Copy link

What's new in ESASky in 2020?

<https://sky.esa.int>

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0:04 / 3:12

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