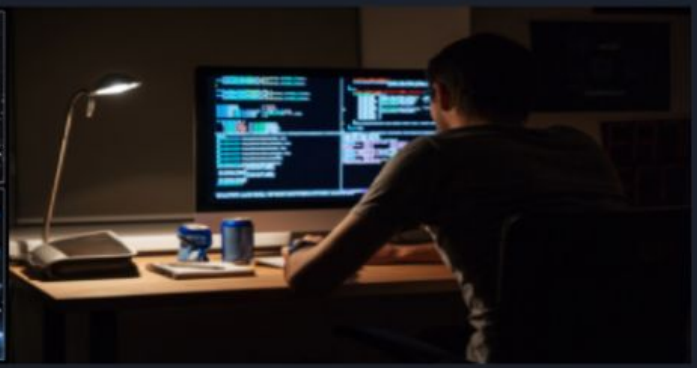
Astronomical Data Science.....



Today we will see ……

DAY 2:

- Introduction to Digital Image Processing

In this Session

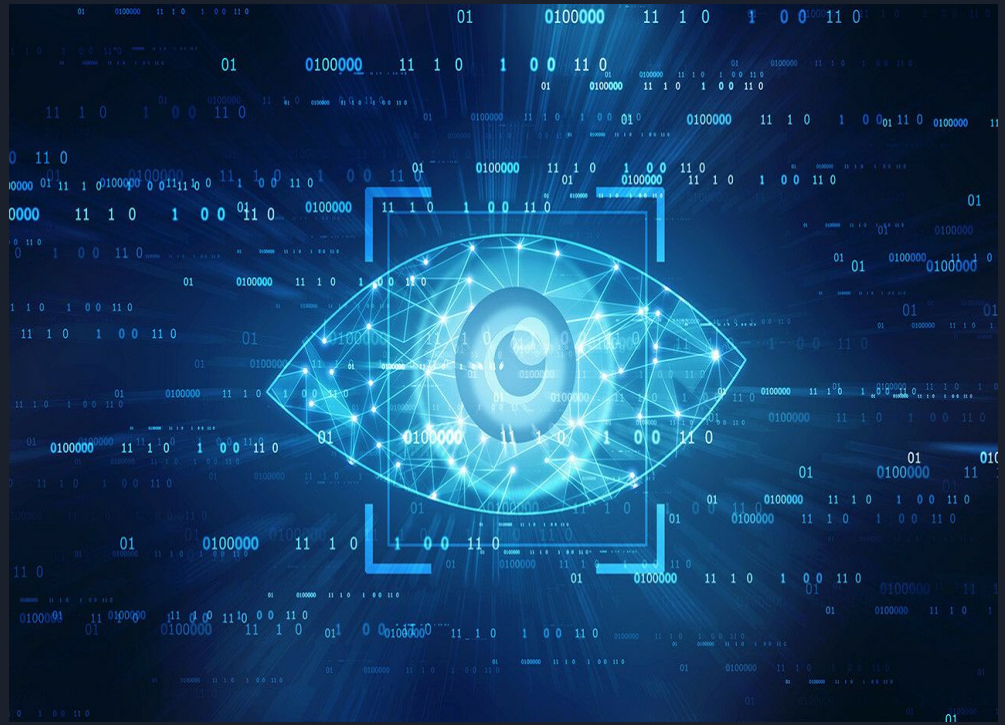
1. Digital Images
2. How are Astronomical Images Processed
3. Digital Image Processing and Computer Vision
4. Multiwavelength Whirlpool Galaxy Revealing its Secrets
5. Common Image File Formats

DIGITAL IMAGE PROCESSING

Image improvement for human perception

Helps to see

- Small size
- Far distance objects

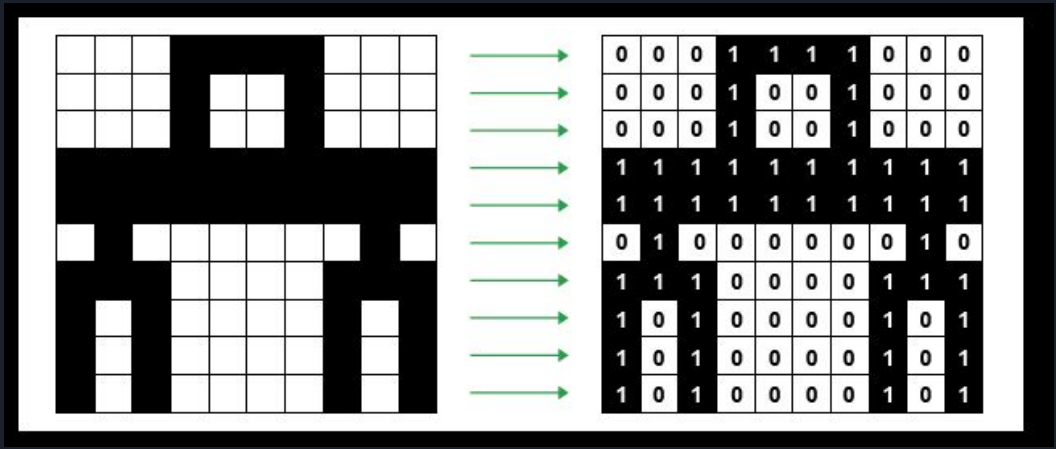


What is a digital image…

1. Spatial (what area and how detailed)
2. Spectral (what colour – bands)
3. Radiometric (colour depth)

45	51	88	89	94	100	98	103	104	104
47	146	102	100	118	183	125	101	99	100
34	135	33	32	53	88	73	34	29	30
48	84	39	63	55	25	33	32	31	31
151	43	114	151	152	135	134	129	134	165
208	115	35	33	36	39	39	72	93	176
210	171	39	34	39	40	109	86	77	208
209	175	40	39	37	53	90	39	80	222
200	185	49	38	35	75	72	45	90	197
66	85	39	35	33	52	86	49	49	83

Binary images

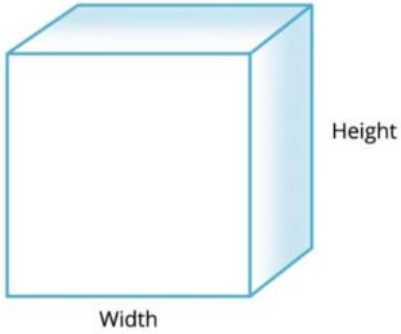


Gray scale images

Color Image

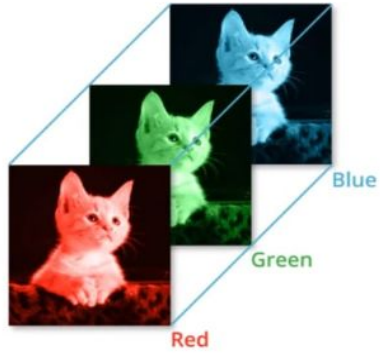
Width x Height x Depth

3D Array

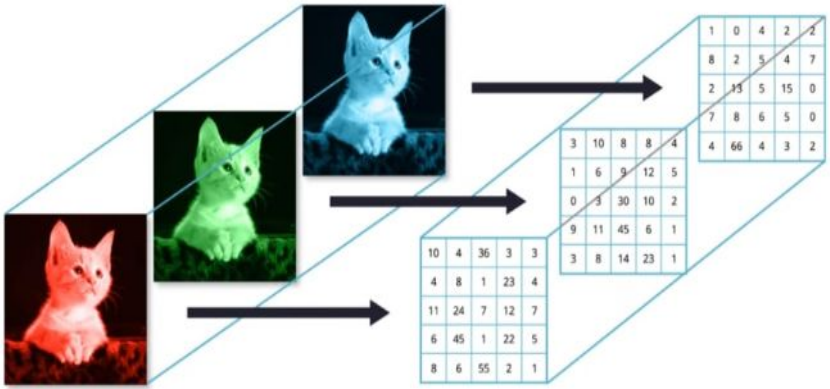


RGB Image

5 x 5 x 3



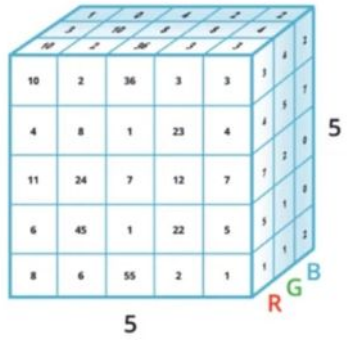
RGB Image

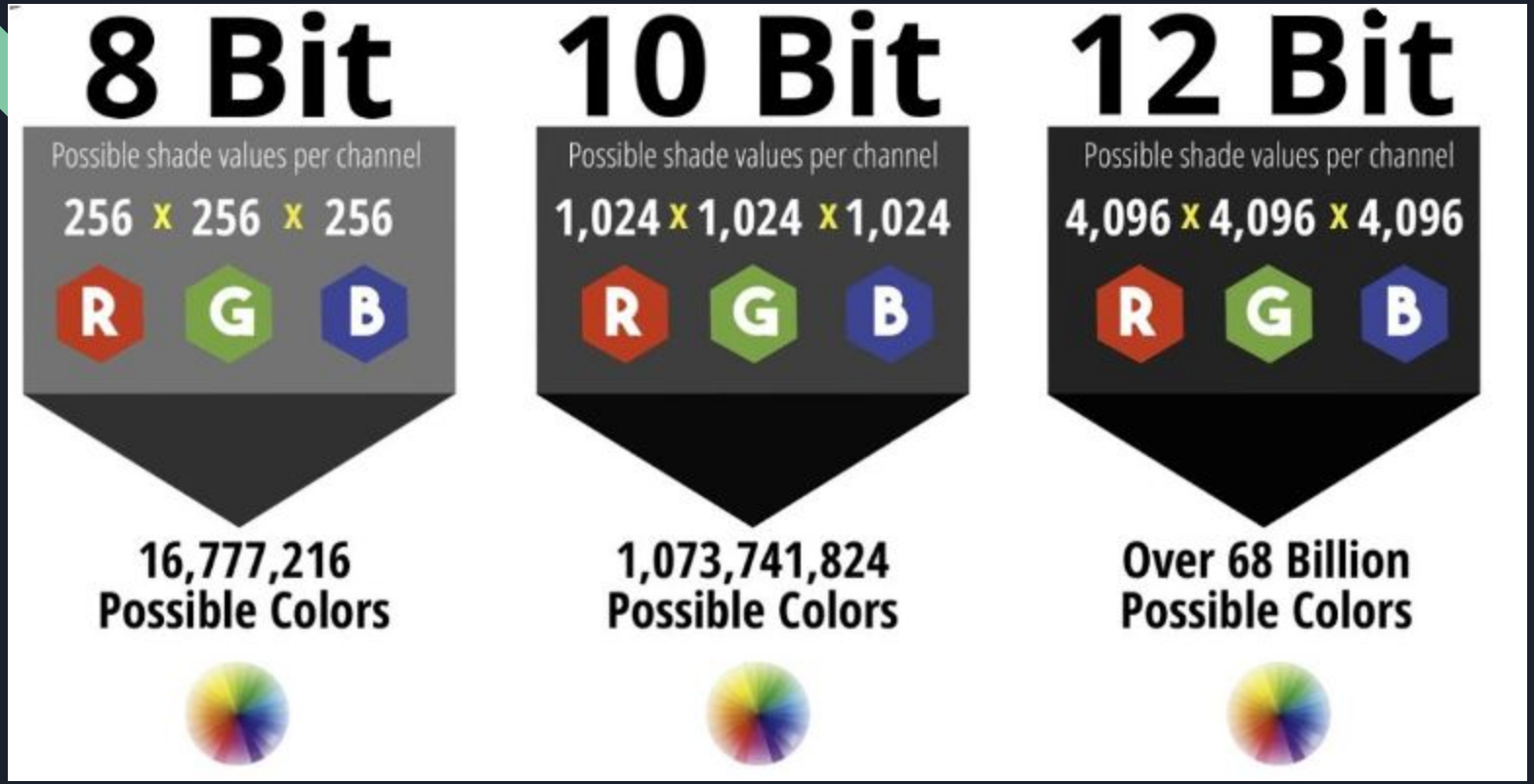


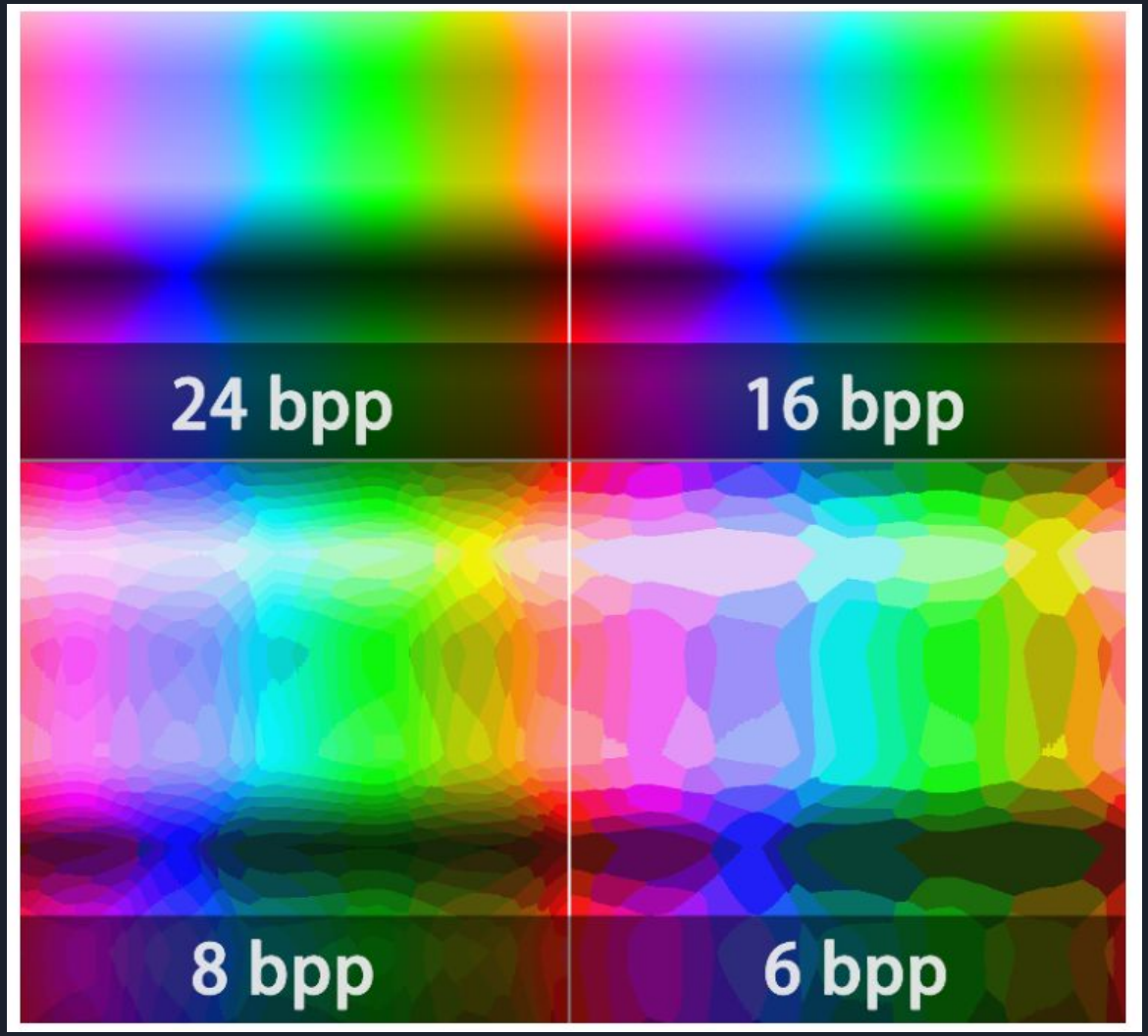
RGB Image

5 x 5 x 3

3D Array



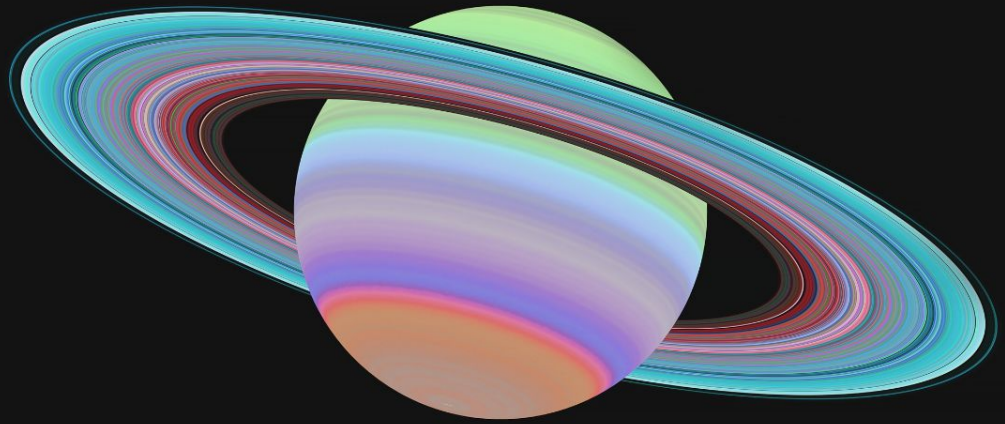

8 Bit
Possible shade values per channel
256 x 256 x 256
R G B
16,777,216
Possible Colors
10 Bit
Possible shade values per channel
1,024 x 1,024 x 1,024
R G B
1,073,741,824
Possible Colors
12 Bit
Possible shade values per channel
4,096 x 4,096 x 4,096
R G B
Over 68 Billion
Possible Colors


24 bpp
16 bpp
8 bpp
6 bpp

How are Astronomical Images Processed?

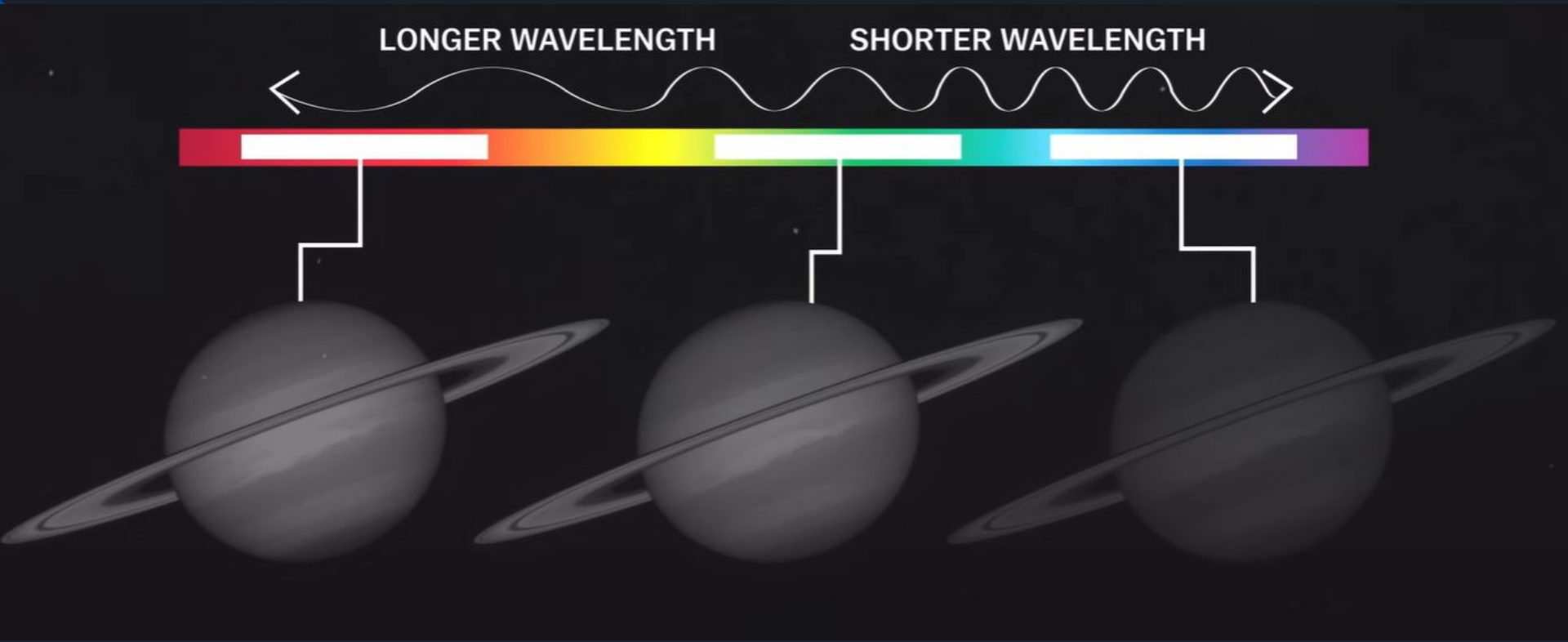
The colors in Images of Planets, Nebula, or Supernova are they even real!?

Telescopes capture images in wavelengths that surpasses a human eye ability to see it!
So what are we actually seeing while glancing at our cosmic beauty in different bands??

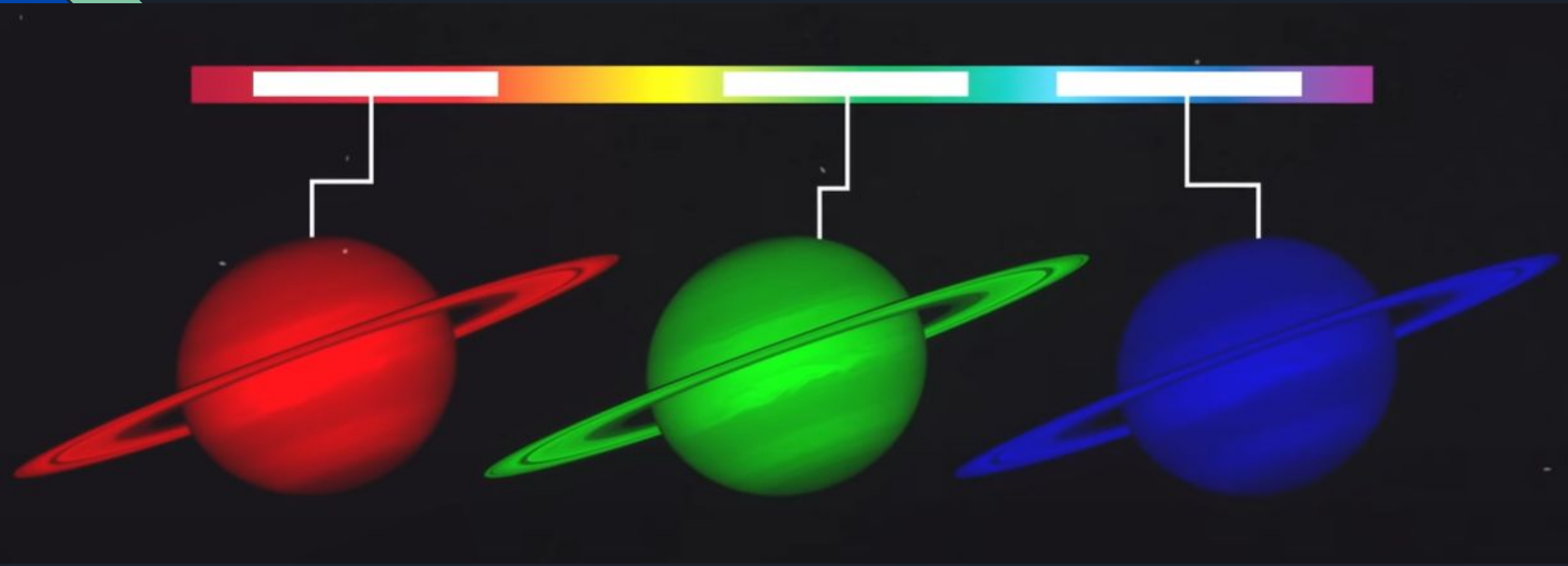


Saturn as seen in the Ultraviolet Band!

Black and white image from telescope is received first!



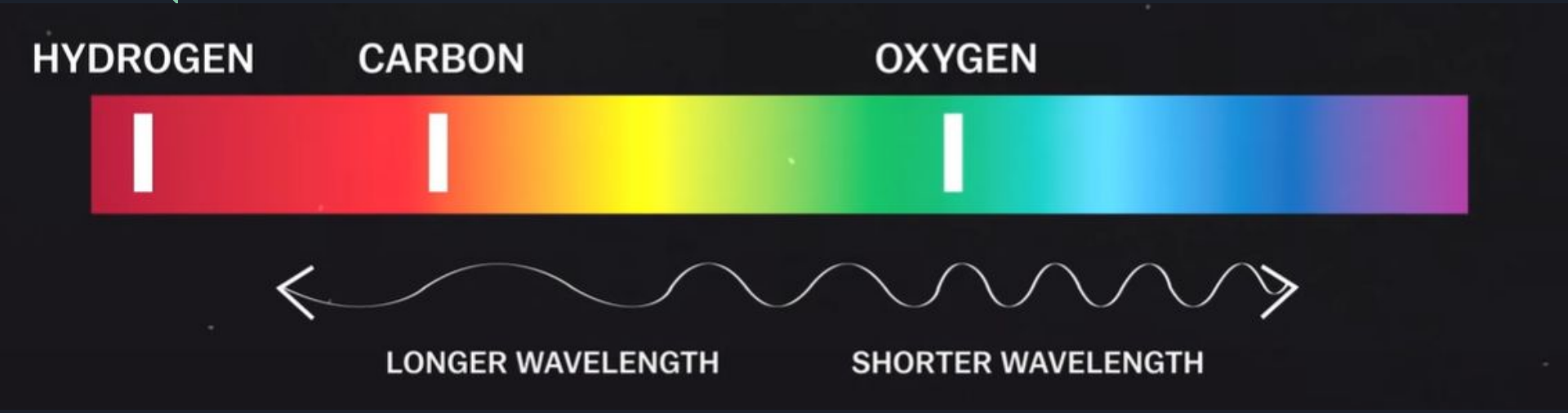
Filters separate light into long, medium and short wavelengths.
This is called broadband filtering since it targets general ranges of light!



Each of three black-and-white images are then assigned a color based on their position on the visible spectrum.

The combined result is a “true colour” image that our eyes would see!

Narrow band filtering!

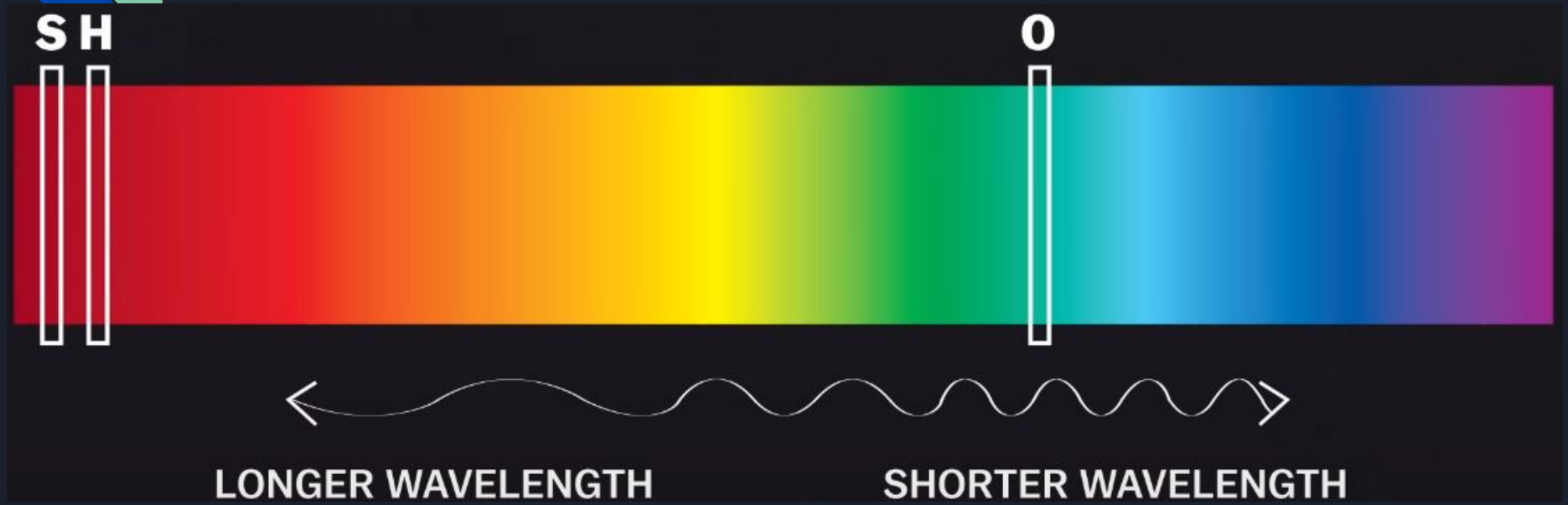


Telescopes like Hubble can record very narrow bands of light coming from individual elements. For example, Hydrogen, Carbon and Oxygen. The colors are then used to keep track their presence in an image.

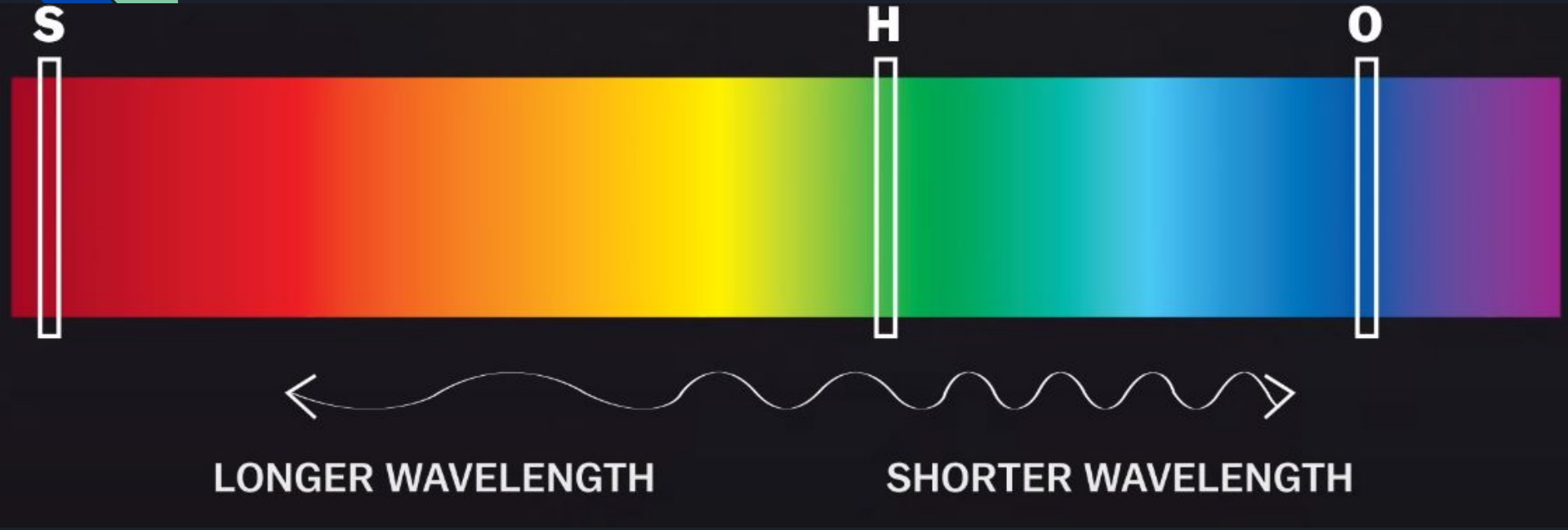
Example:- The famous Pillars of Creation Image

Coloring these gases as we'd actually see them would produce….

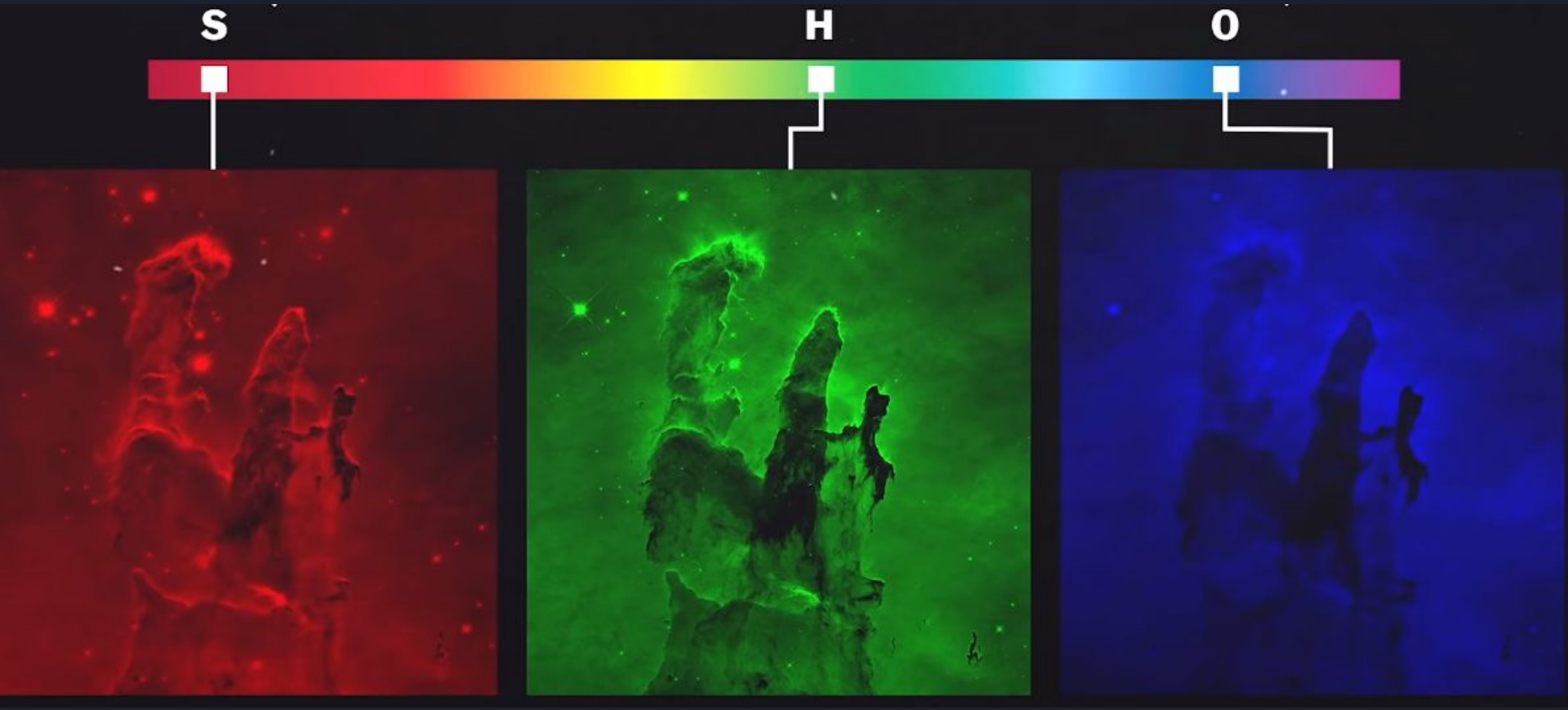
This image - that’s what our eyes would see if looking at the pillars of creation!
Not as useful for visual analysis…



Now, as sulfur and hydrogen are in red region. To separate them, we can assign these elements to…



…red, green and blue according to their place in chromatic order.



Wavelength order: S > H > O
Color order: R > G > B

Comparing colorized map of elements image vs true color image

Colorized map of elements

True Color Image

Credits

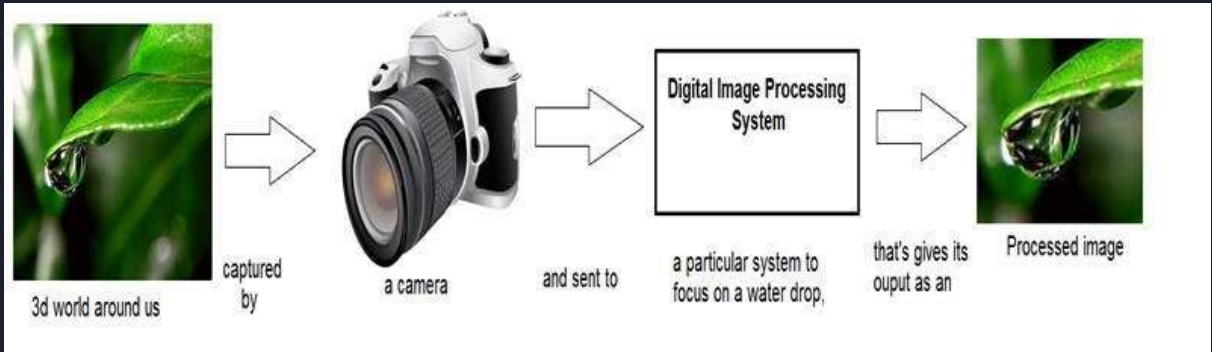
If you want to see full animated video on this, please check this YouTube video.

These visualizations were taken from that video itself.

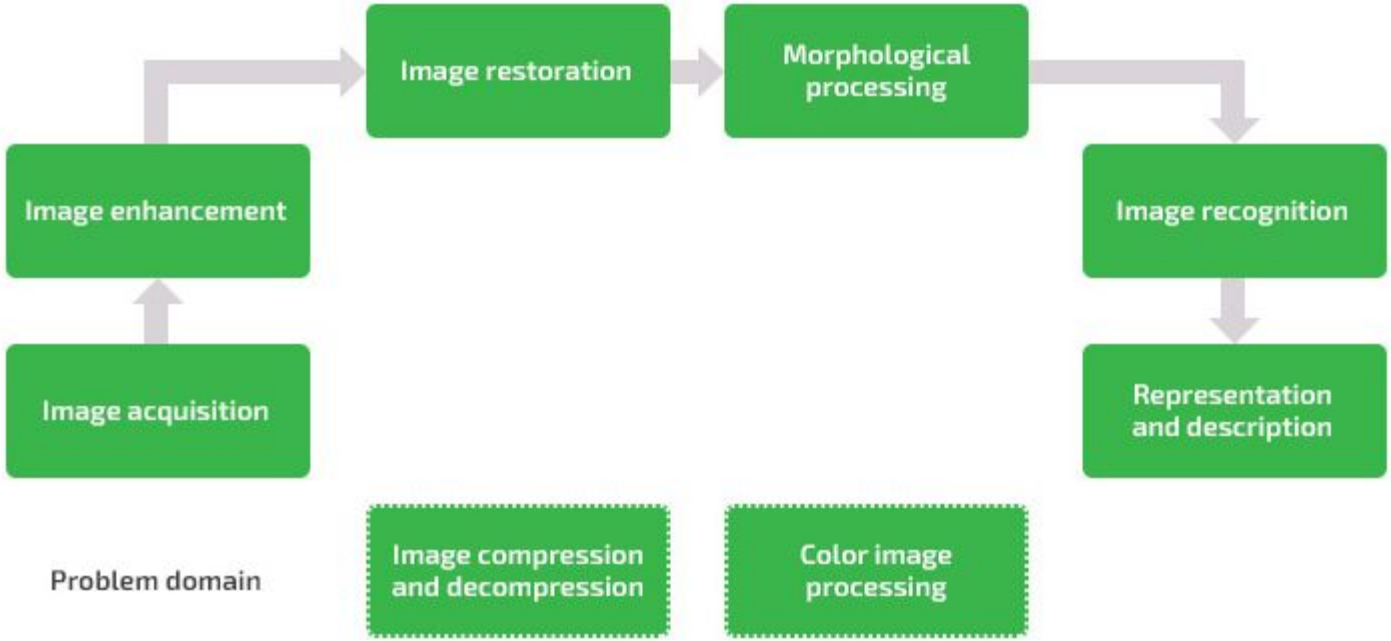
What is digital image processing and computer vision?

Algorithms, to process image

- Low level: sharpening, contrast, enhancement
- Mid level: image features are extracted, segmentation
- High level: understanding, recognition



KEY PHASES OF DIGITAL IMAGE PROCESSING



1. **Image acquisition** is the process of capturing an image with a sensor (such as a camera) and converting it into a manageable entity (for example, a digital image file). One popular image acquisition method is scraping.

At Apriorit, we've created several custom image acquisition tools to help our clients collect high-quality datasets for training neural network models.

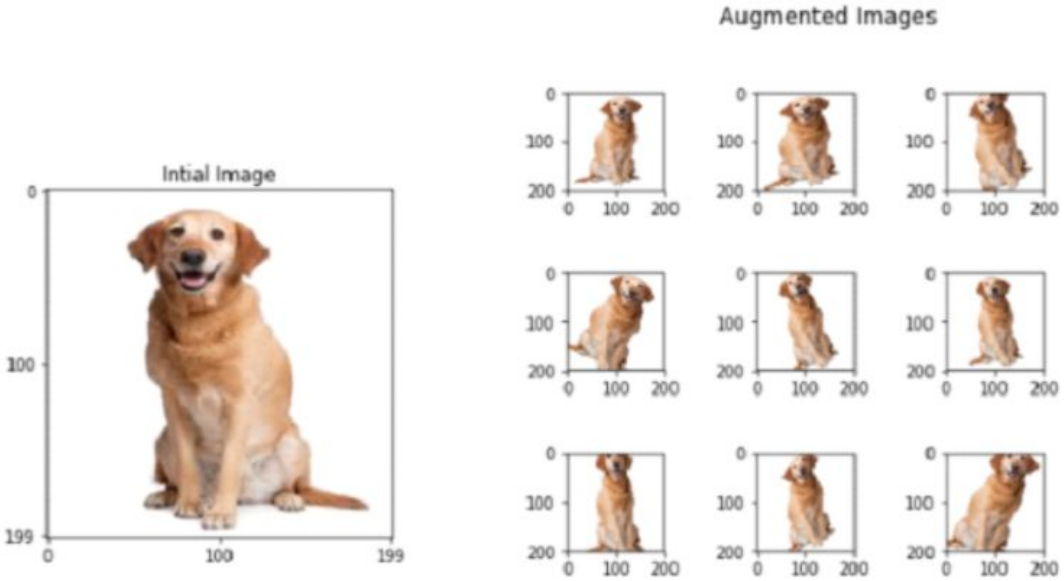
2. **Image enhancement** improves the quality of an image in order to extract hidden information from it for further processing.

3. **Image restoration** also improves the quality of an image, mostly by removing possible corruptions in order to get a cleaner version. This process is based mostly on probabilistic and mathematical models and can be used to get rid of blur, noise, missing pixels, camera misfocus, watermarks, and other corruptions that may negatively affect the training of a neural network.

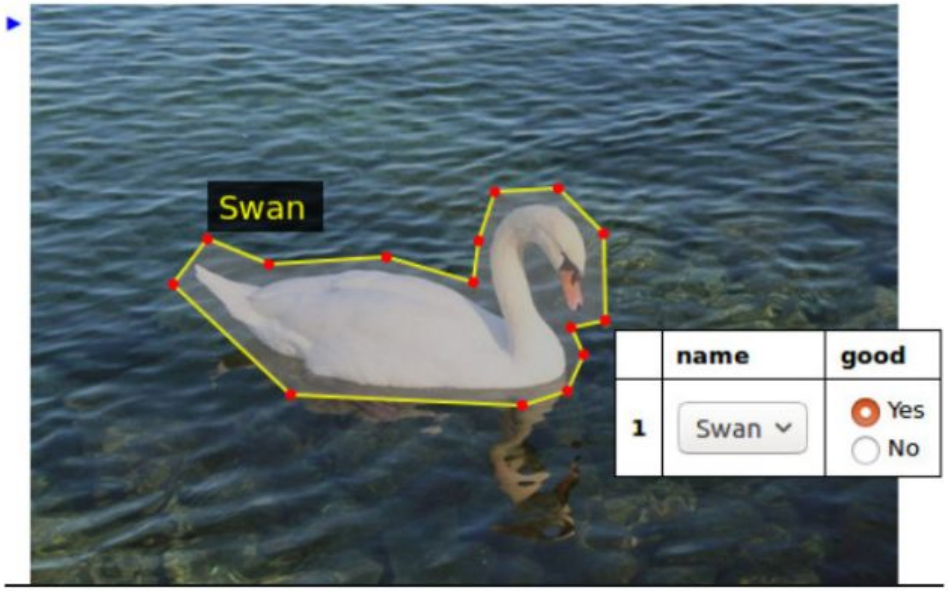
4. **Color image processing** includes the processing of colored images and different color spaces. Depending on the image type, we can talk about pseudocolor processing (when colors are assigned grayscale values) or RGB processing (for images acquired with a full-color sensor).

5. **Image compression and decompression** allow for changing the size and resolution of an image. Compression is responsible for reducing the size and resolution, while decompression is used for restoring an image to its original size and resolution.

These techniques are often used during the image augmentation process. When you lack data, you can extend your dataset with slightly augmented images. In this way, you can improve the way your neural network model generalizes data and make sure it provides high-quality results.



6. **Morphological processing** describes the shapes and structures of the objects in an image. Morphological processing techniques can be used when creating datasets for training AI models. In particular, morphological analysis and processing can be applied at the annotation stage, when you describe what you want your AI model to detect or recognize.



An example of the annotation process of morphological analysis

7. **Image recognition** is the process of identifying specific features of particular objects in an image. AI-based image recognition often uses such techniques as object detection, object recognition, and segmentation.

This is where AI solutions truly shine. Once you complete all of these phases, you're ready to combine artificial intelligence and image processing. The process of deep learning development includes a full cycle of operations from data acquisition to incorporating the developed AI model into the end system.

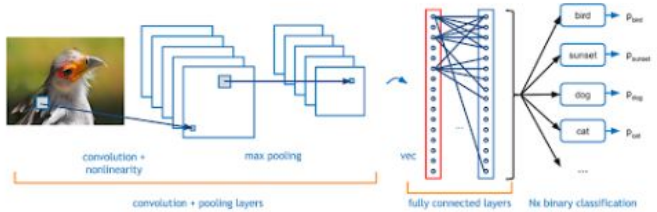
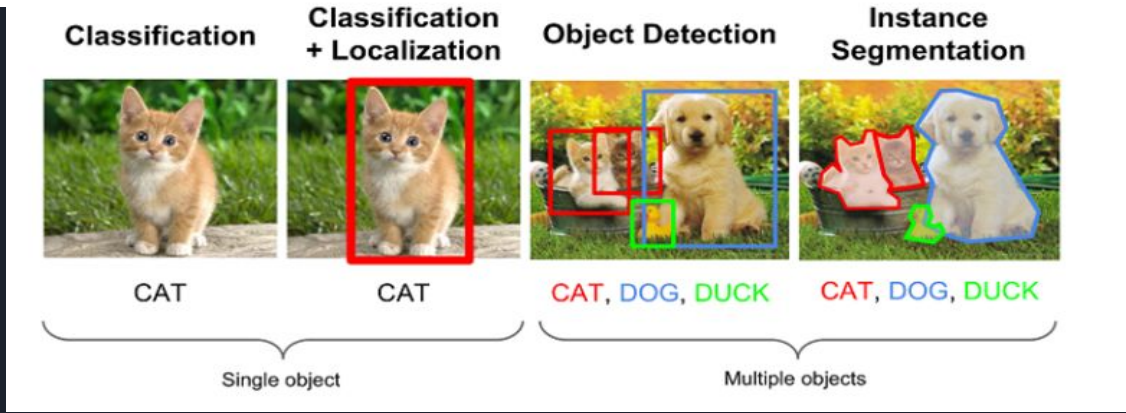
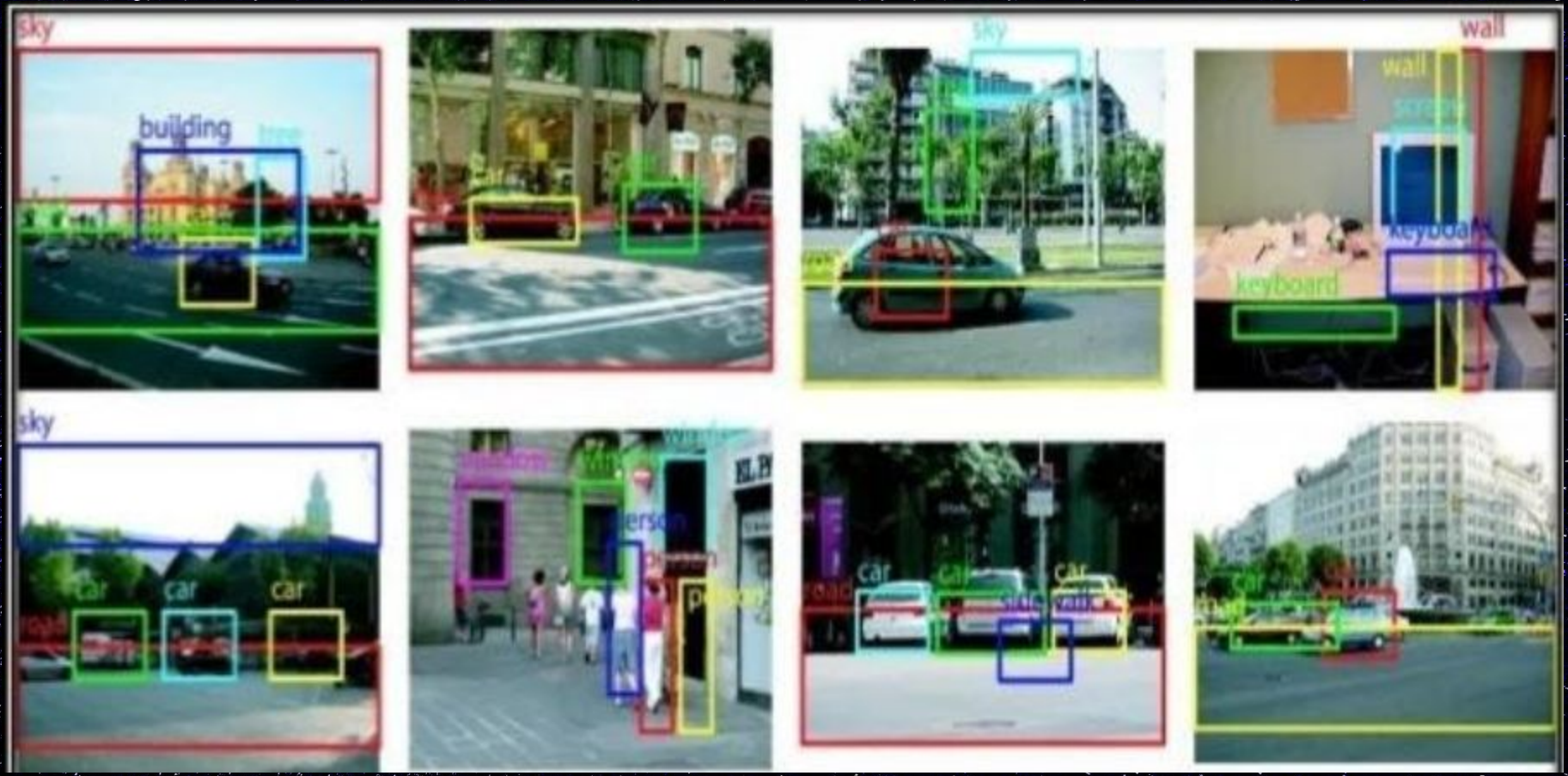
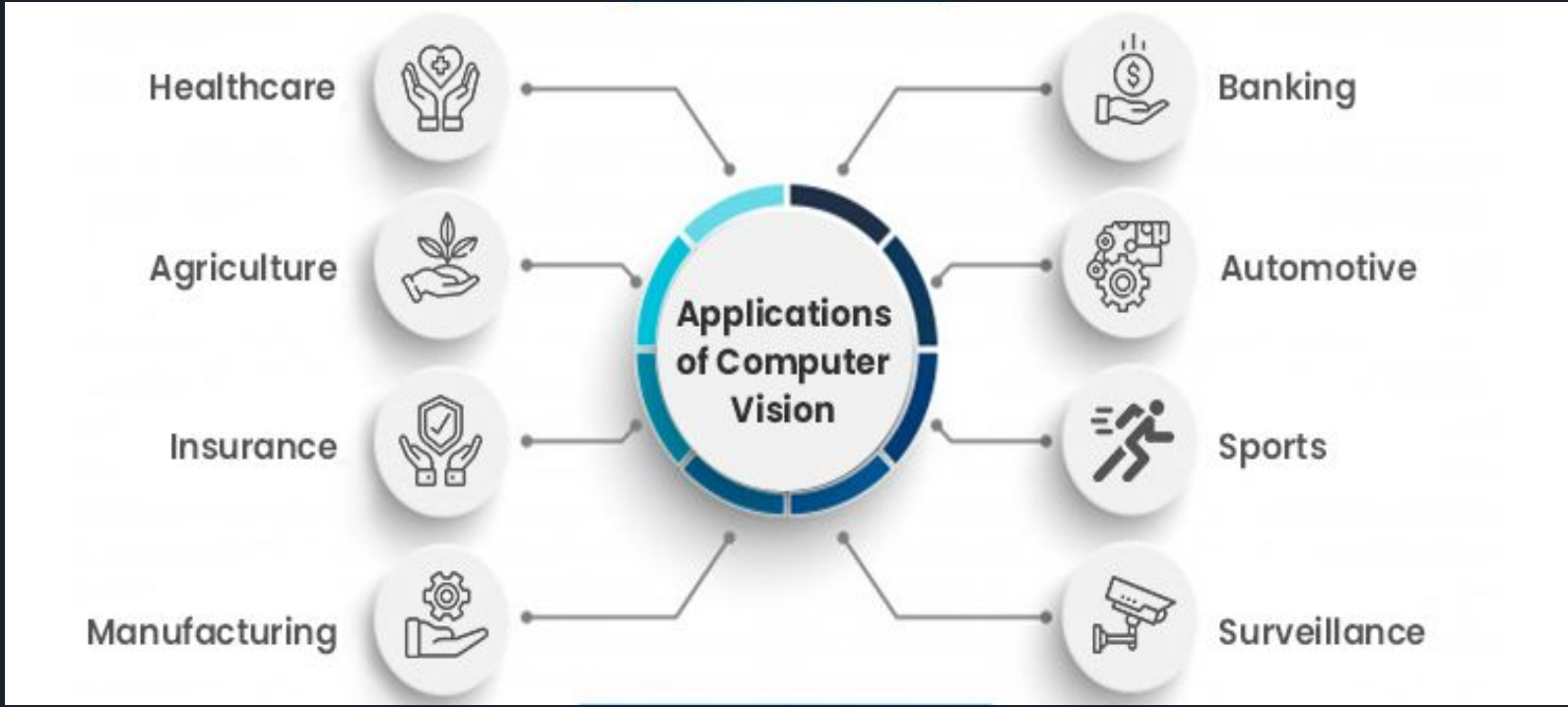


Image recognition with a CNN

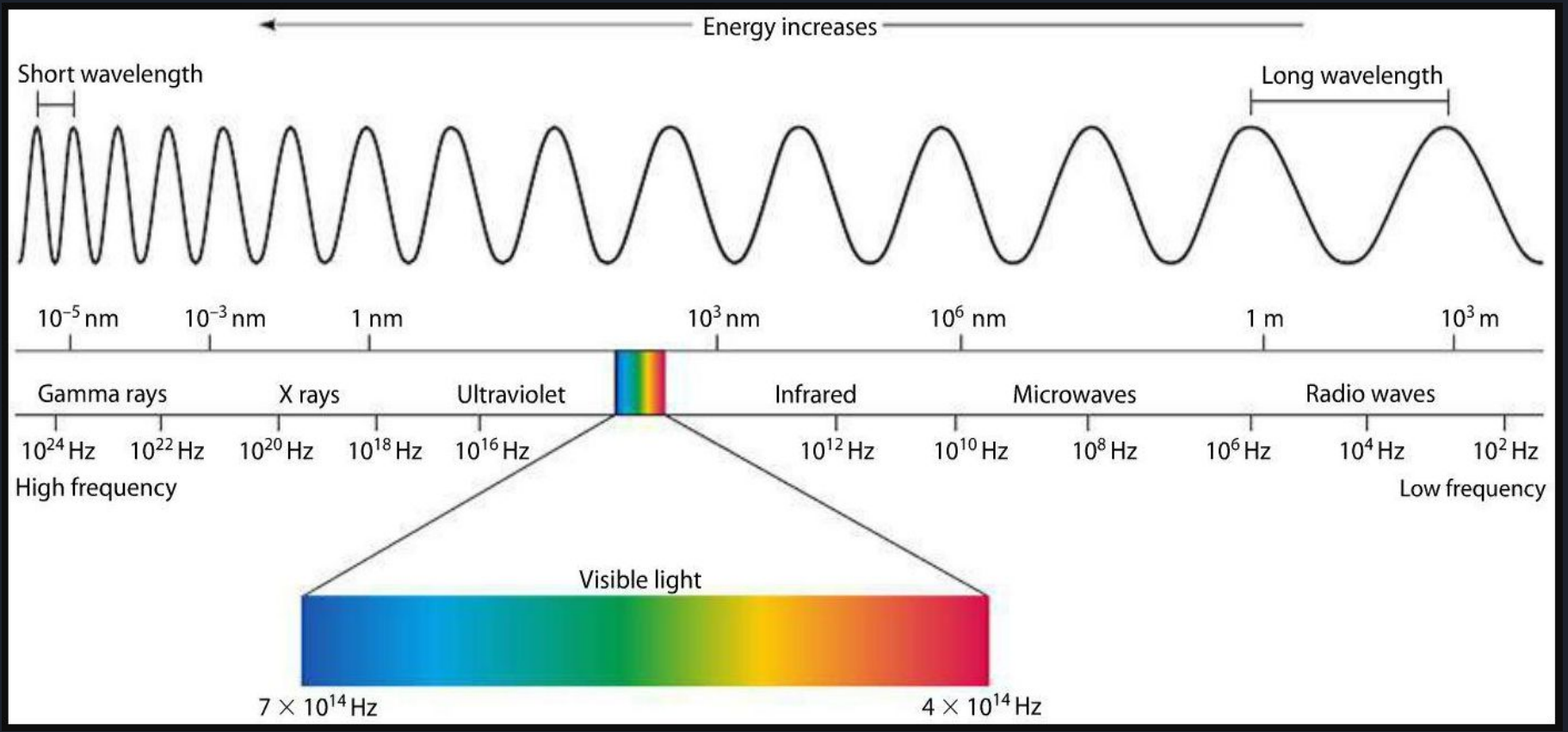



male, 55 years, laugh
female, 49 years, smile


sky
building
sky
wall
wall
keyboard
sky
car
car
car
road
car
car
car


Applications of Computer Vision
Healthcare
Agriculture
Insurance
Manufacturing
Banking
Automotive
Sports
Surveillance

Light is the Visible Portion of the Electromagnetic Spectrum




Radio
Microwave
Infrared
UV
X-Ray
Gamma Ray
Radio
60,000 nm
600 K
Infrared
1200-800 nm (10-3.6 um)
4,500 K
Optical
450-750 nm
6,000 K
Ultraviolet
400-200 nm
10,000 K
X-ray
100-10 nm
10,000,000 K
Multiwavelength Whirlpool Galaxy
COLD GAS: Radio waves reveal regions of gas cool enough for CO_2 molecules to exist.
COOL STARS: Infrared shows smaller cool red stars that make up most of the galaxy.
SOLAR STARS: Optical light comes from stars around the size of the Sun.
HOT STARS: Ultraviolet shows the larger hot blue stars that are less frequent in galaxies.
HOT GAS: X-rays are emitted from the hottest regions of gas where atoms are ionized.
COOL LOW ENERGY RADIATION
VISIBLE LIGHT
HOT HIGH ENERGY RADIATION

Common image file formats

- GIF (Graphic Interchange Format) -
- PNG (Portable Network Graphics)
- JPEG (Joint Photographic Experts Group)
- TIFF (Tagged Image File Format)
- PGM (Portable Gray Map)
- FITS (Flexible Image Transport System)