

Morphology of galaxies

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SCHOOL OF
PHYSICAL SCIENCES
AND NANOTECHNOLOGY

What other type of galaxies are there?

- Galaxies were first classified in the 1920s depending on their appearances through optical telescopes.

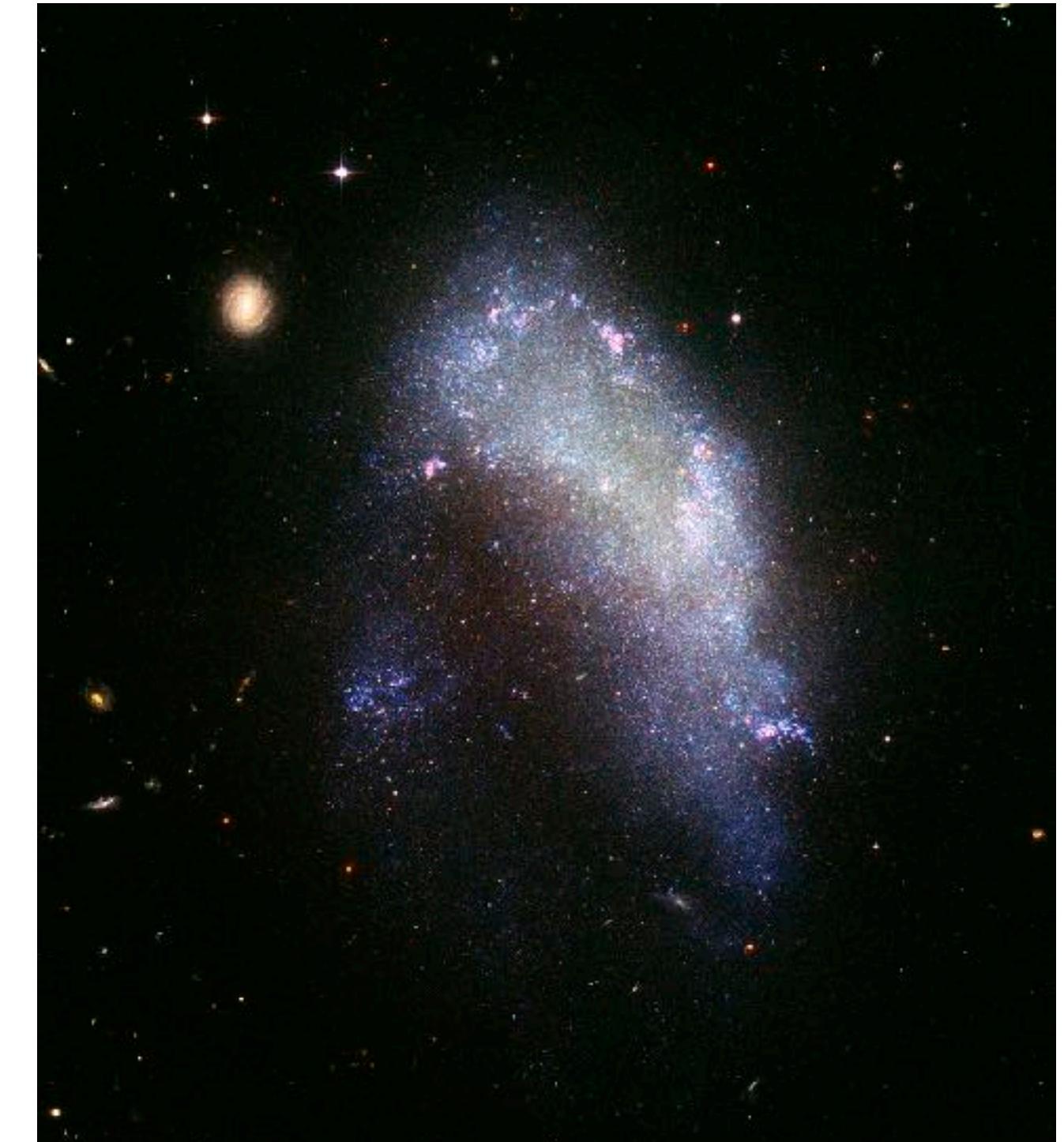
Spiral galaxy
M51



Elliptical galaxy
NGC 1132



Irregular galaxy
NGC 1427A



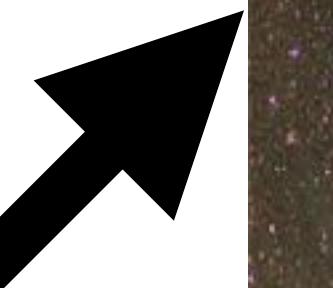
Our Galaxy

What is the galaxy made of?

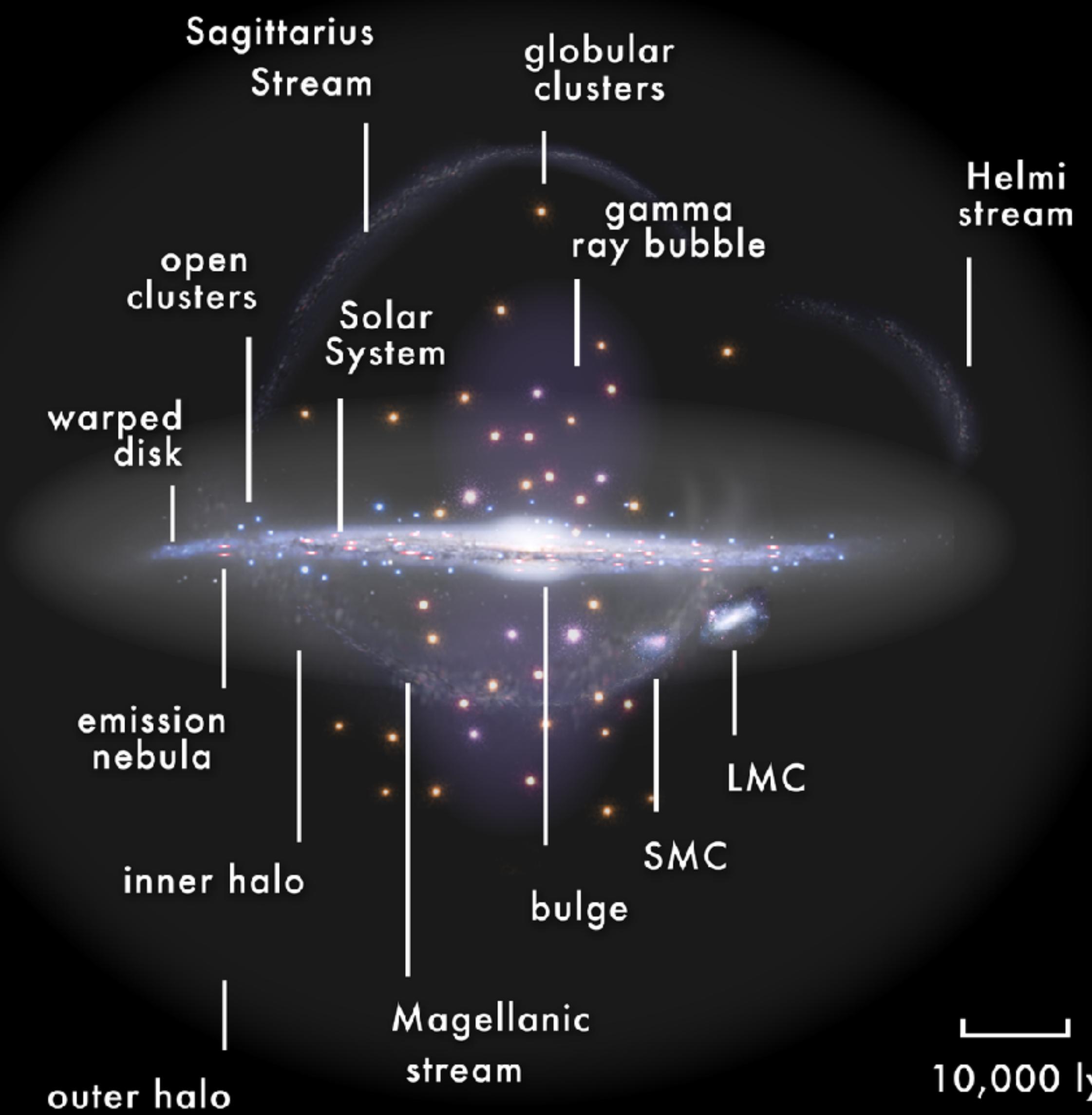
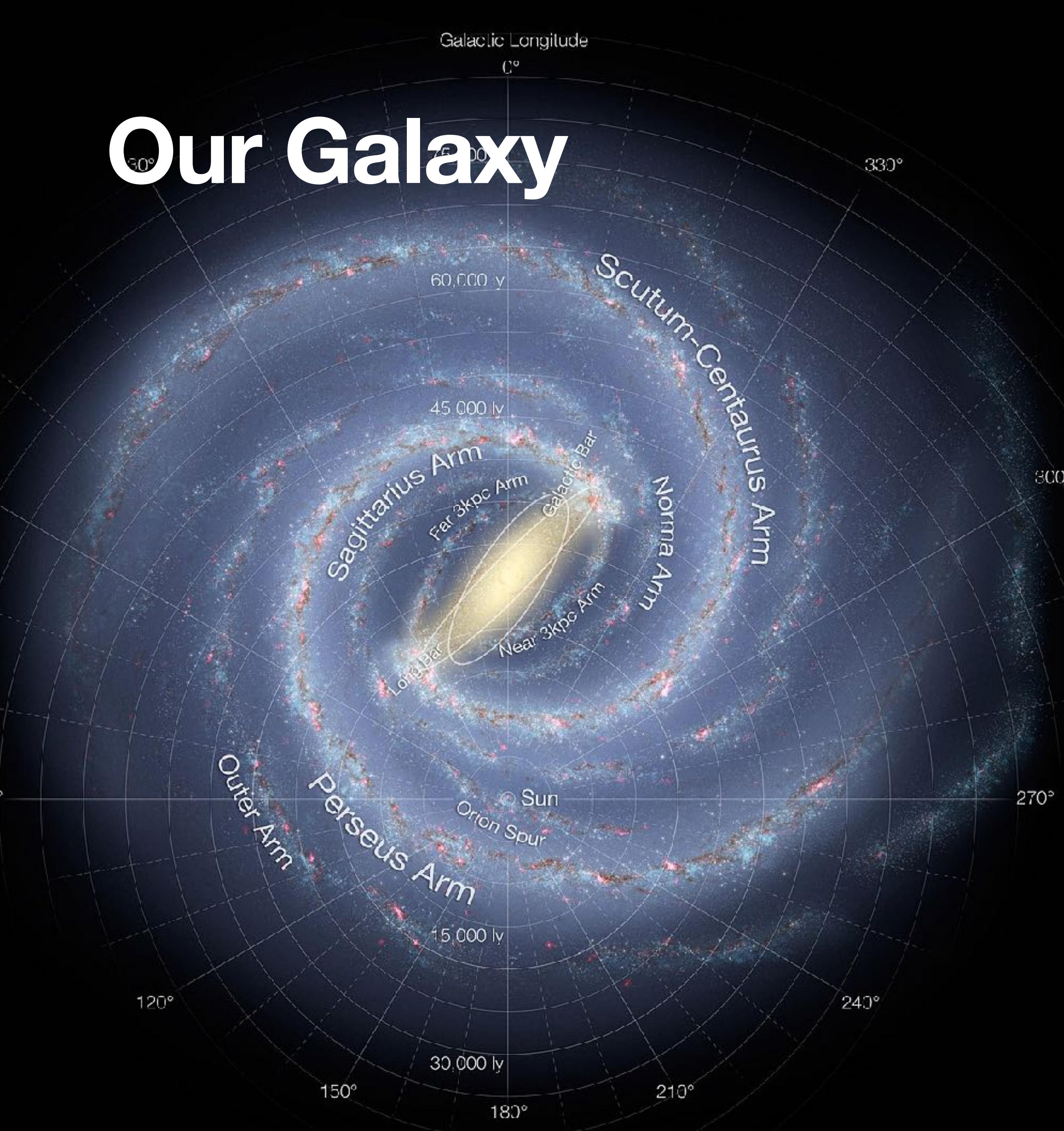
The Galaxy is composed of:

- Stars
- Dust
- Gas
- And Dark matter

Here we see the stars (bright parts) and the dust (dark parts)

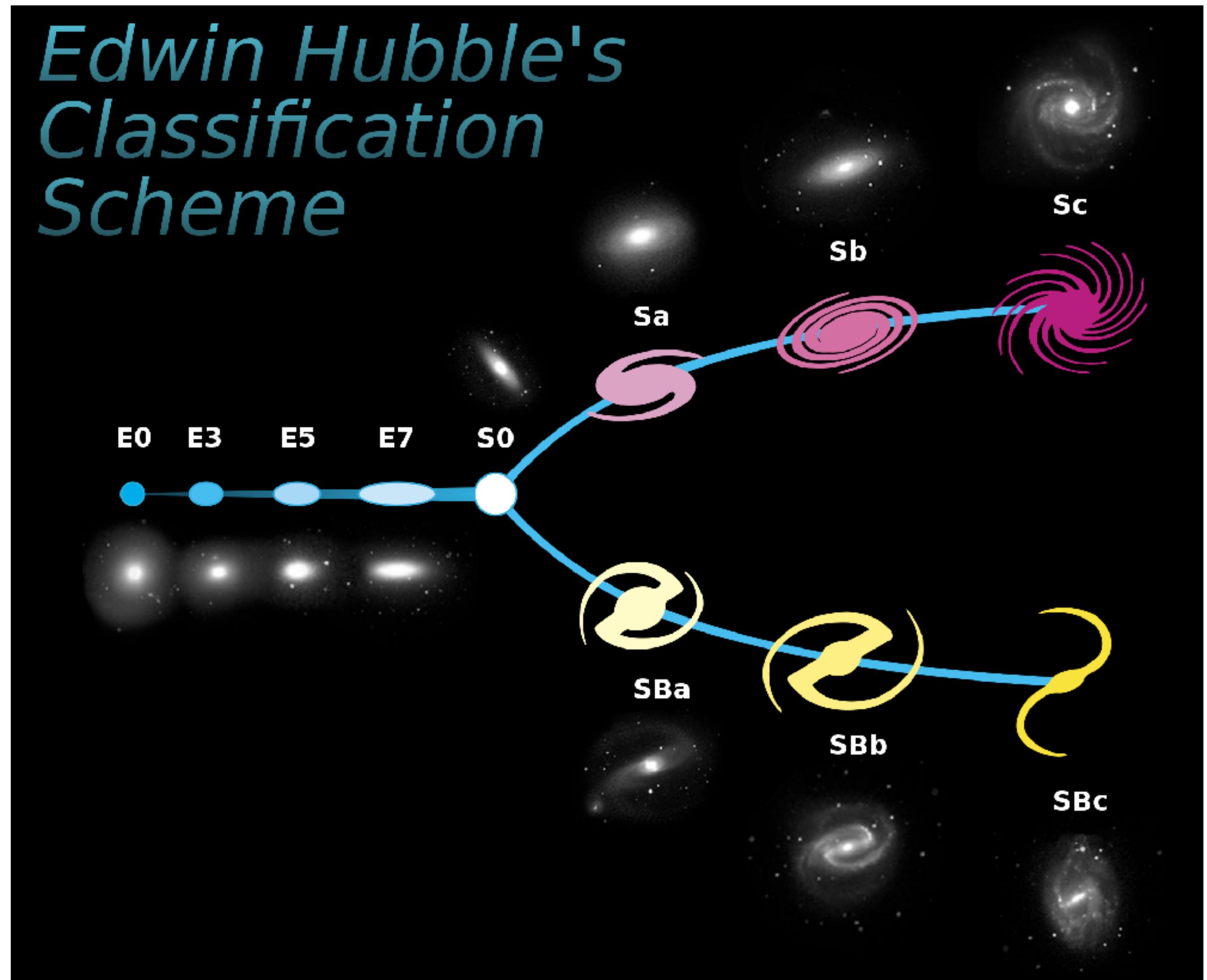


Our Galaxy

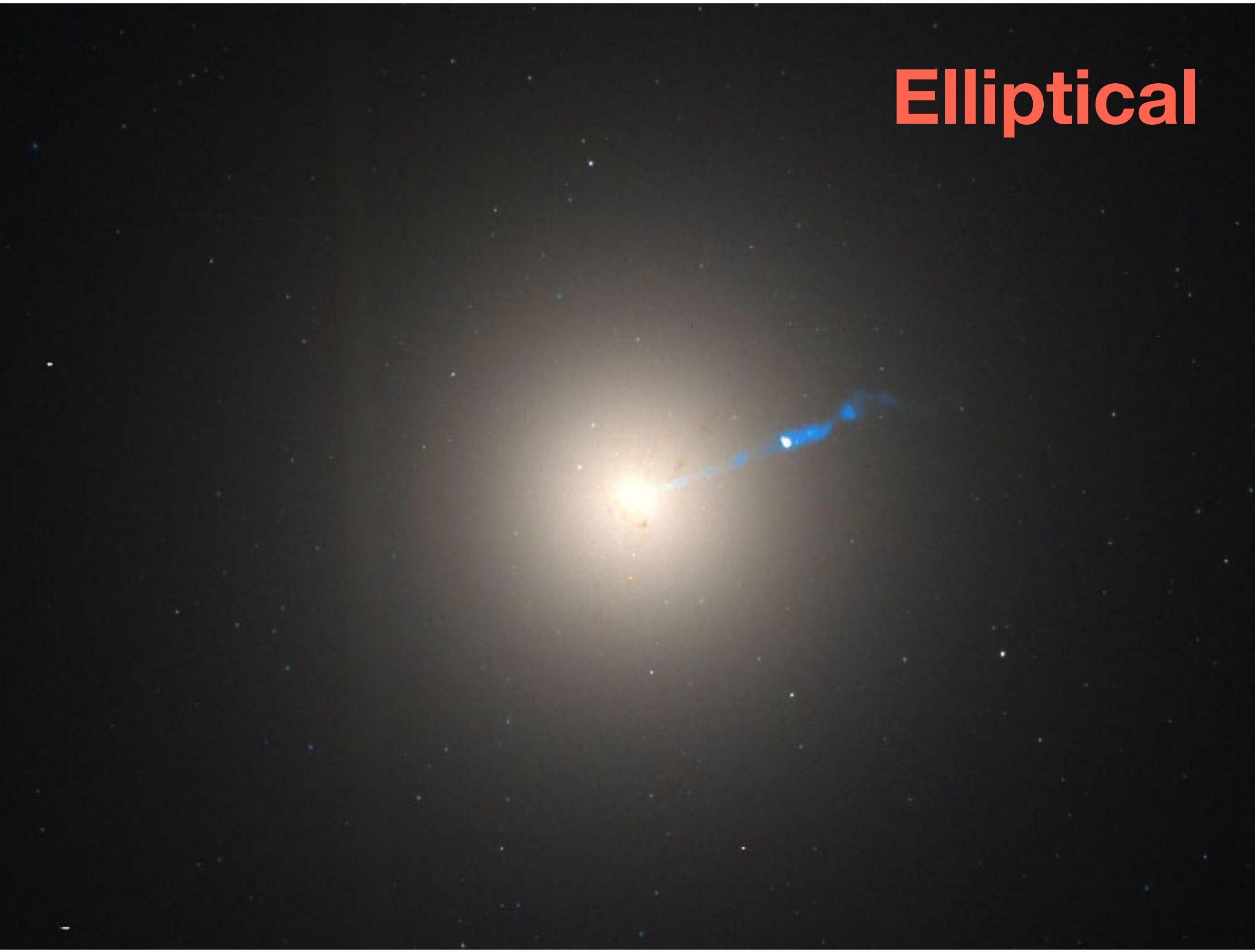


The Hubble classification system

- Also called the **Hubble tuning fork**
- This is the sequentially arranged Hubble classification
- **Elliptical** are also called **early type galaxies**
- **Spirals** are called **late type galaxies**
- The early and late type classification is a historical scheme and is evolutionary actually the other way around:
 - late type spirals are actually younger galaxies compared to the early type ellipticals, which are the older galaxies.



What type of galaxy are these?



Elliptical

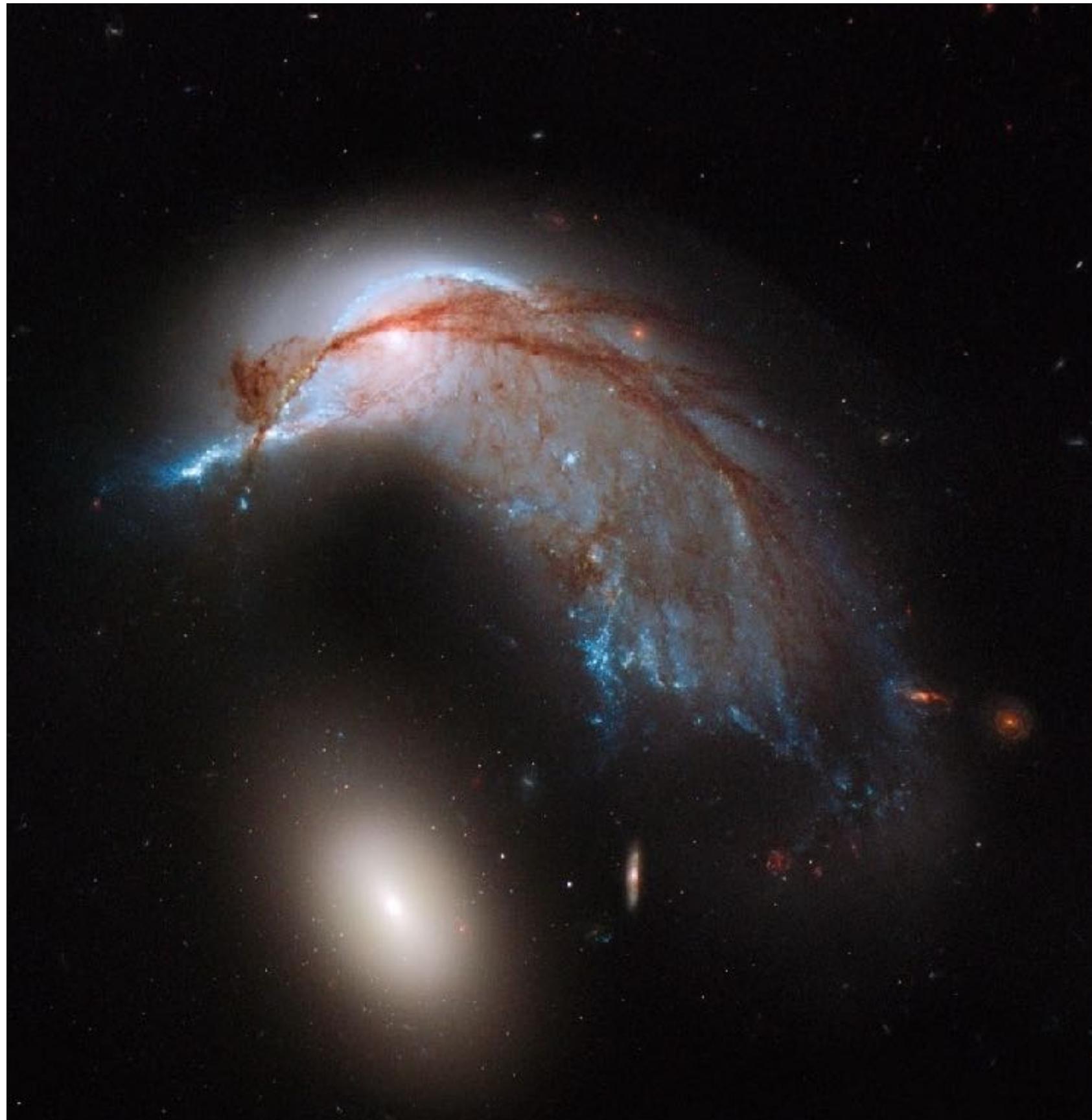


Spiral

How would you classify these?

These are galaxies that are currently undergoing a major merger. A major merger is a merger of two similar sized galaxies.

Arp-142



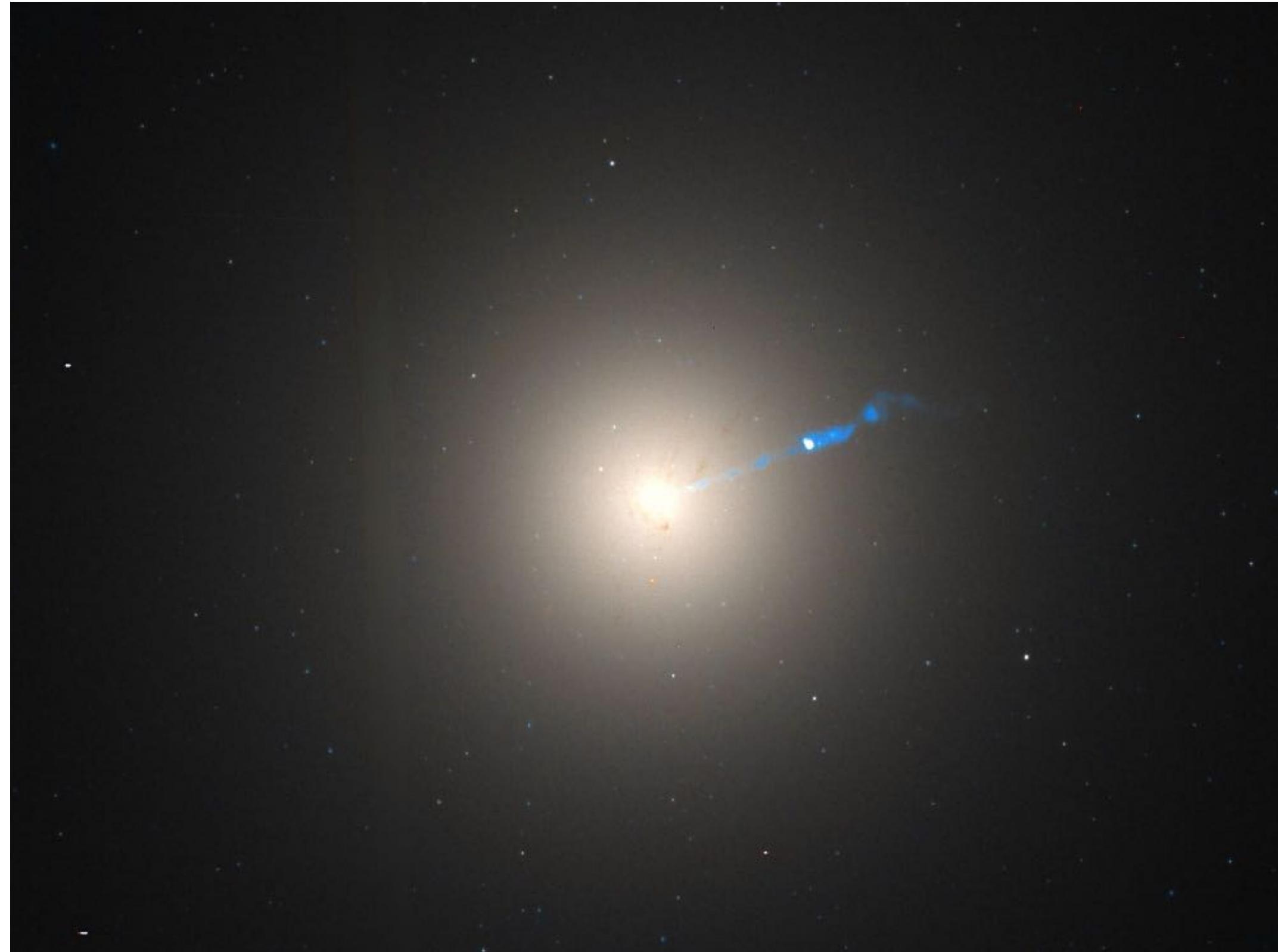
NGC 7764A



How can we automatically classify them?

Yellow (red) in colour -> mostly made of old stars

We do not see much structure



Blue in colour -> has a lot of young stars

Disk + spiral structure, sometimes also bars



The Sérsic model

The Sérsic profile (or Sérsic model) is a mathematical function that **describes how the intensity of a galaxy varies with distance from its center.**

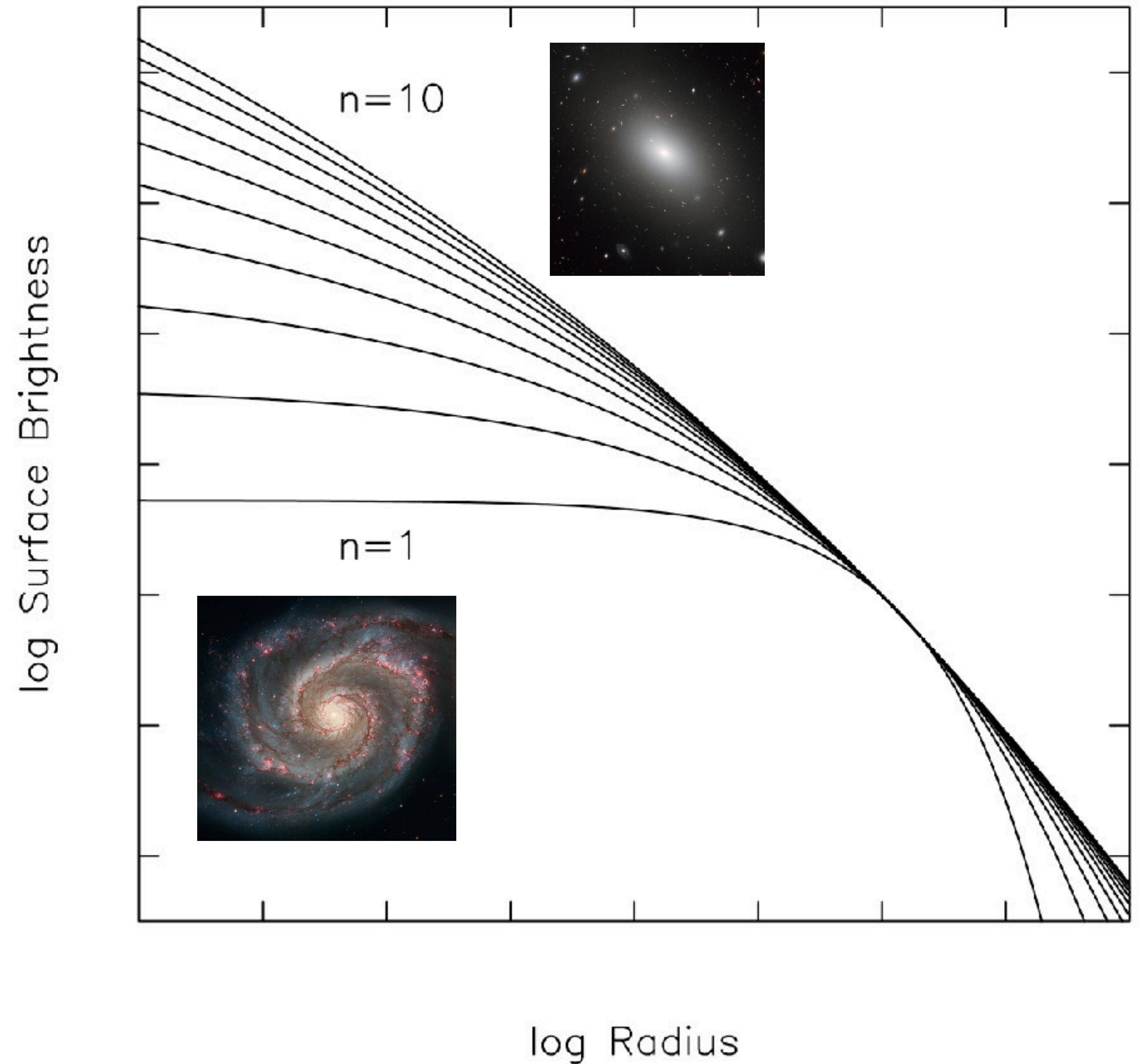
The Sérsic profile has the form

$$I(R) = I_0 \exp\left(-kR^{1/n}\right),$$

where I_0 is the intensity at $R = 0$.

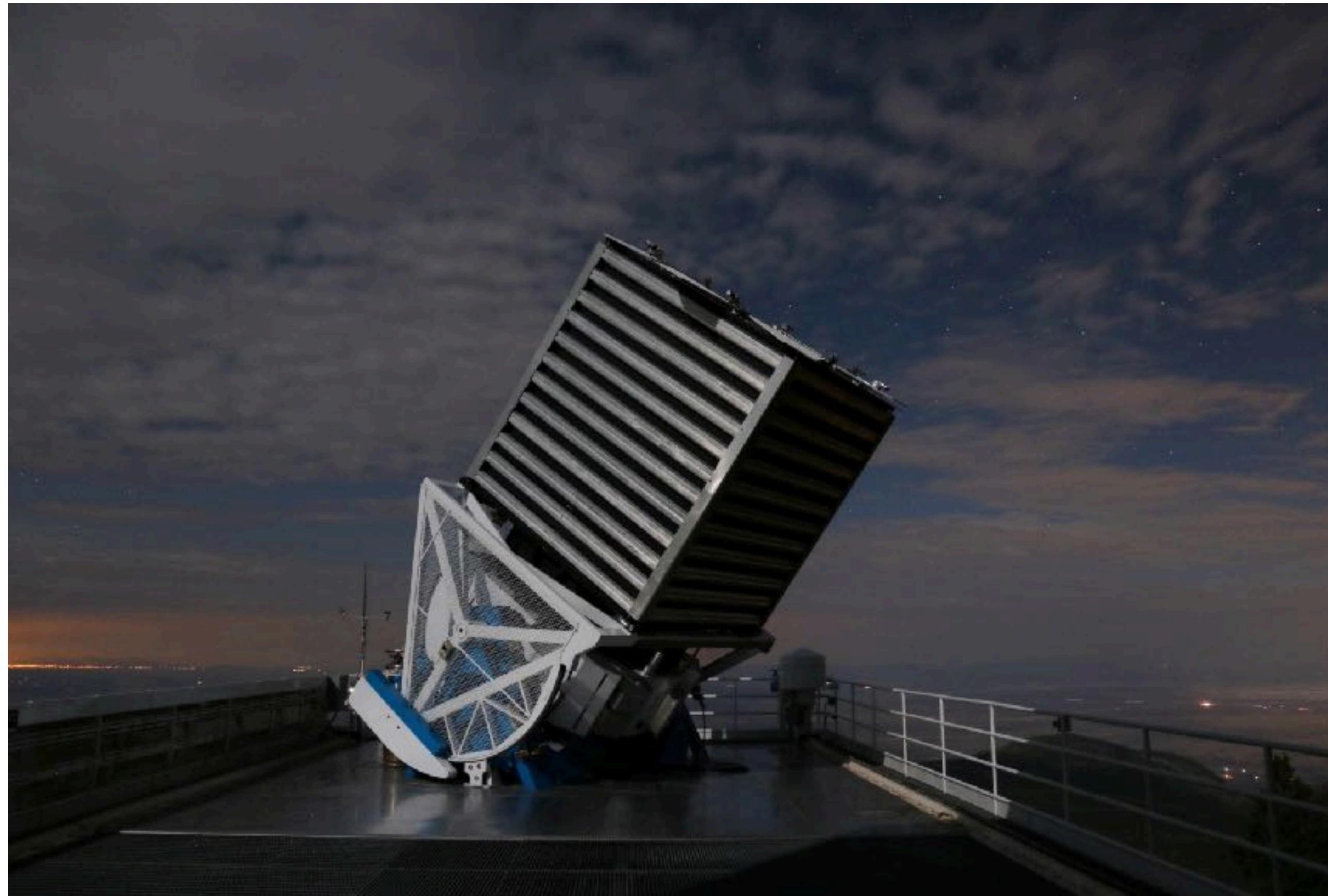
The parameter n , called the "Sérsic index," controls the degree of curvature of the profile.

The smaller the value of n , the less centrally concentrated the profile is and the model is shallow at small radii and steep at large radii.



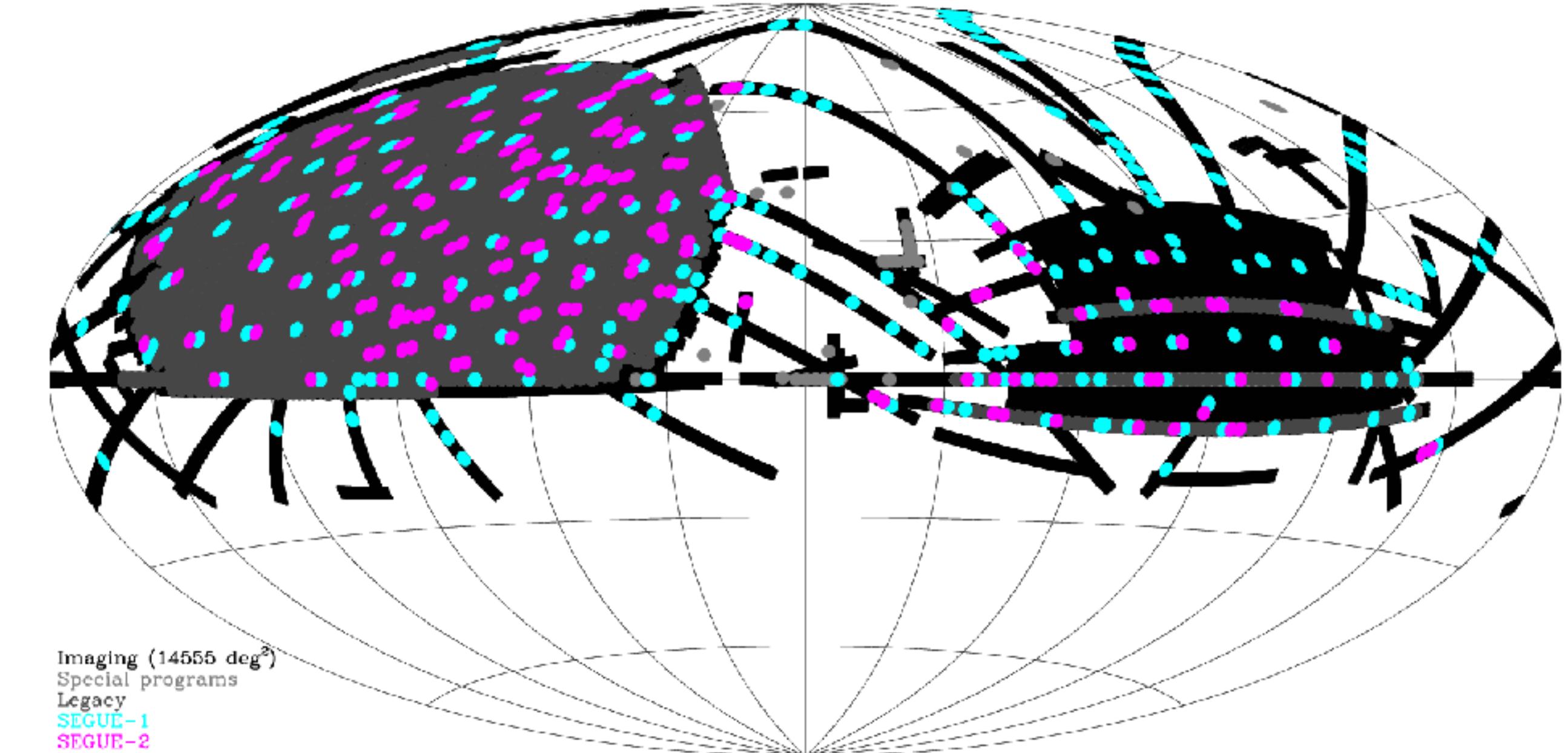
The Sloan Digital Sky Survey

The Sloan Digital Sky Survey or **SDSS** is a major multi-spectral imaging and spectroscopic redshift survey using a dedicated 2.5-m wide-angle optical telescope at Apache Point Observatory in New Mexico, United States. The project began in 2000 and the imaging part finished in 2009.



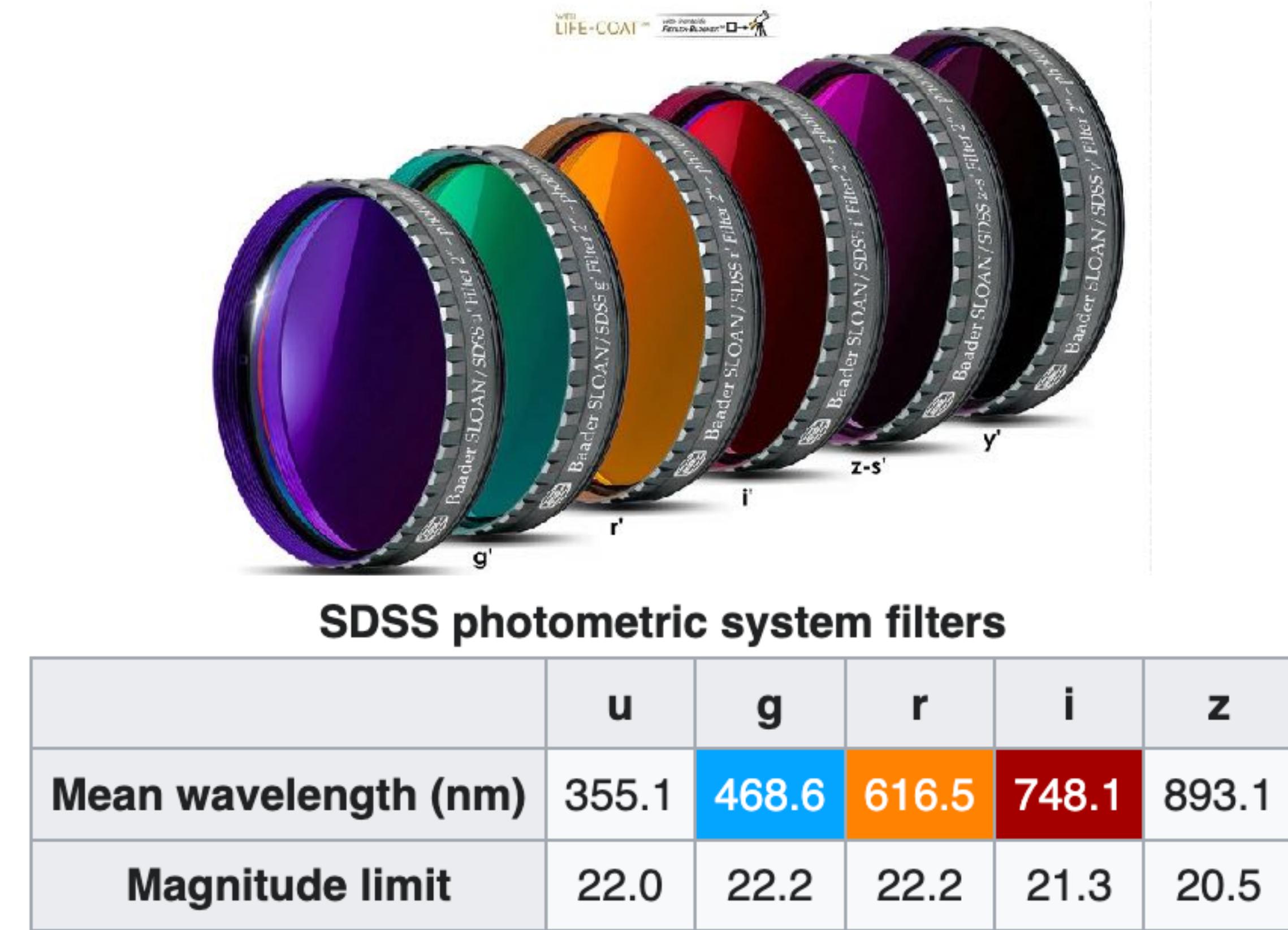
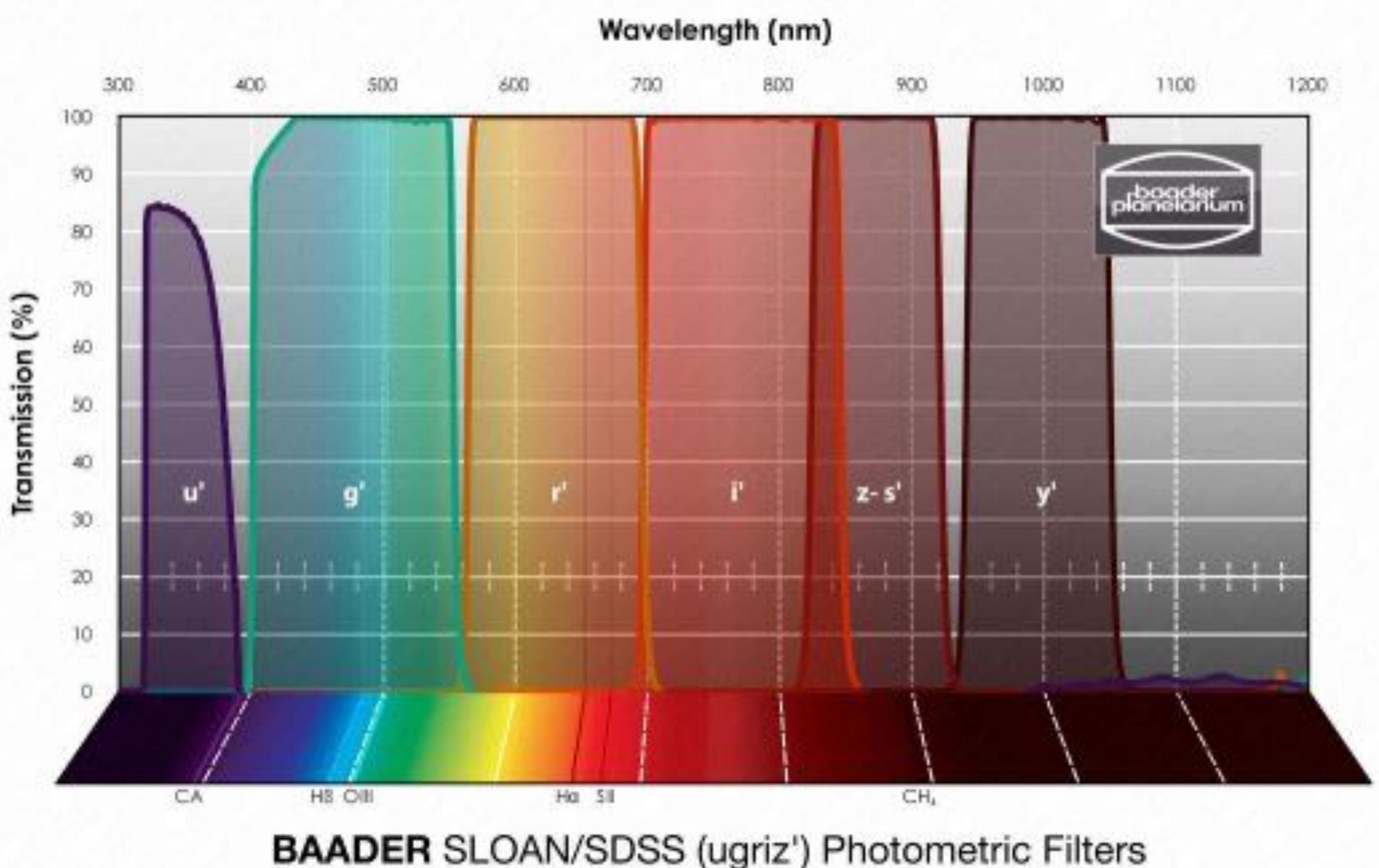
The telescope

Sky coverage of the Survey



The Sloan Digital Sky Survey

Images were taken using a **photometric system of five filters** (named **u, g, r, i and z**). Each filter captures a different wavelength range of light. These images are processed to produce lists of objects observed and various parameters, such as whether they seem pointlike or extended (as a galaxy might).

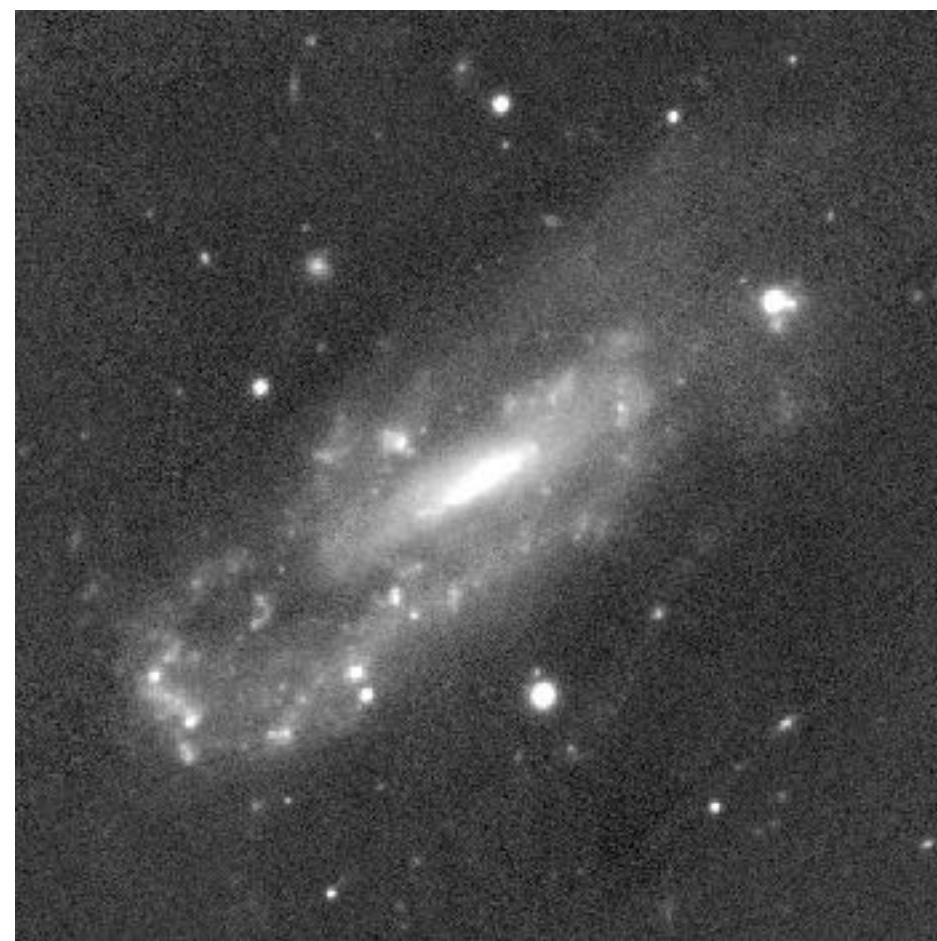


Measuring the brightness of objects

The different filters capture different properties of the objects.

This is an example of Images of the galaxy NGC 3027 in 3 different filters in black and white. And a combination false colour image of the galaxy (right).

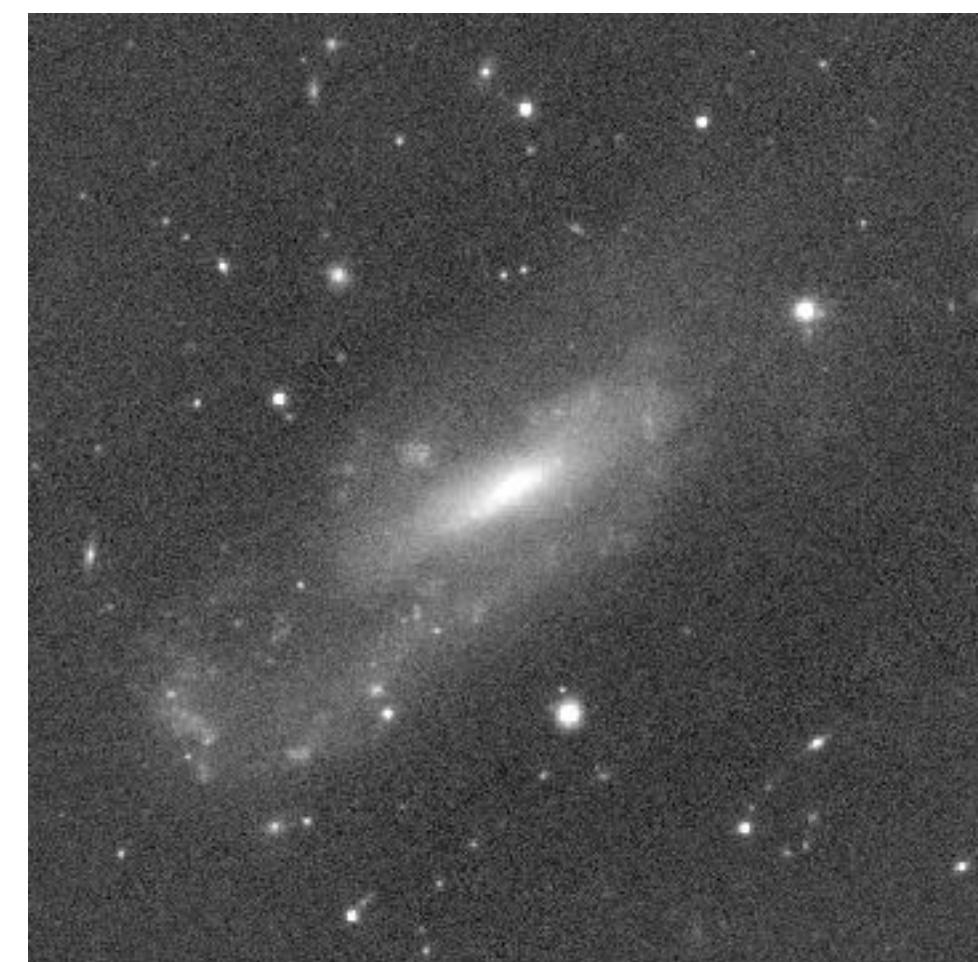
The galaxy looks blue in colour which indicates lots of young stars.



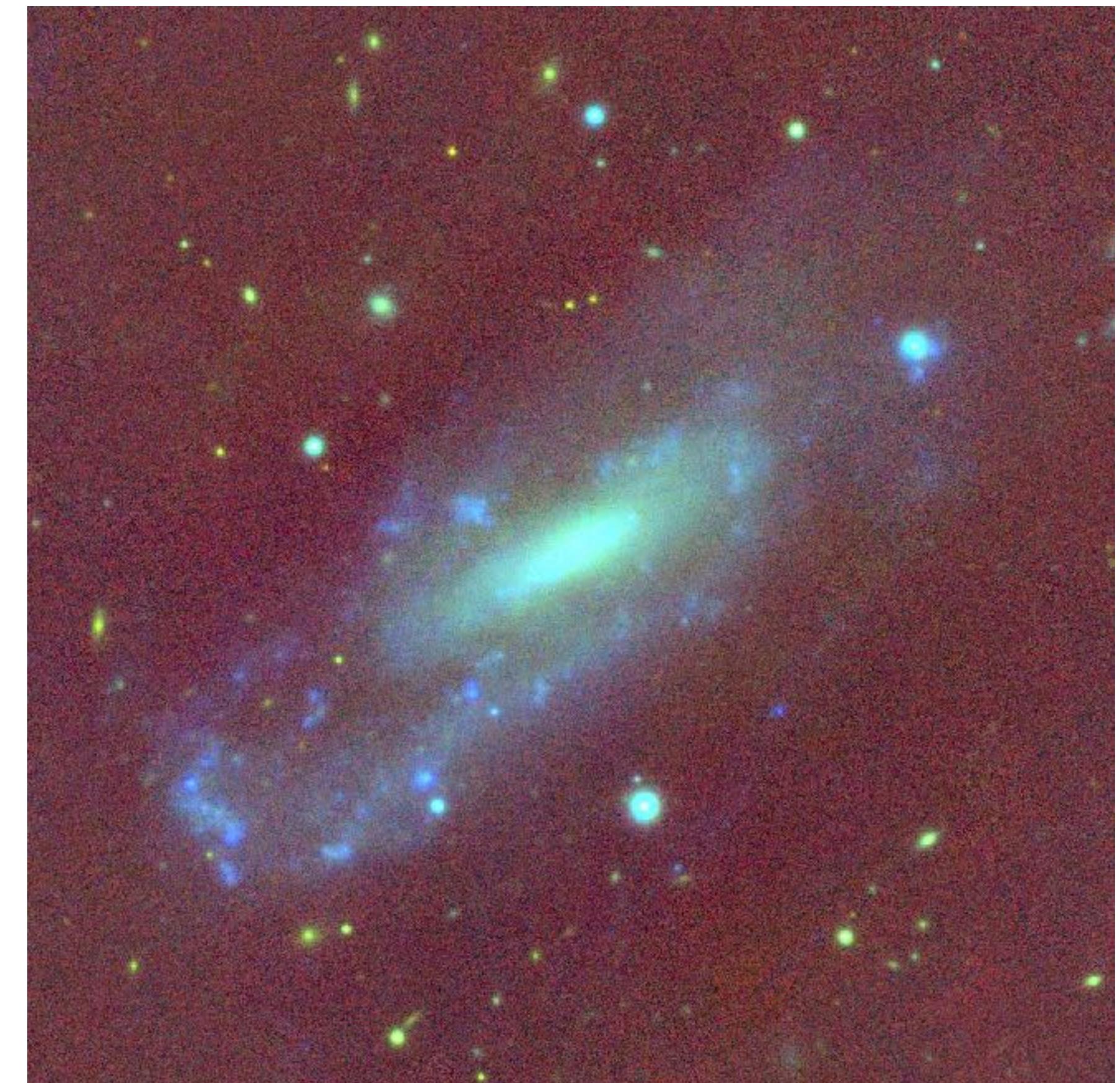
g



r



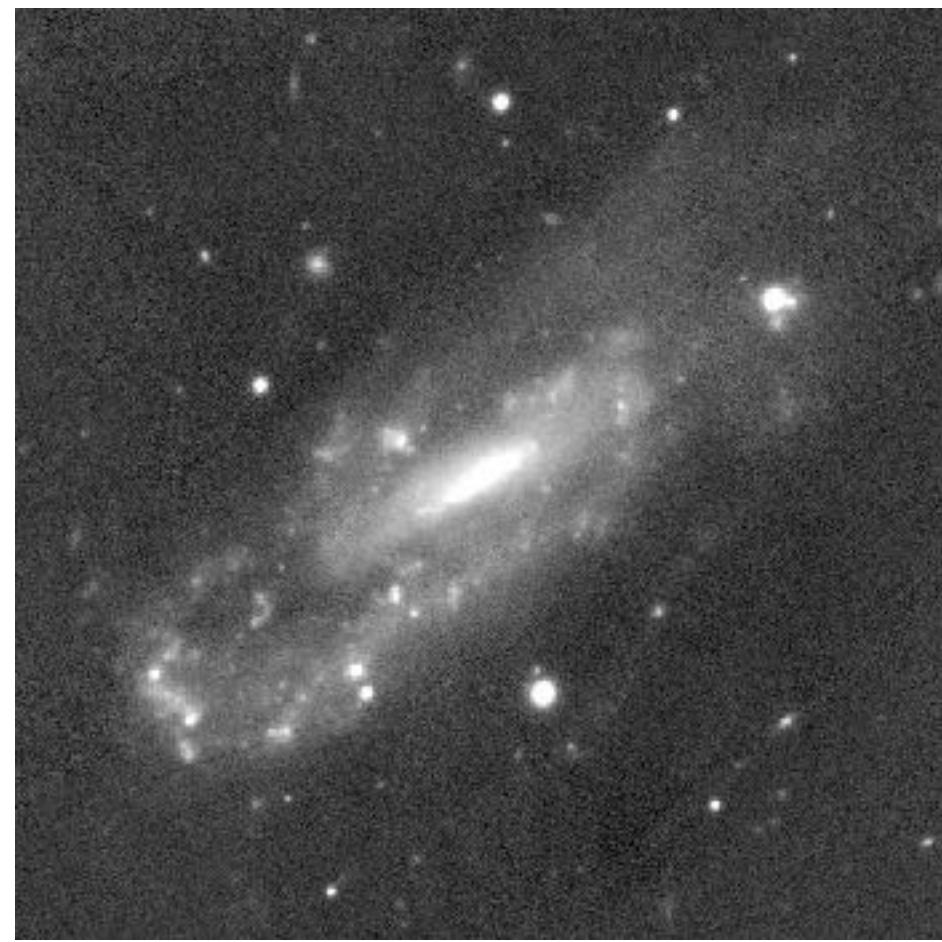
z



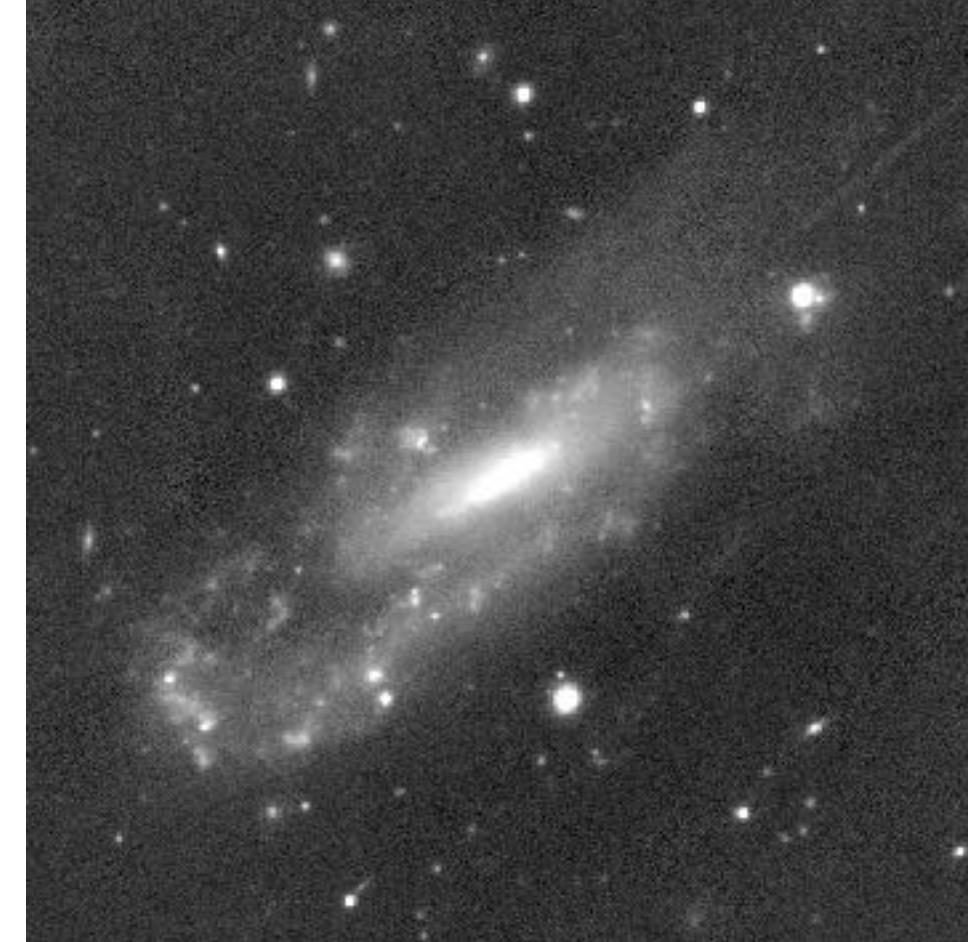
Measuring the brightness of objects

Colours in astrophysics are defined as the difference between two filters.

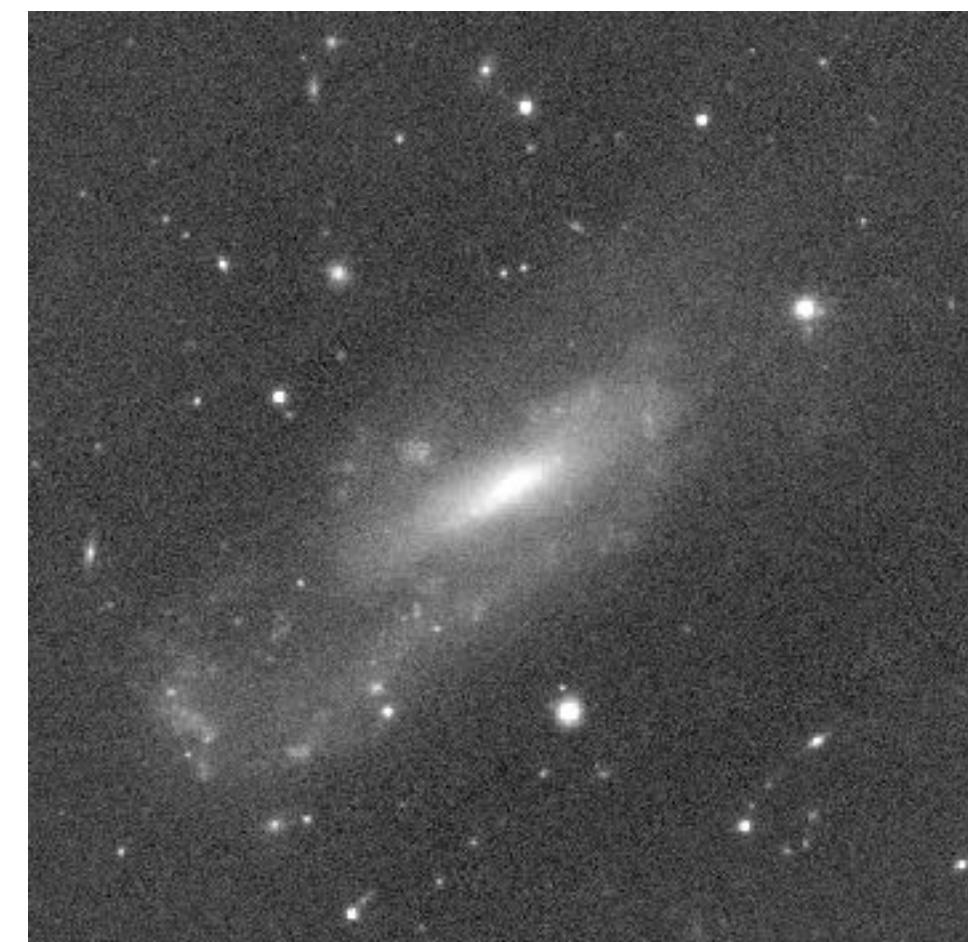
For example g-r or u-g.



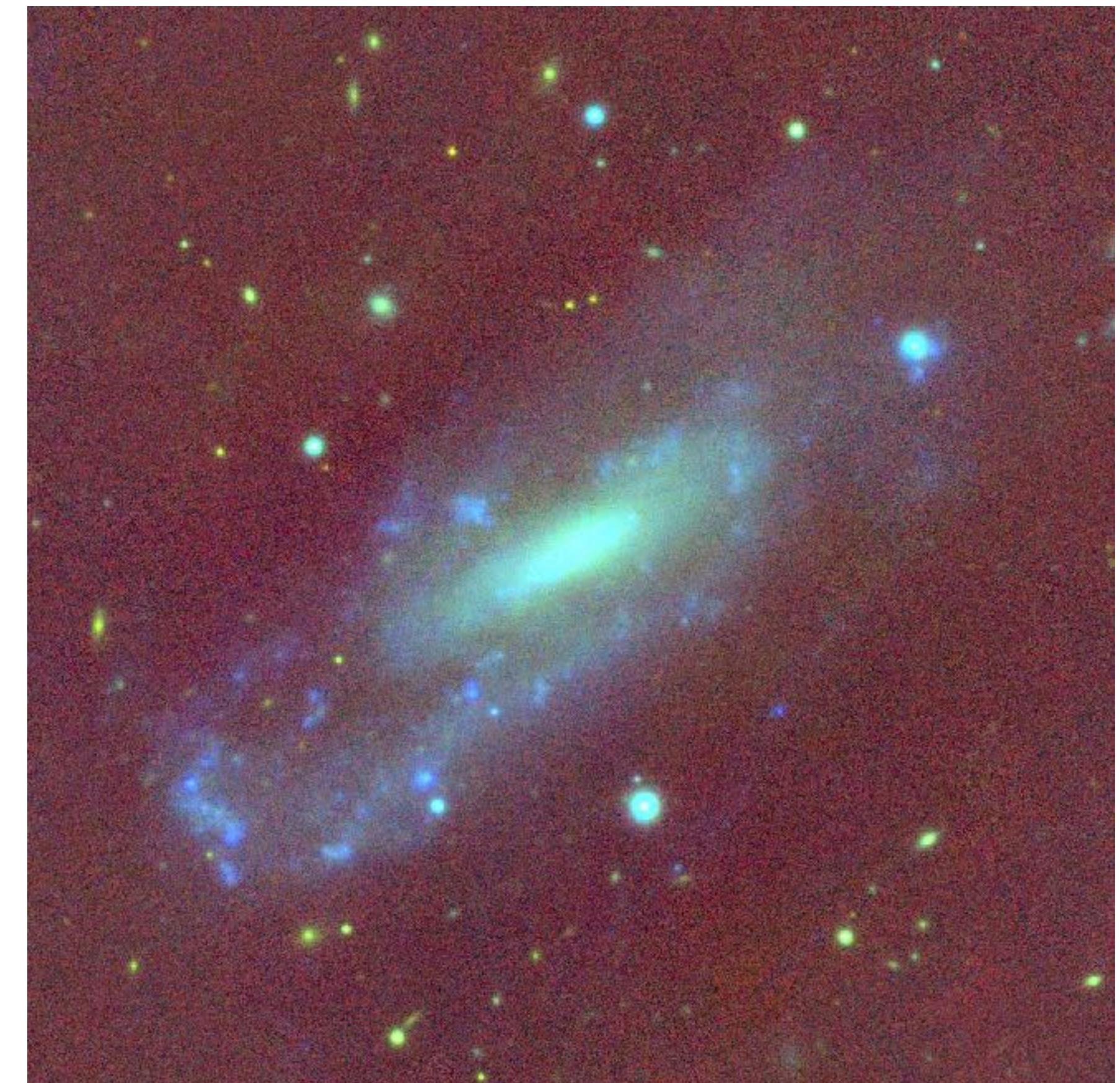
g



r



z



These images are from the PANSTARRS survey
<https://ps1images.stsci.edu/cgi-bin/ps1cutouts>

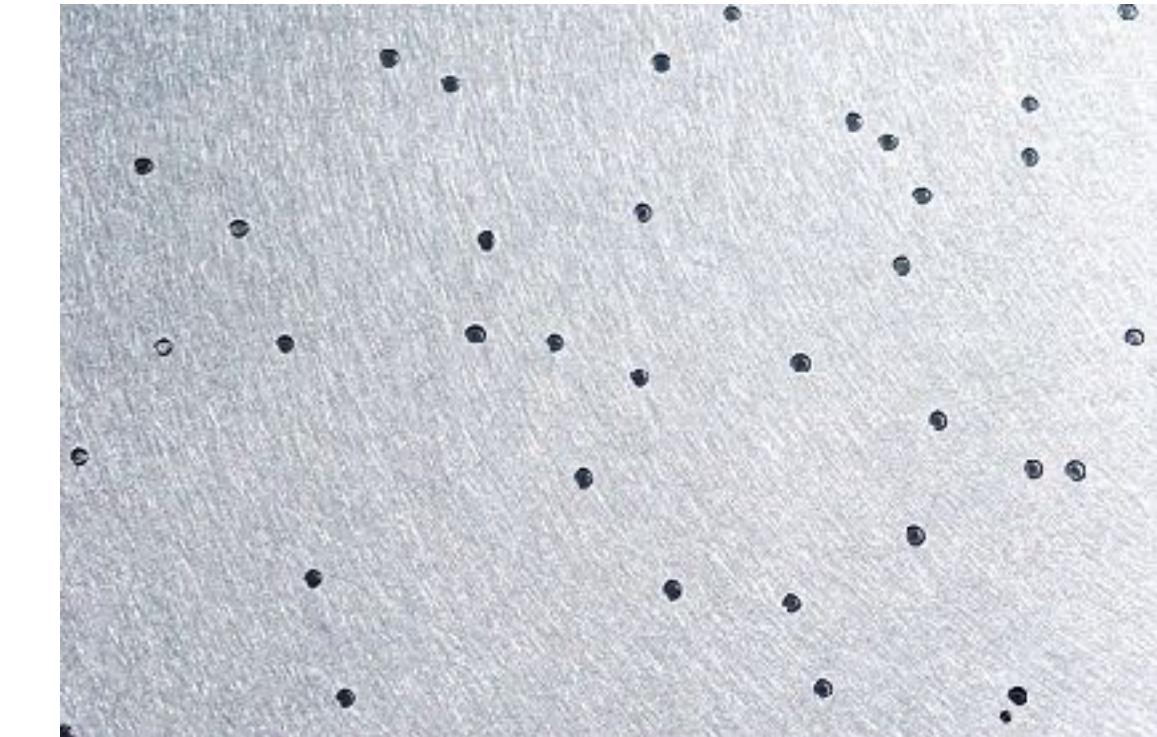
How do we know the distances to galaxies?

Using these photometric image data, stars, galaxies, and quasars are also selected for **spectroscopy**. -> With this we can measure the distance to objects.

The spectrograph operates by feeding an **individual optical fibre for each target through a hole drilled in an aluminum plate**.



Galaxies in the Virgo galaxy cluster



Aluminium plate for spectral observations



https://en.wikipedia.org/wiki/Sloan_Digital_Sky_Survey

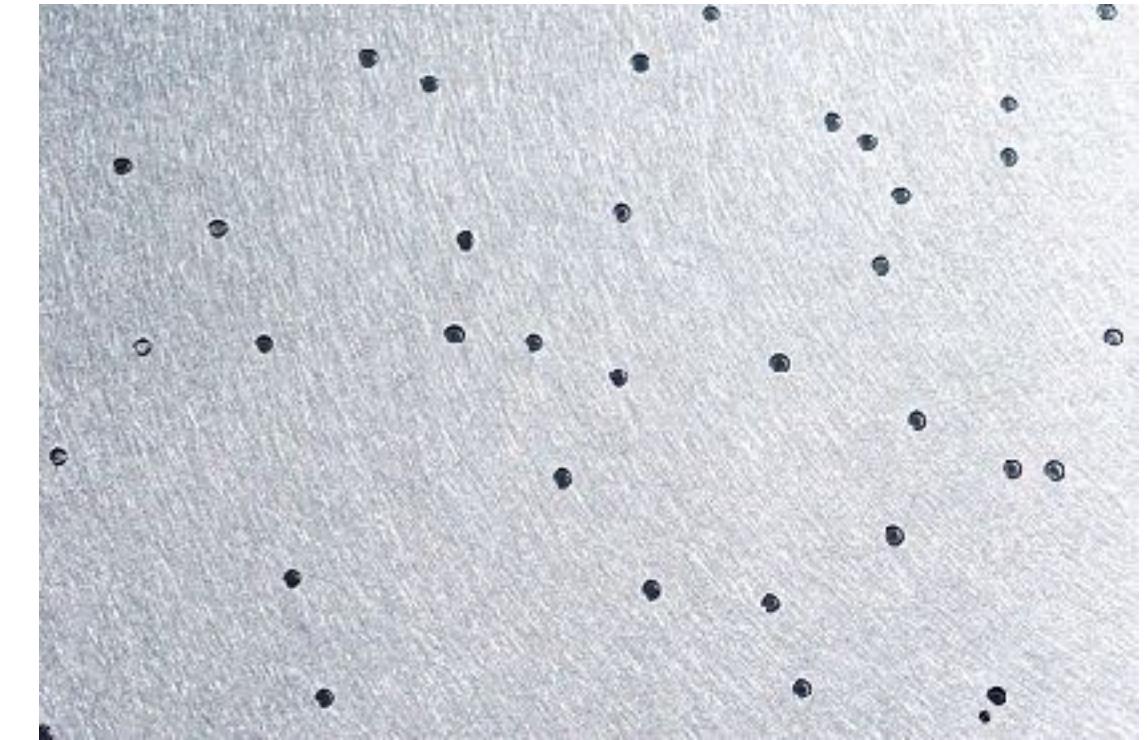
How do we know the distances to galaxies?

The original spectrograph attached to the telescope was capable of recording 640 spectra simultaneously, while the updated spectrograph for SDSS III can record **1000 spectra at once**.

Every night the telescope produces about 200 GB of data. This data is processed and then freely available for everyone to use.



Galaxies in the Virgo galaxy cluster



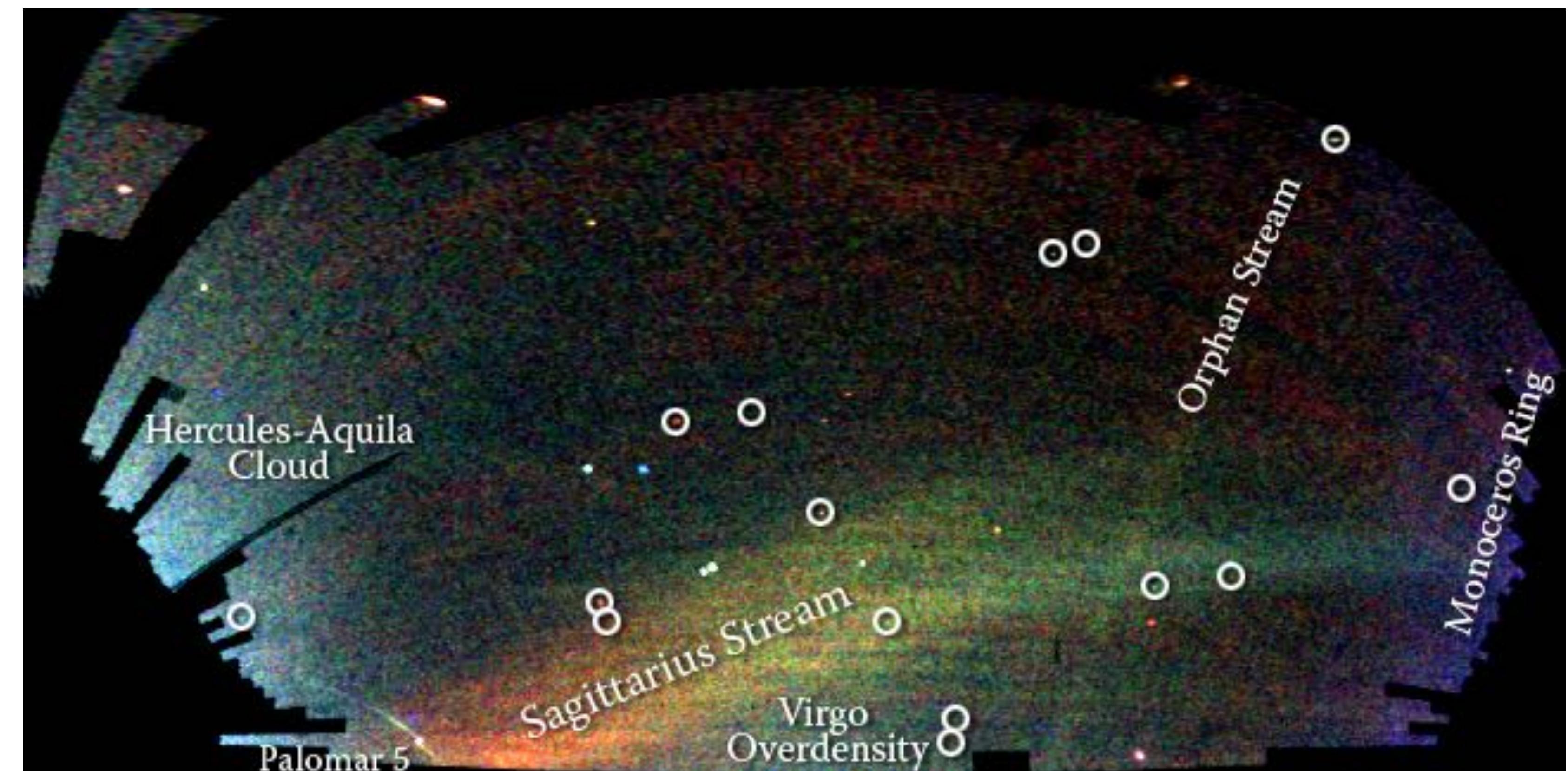
Aluminium plate for spectral observations



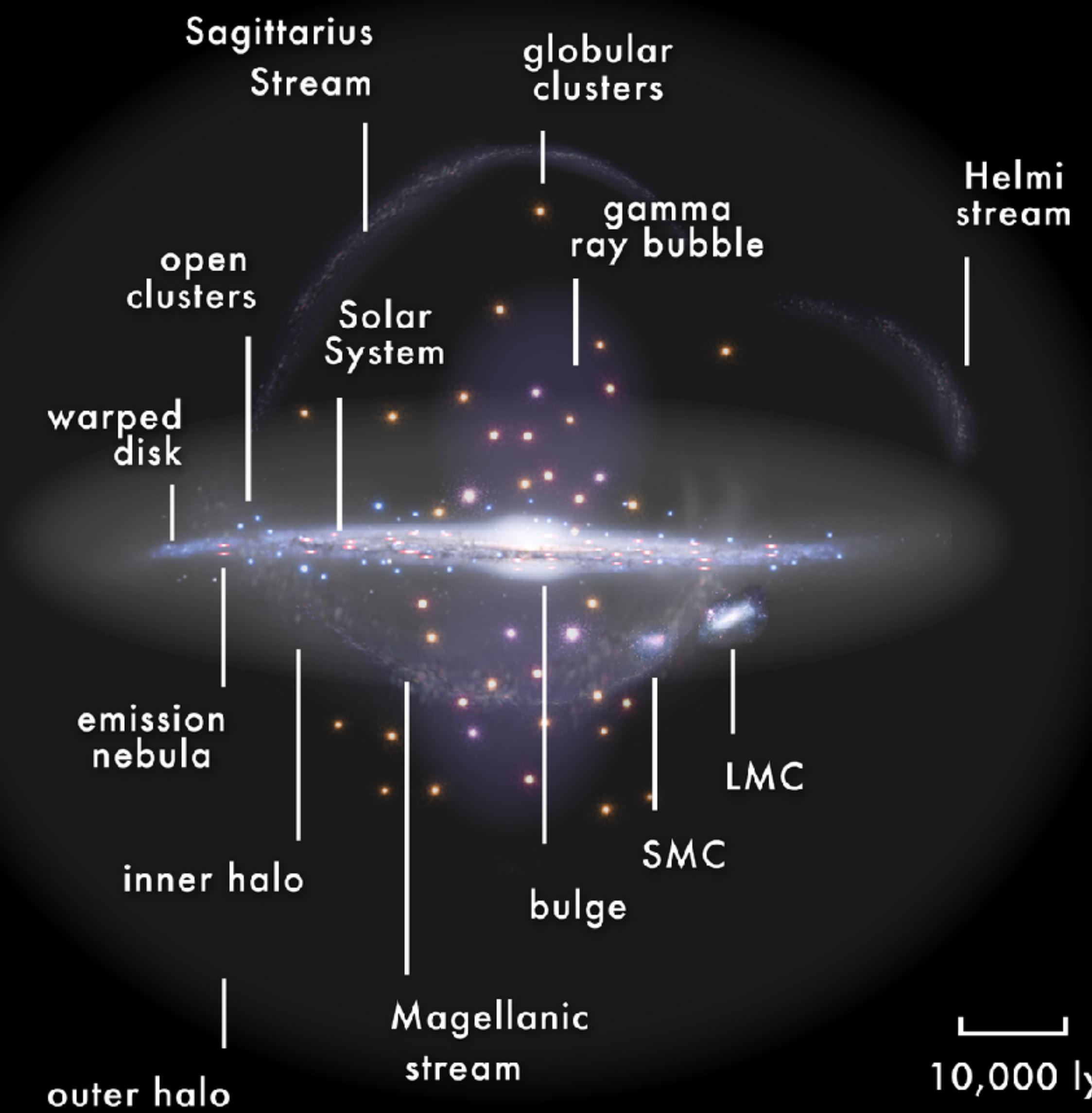
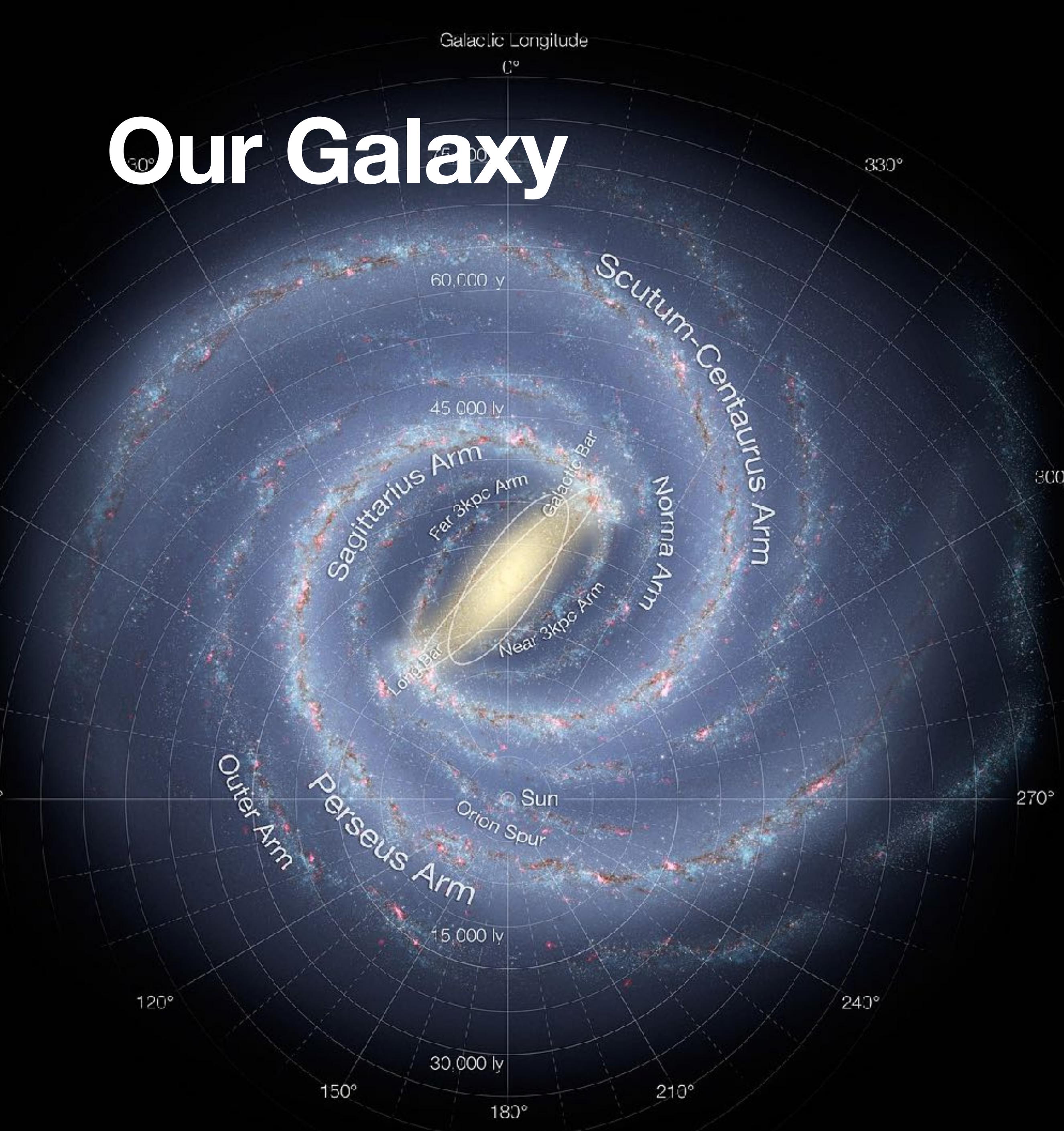
https://en.wikipedia.org/wiki/Sloan_Digital_Sky_Survey

The Sloan Digital Sky Survey

One famous discovery with the survey was the many stellar streams around the Milky Way. These are most likely remains of shredded dwarf galaxies.



Our Galaxy

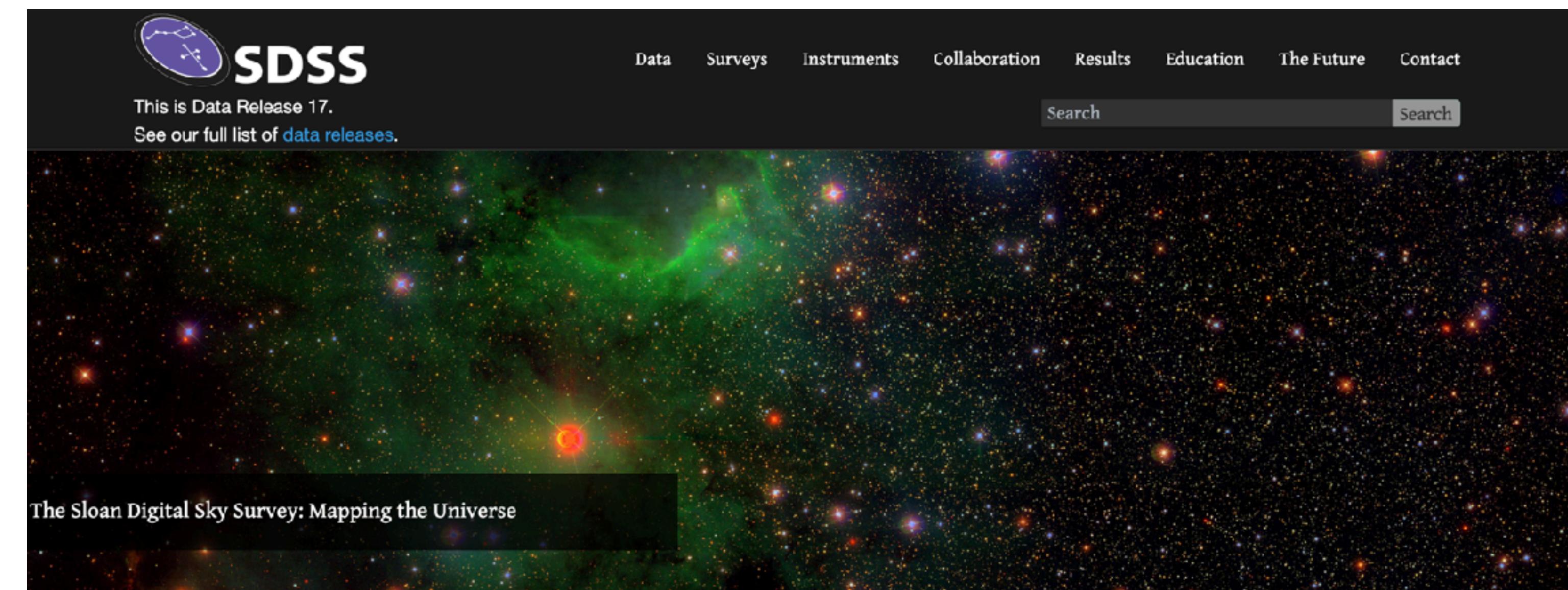


The Sloan Digital Sky Survey

Resources:

The SDSS website: <https://www.sdss4.org/>

SQL tutorial: <https://skyserver.sdss.org/dr14/en/help/howto/search/searchhowtome.aspx>



The Sloan Digital Sky Survey has created the most detailed three-dimensional maps of the Universe ever made, with deep multi-color images of one third of the sky, and spectra for more than three million astronomical objects. Learn and explore all phases and surveys—past, present, and future—of the SDSS.



Thank you!