

Introduction to Astrophysics and Cosmology

Introduction to astrophysics

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Infrared astronomy

**What are the astronomical sources?
Where would the observatories be?**

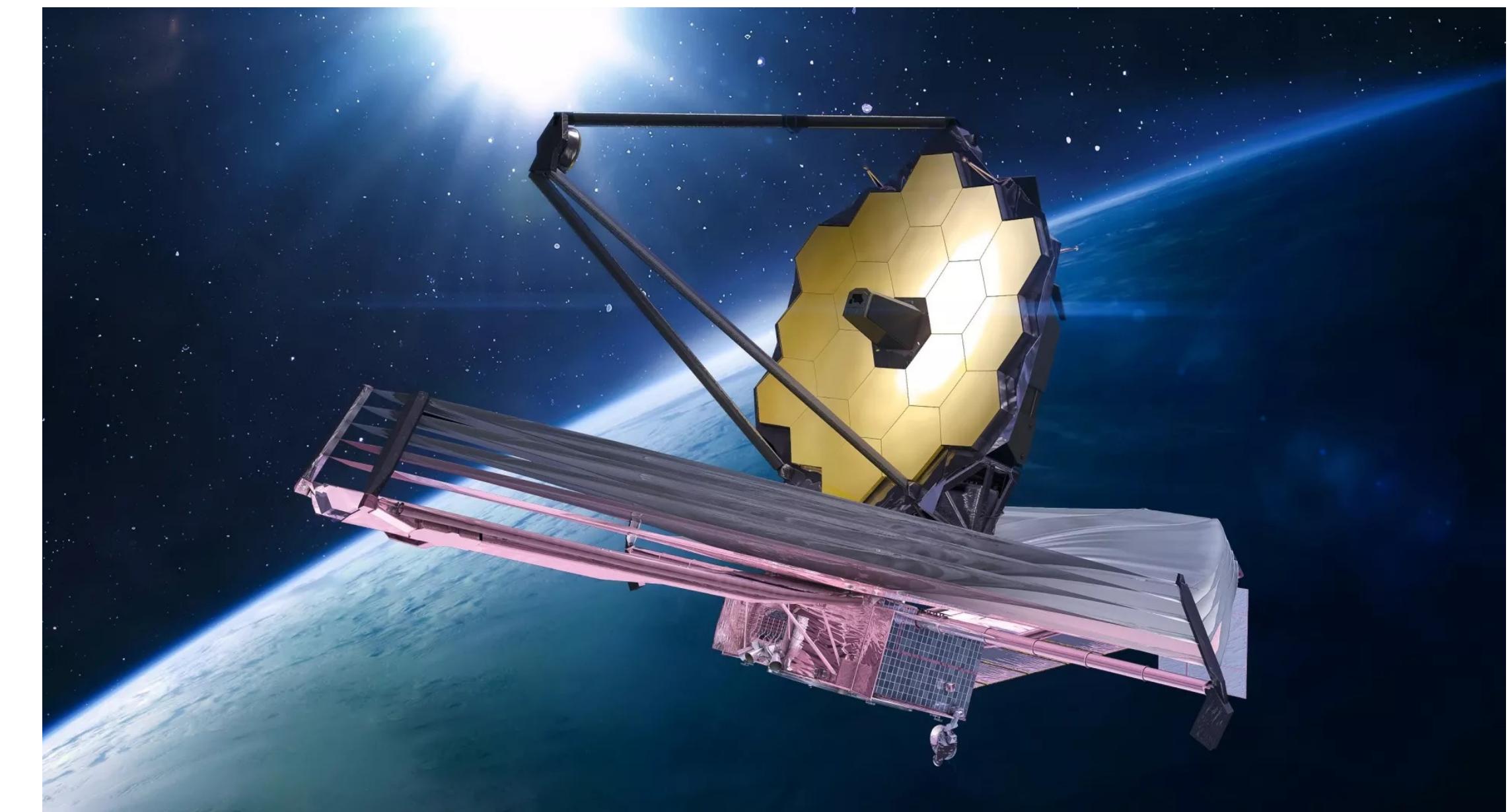
Infrared astronomy

- Telescopes on high mountains can observe in the near-infrared, e.g. VISTA, UKIRT etc.
- Observatories on airplanes: e.g. SOFIA, Galileo Observatory, Kuiper Airborne observatory
- Space observatories: Spitzer, AKARI, Herschel observatory, James Webb Space Telescope (JWST), WISE
- Difficulty: requires cryostatic cooling (e.g. liquid nitrogen cooling)

SOFIA observatory



James Webb Space Telescope (JWST)



Infrared astronomy

- Sources: interstellar dust, old stars, supernova remnants

SPITZER image of stellar winds creating bow shocks around a giant star



Herschel image of the Andromeda galaxy - emission from cold dust



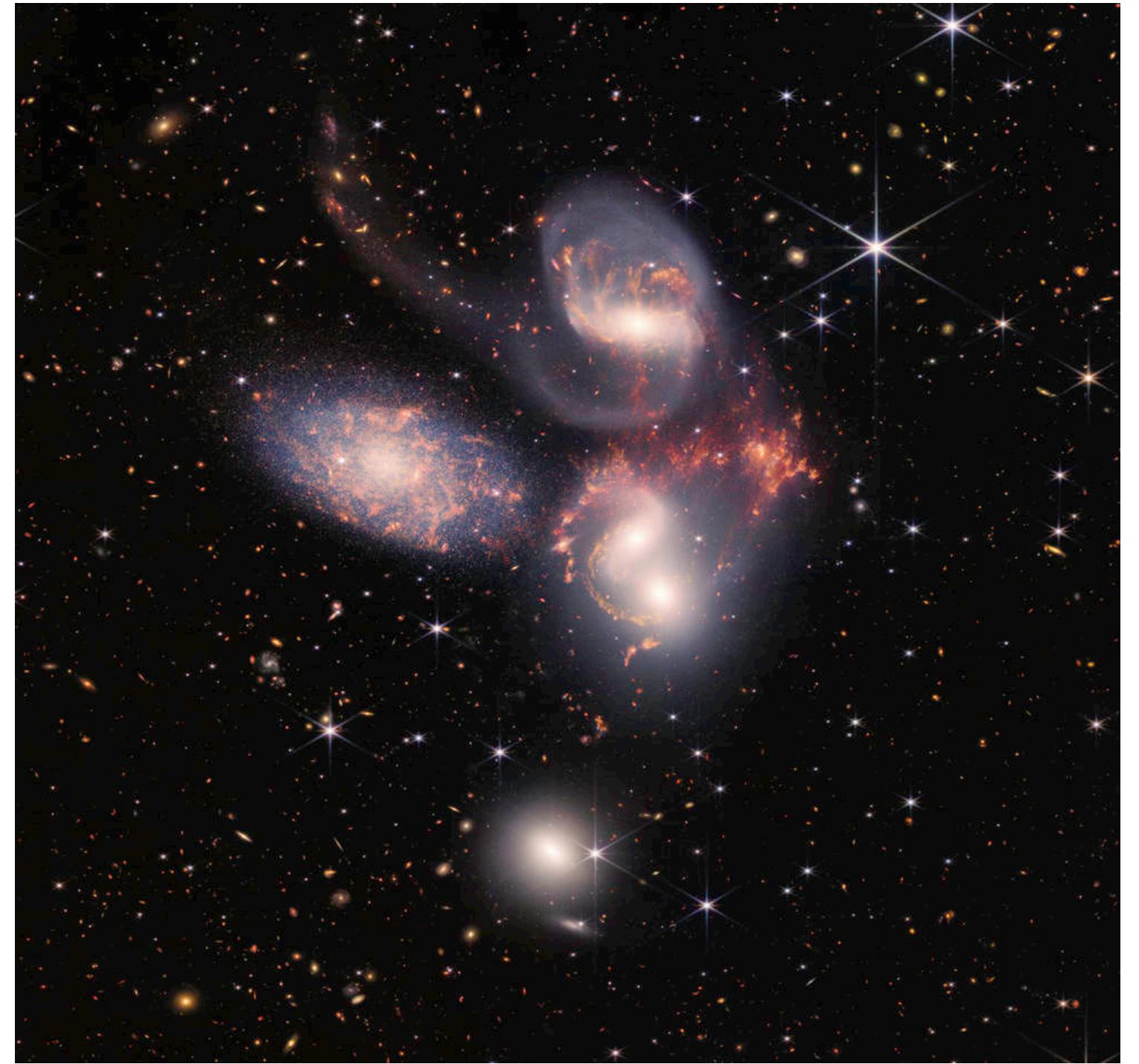
Infrared astronomy

- Images from the new JWST telescope



High redshift galaxies

Dust in galaxies



Interstellar medium, dust



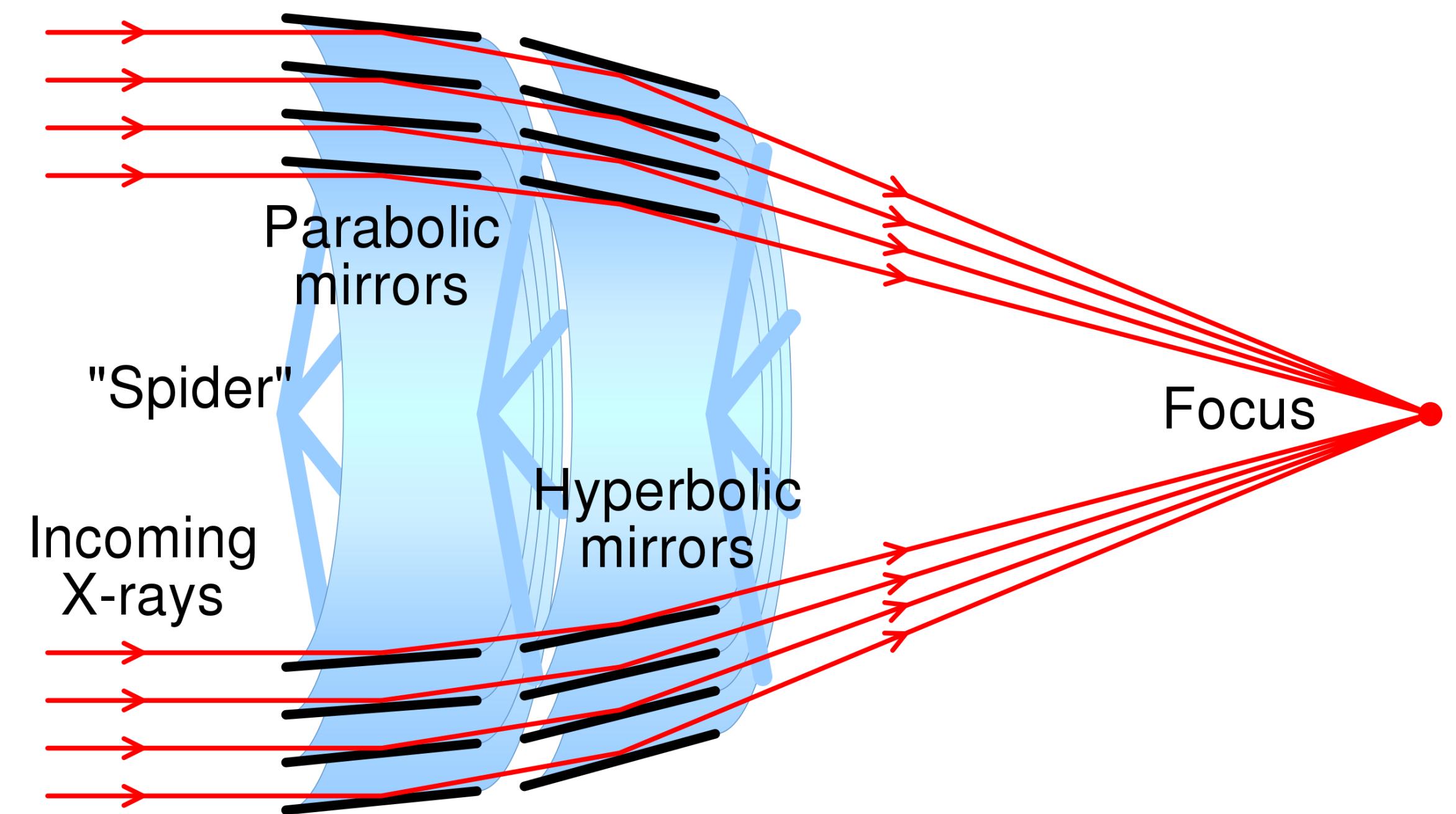
X - ray astronomy

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Where would the observatories be?**

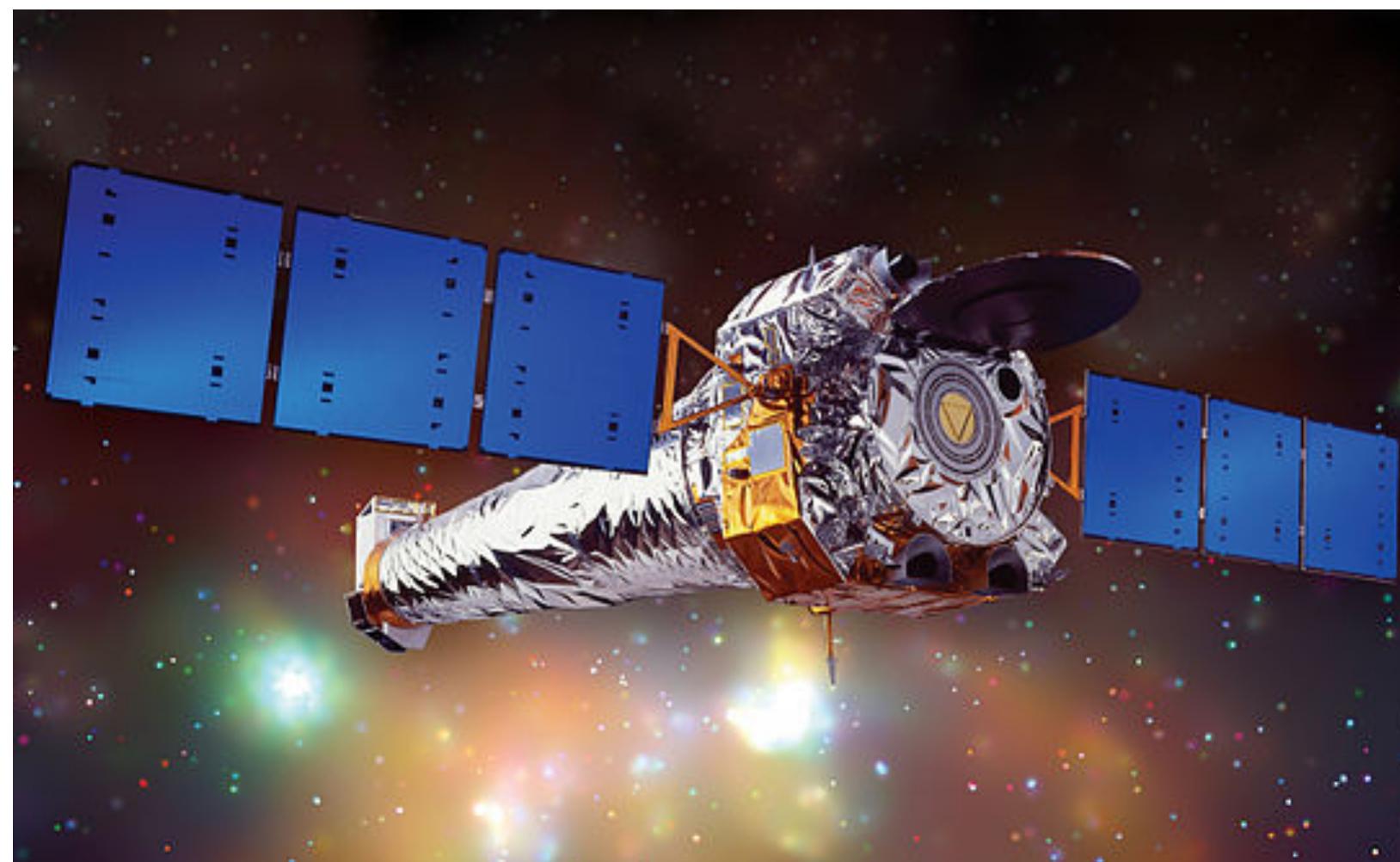
X - ray astronomy

- Only detectable above the atmosphere: balloon experiments and satellites
- X-rays are reflected from metal surfaces only when they are incident at grazing angles (otherwise, they pass through metals). Hence X-ray telescopes are designed very differently from optical telescopes.
- Also, mirrors in X-ray telescopes have to be much smoother than mirrors in optical telescopes because of the small wavelength of X-rays.
- Examples: ROSAT, Chandra, XMM-Newton

Schematics of X-ray telescope optics



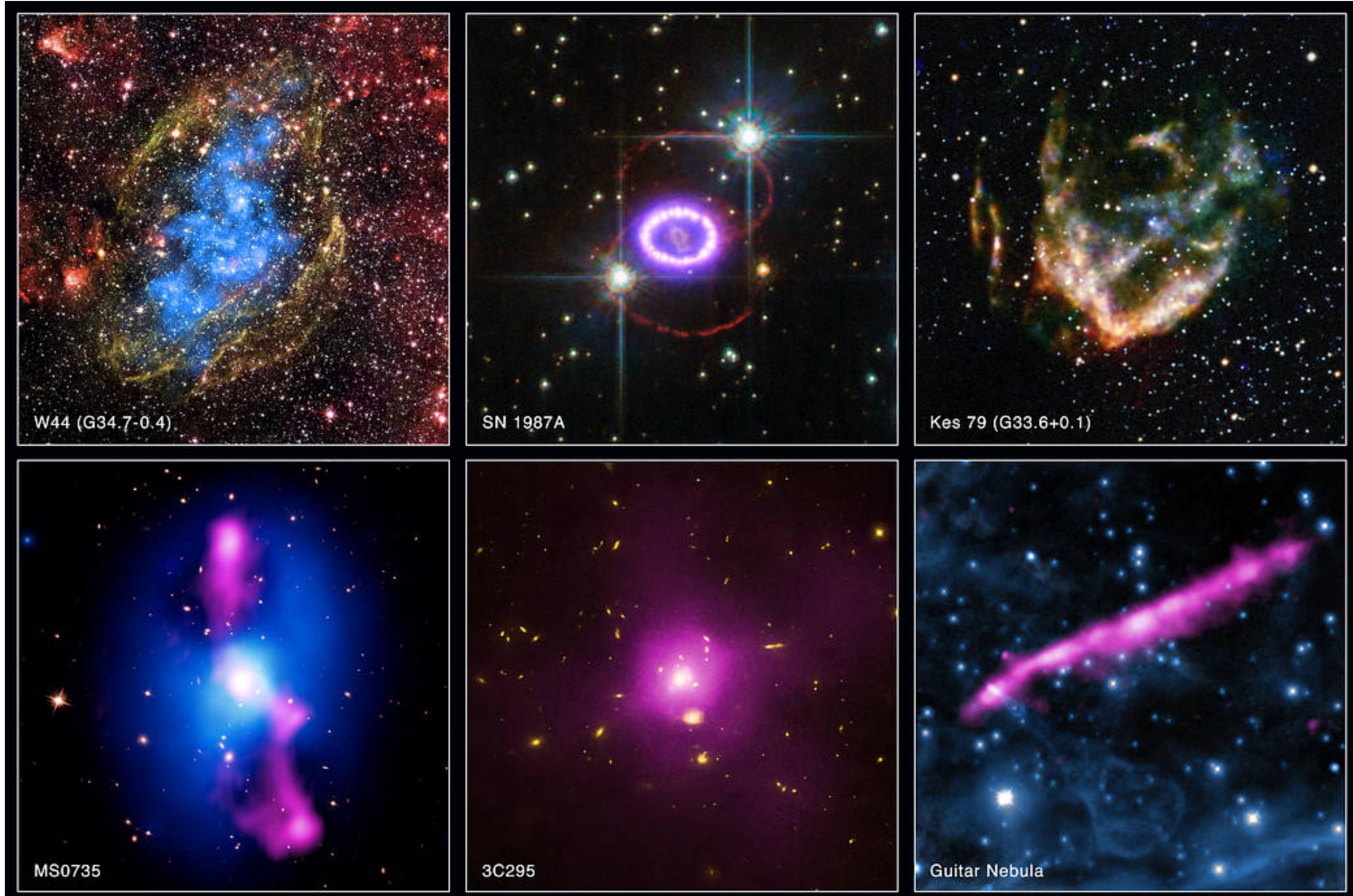
Chandra X-ray telescope



X - ray astronomy

Composit images with Chandra X-ray data

- Sources: hot plasma (millions of K)
- Examples: the Sun, Supernova remnants, intra cluster matter in galaxy clusters, AGN, accreting binary stars, neutron star or black hole binaries.



Gamma-ray astronomy

**What are the astronomical sources?
Where would the observatories be?**

Gamma-ray astronomy

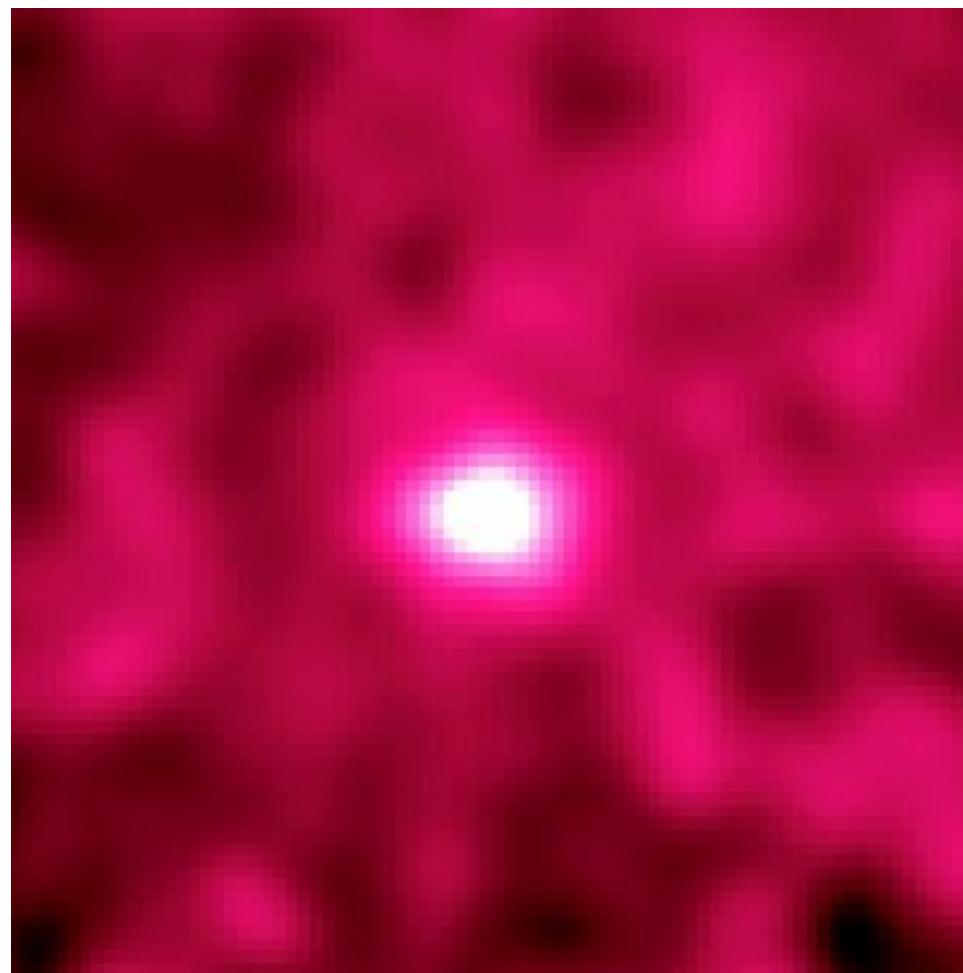
- Radiation above a 100 keV (from high energy sources)
- Sources: solar flares, supernovae, hypernovae, pulsars, blazars (AGN with the jet pointing towards Earth), thunderstorms on Earth, etc.
- Gamma-ray telescopes (satellites): INTEGRAL, Fermi, Egret, AGILE, etc.
- Indirect detection through particle showers in the atmosphere (see cosmic ray section)

Fermi satellite



<https://fermi.gsfc.nasa.gov/>

The Moon in gamma rays,
the gamma rays are
produced by cosmic ray
particle bombardment of
the surface

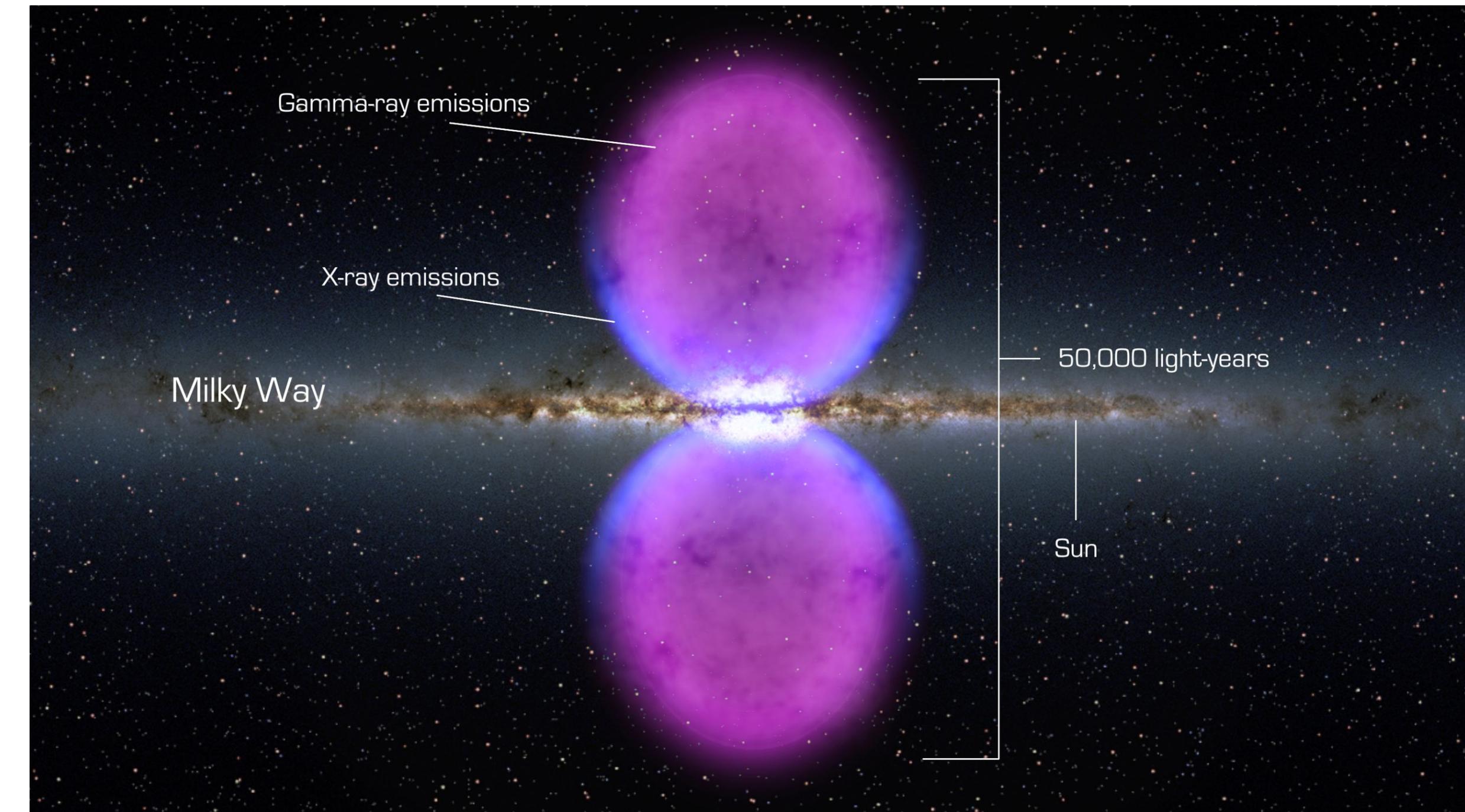
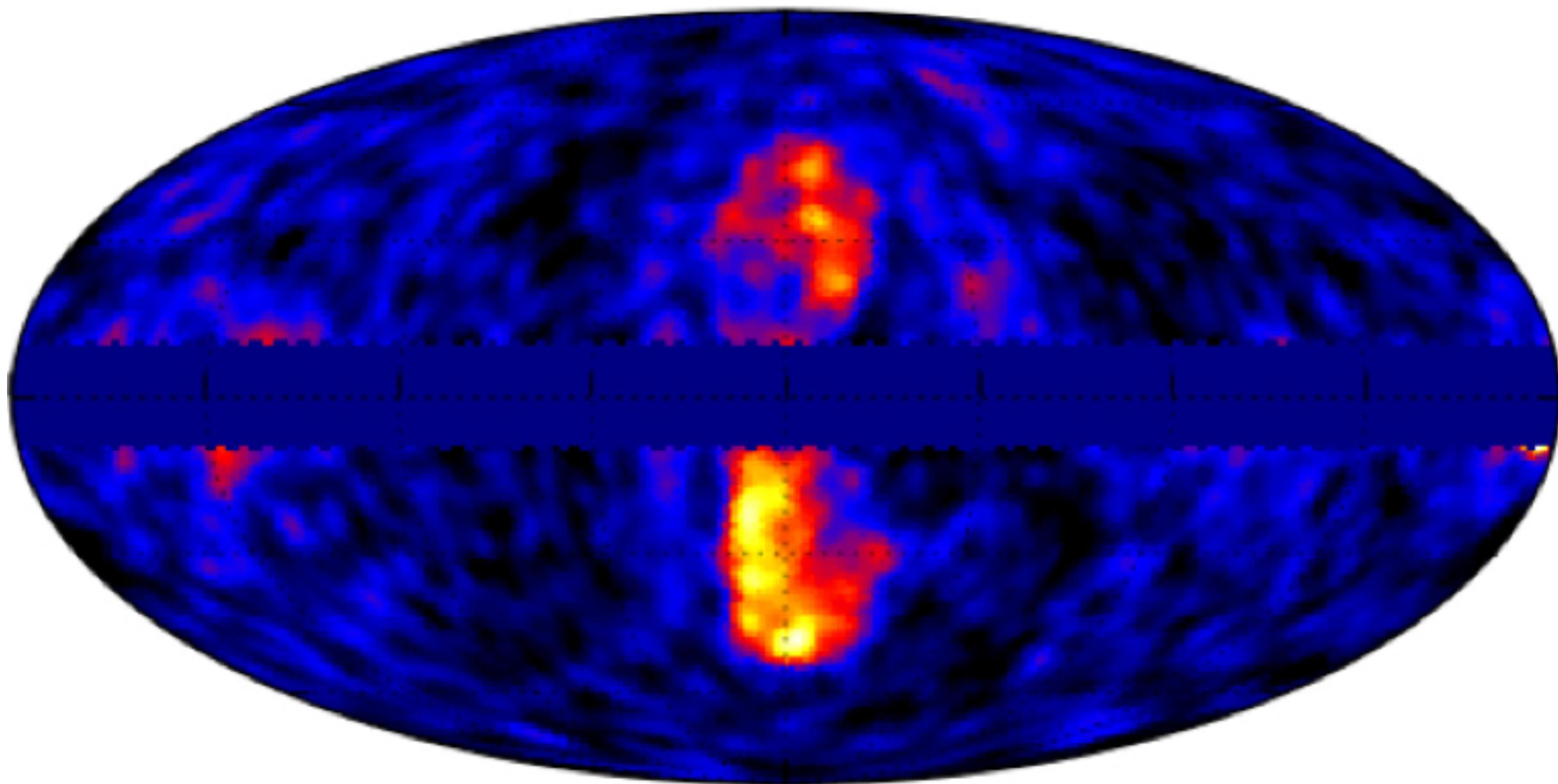


https://en.wikipedia.org/wiki/Gamma-ray_astronomy



Gamma-ray astronomy

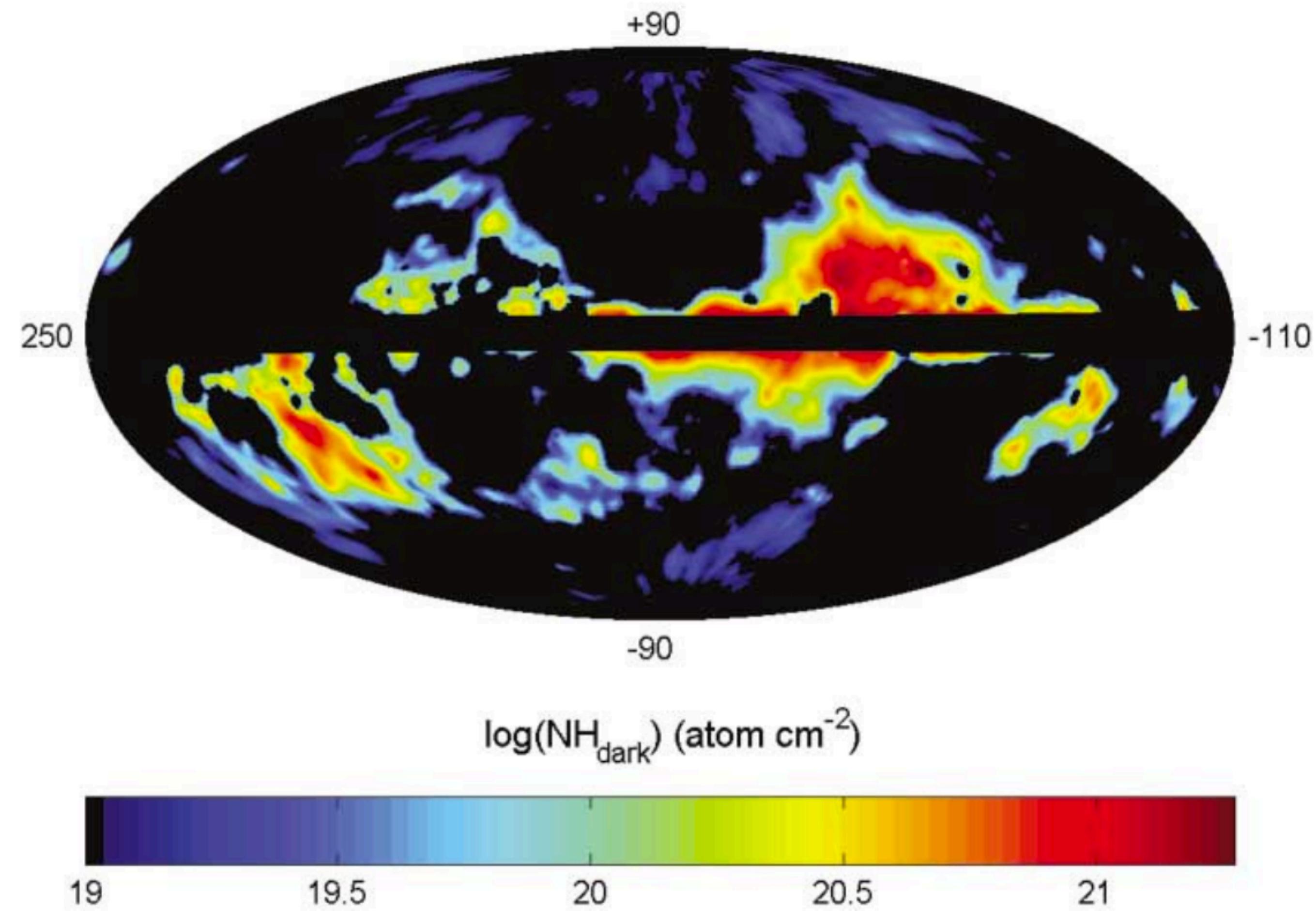
- Fermi bubbles: large scale diffuse gamma ray emission attributed to the activity in the centre of the Galaxy. Current theory is that they are either produced by the black hole or by intense star formation activity.



https://en.wikipedia.org/wiki/Gamma-ray_astronomy

Gamma-ray astronomy

- Dark gas in the Galaxy
- Using the diffuse gamma ray radiation, we can calculate the number of particles in the Inter Stellar Medium (ISM) and compare that with observations of neutral hydrogen (HI) and CO. Turns out, there is some extra material that we are not sure what it is. More neutral HI or more molecular gas not traced by CO.



Calculate the resolution for a few telescopes

The Giant Metrewave Radio Telescope (GMRT) near Pune has several antennas spread over a region of size about 10 km. Make an estimate of the resolution (in arcseconds) which this telescope is expected to have. How large will an optical telescope have to be to achieve similar resolution in visible light?



$$\theta = 1.22 \frac{\lambda}{D}$$

Naming conventions

Astronomical objects have various naming conventions

- historical catalogs
 - Henry Draper Catalog (HD ...) for stars
 - Messier for galaxies and nebulas e.g. M101
 - New General Catalogue (NGC ...) for galaxies
 - Third Cambridge Catalogue of Radio Sources (3C 273, ...) for bright radio sources
 - Constellation name + number e.g. Cygnus A, Sgr A*
- Survey or telescope name + coordinates e.g. PKS ... (PKS stands for the Parkes telescope)
- dates (for transient events) e.g. SN1987A

Guidelines are provided by the International Astronomical Union (IAU)

Useful websites

Some websites that astronomers use regularly:

To find publications:

Astrophysics Data System (ADS) - <https://ui.adsabs.harvard.edu/#> (this is like a library for papers)

ArXiv - <https://arxiv.org/> (preprint publications, free access)

Any sort of data catalogue + information on objects:

Centre de Données astronomiques de Strasbourg (CDS) Strasbourg astronomical Data Center
<http://cds.u-strasbg.fr/>

Information on extragalactic objects:

NASA/IPAC Extragalactic Database (NED) <https://ned.ipac.caltech.edu/>

Science quality images from various surveys:

Skyview: <https://skyview.gsfc.nasa.gov/current/cgi/titlepage.pl>

+ there are many more free to access data bases

To look at pretty images of the sky, not directly for science:

Wikisky: <http://www.wikisky.org/>

GLEAMoscope: <https://gleamoscope.icrar.org/gleamoscope/trunk/src/>