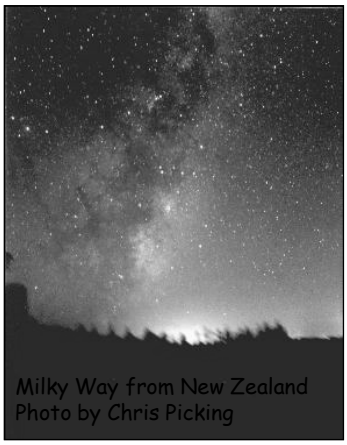
The Milky Way

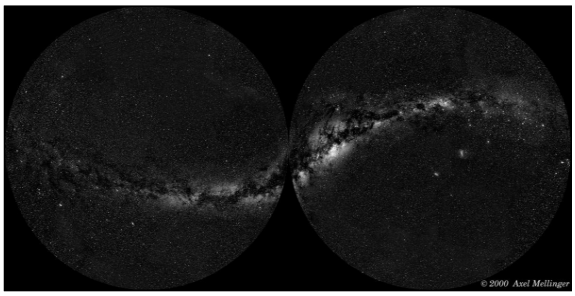
- From a dark site the Milky Way can be seen as a broad band across the sky
  - What is it?
    - telescopes resolve it into many faint (i.e. distant) stars
  - What does it tell us?
    - that we live in a spiral galaxy
  - How does it relate to the Solar System?

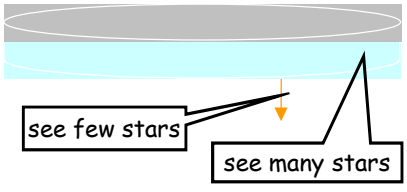


Milky Way from New Zealand
Photo by Chris Picking

A band or a disc?

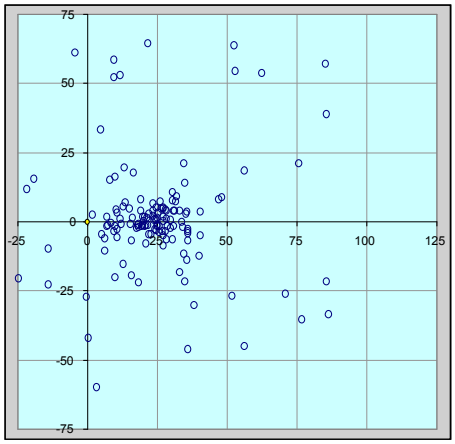
- If the Milky Way forms a band around the night sky
  - plausible explanation is that we are inside a disc-shaped stars
  - see many more stars looking in plane of disc





Where are we?

- The Milky Way band cuts the sky in half
  - the Sun is very near the mid-plane of the disc
- The system of globular clusters centres about 25000 l.y. from the Sun
  - distances determined from HR diagram
  - this is the centre of the Milky Way
  - we are a long way from the centre (but nowhere near the edge)

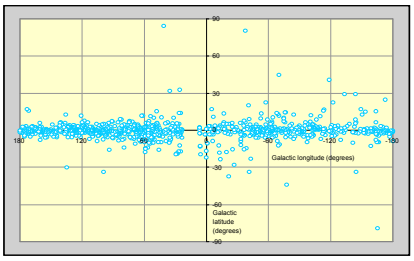


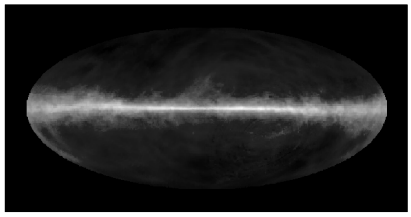
Susan Cartwright *Our Evolving Universe* *3*

The disc and the halo

- Open clusters are found close to the Milky Way on the sky
  - they belong to the disc
- Globular clusters aren't
  - they form a spherical "halo" around the disc
- Hydrogen gas is very concentrated in the mid-plane of the disc
  - new star formation confined to disc

➔ The disc contains younger stars than the halo





Susan Cartwright *Our Evolving Universe* *4*

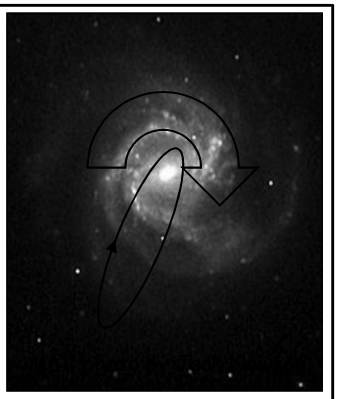
The dynamic Milky Way

- The Sun orbits the Galactic centre at about 200 km/s
- Other disc stars near the Sun are moving at only ~20 km/s relative to the Sun

➔ The whole disc must be rotating
  - although stars further out take longer to complete each circuit

- Globular clusters move fast relative to the Sun

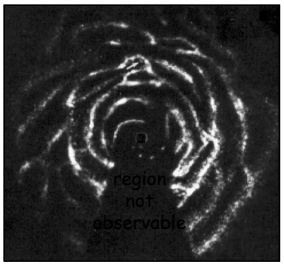
  ➔ they orbit in random directions

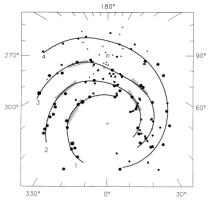


Mapping the Milky Way

- We can use the rotation of the disc to map the Milky Way in hydrogen gas
  - neutral hydrogen emits a radio spectral line at 21 cm
  - orbital motion produces Doppler shift
  - use geometry to work out location of cloud

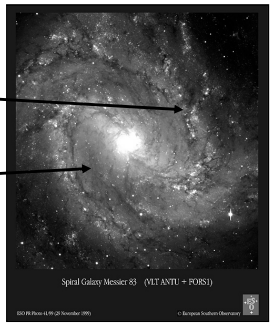
➔ The Milky Way appears to be a rather untidy spiral
  - similar results from mapping the ionised hydrogen associated with hot (massive, young) stars

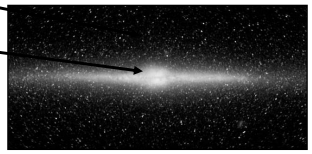




Stellar populations

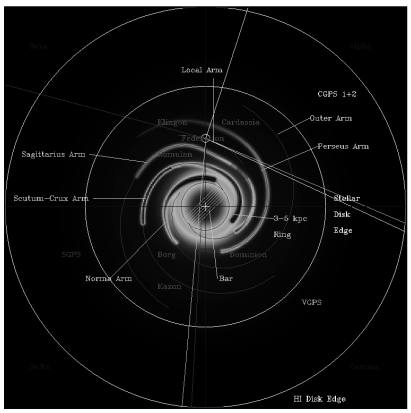
- The Milky Way thus has at least four distinct populations of stars:
  - the spiral arms
    - young objects, including massive blue stars
    - rotating system, second generation (high in heavy elements)
  - the rest of the disc
    - including the Sun; wide age range
    - rotating, high in heavy elements
  - the halo
    - including the globular clusters
    - non-rotating, low in heavy elements, old
  - the central bulge
    - of old stars, seen in infra-red light which penetrates the dust
    - slowly rotating, high in heavy elements (with wide spread)





At home in the Milky Way

- We saw that planetary systems prefer stars with high heavy element content
  - planetary systems are only likely to be common in the disc and spiral arms
    - possibly the bulge too
  - we are more or less where we might expect to be!
    - however, the Sun has higher than usual heavy element content for its age
    - could planets as old as ours be rare?



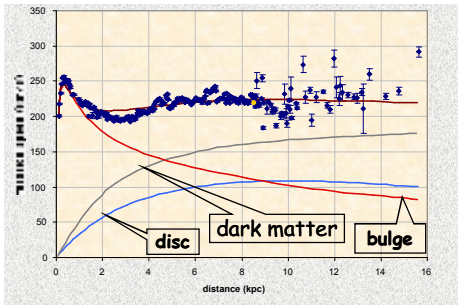
Our Galaxy and others

- By looking in the infra-red we can see through the dust
  - the Milky Way looks remarkably like NGC891
- By looking in radio we have mapped out spiral arms
  - the Milky Way resembles galaxies such as M61

➔ The Milky Way is a typical large spiral galaxy
  - (like the Sun, larger than most, but not a champion!)

What you see isn't all you get: the dark side of the Milky Way

- We can use Newton's laws to analyse the Milky Way's rotation
  - it's too fast!
    - the gravitational force is more than we can account for by the masses of stars
  - we need to assume that most of the Milky Way's mass is ***dark matter***
    - as yet we do not know exactly what this is
    - see seminar later

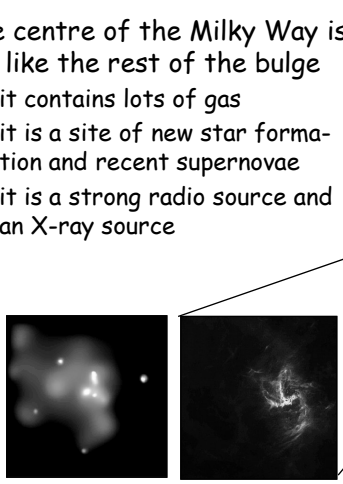


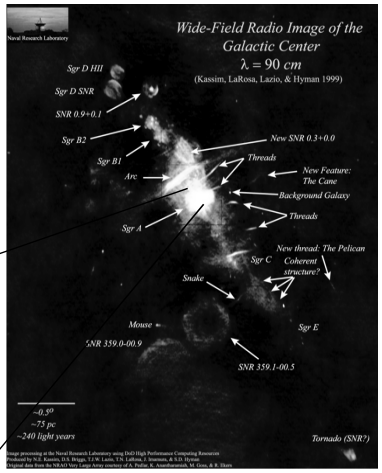
What do we know about the Milky Way?

- It is disc shaped
  - from its appearance in the night sky
- It has a bulge of older stars, and is surrounded by a halo of globular clusters and other very old stars
  - bulge from infra-red observations, globular clusters from visual
- We are about 25000 l.y. from the centre
  - from studying globular clusters
- The disc rotates
  - from Doppler shift studies of velocities of nearby stars and gas clouds
- Gas is confined to the disc
  - from radio studies
  - therefore only old stars in bulge and halo
- There are spiral arms
  - from maps of neutral hydrogen and young stars
- Most of the mass is dark
  - from analysis of rotation curve

And finally… the Galactic centre

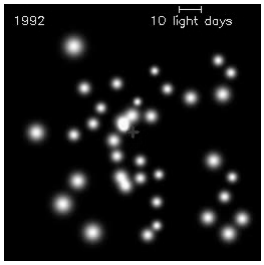
- The centre of the Milky Way is not like the rest of the bulge
  - it contains lots of gas
  - it is a site of new star formation and recent supernovae
  - it is a strong radio source and an X-ray source



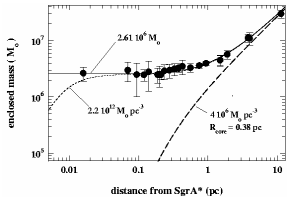


Heart of darkness?

- Using infra-red we can observe stars within 1 l.y. of the centre of the Galaxy
  - they move, visibly
  - applying Newton's laws we find that there must be a central mass of 3 **million** solar masses



movie from MPE Garching



- this is associated with the central radio source

…almost certainly a massive black hole