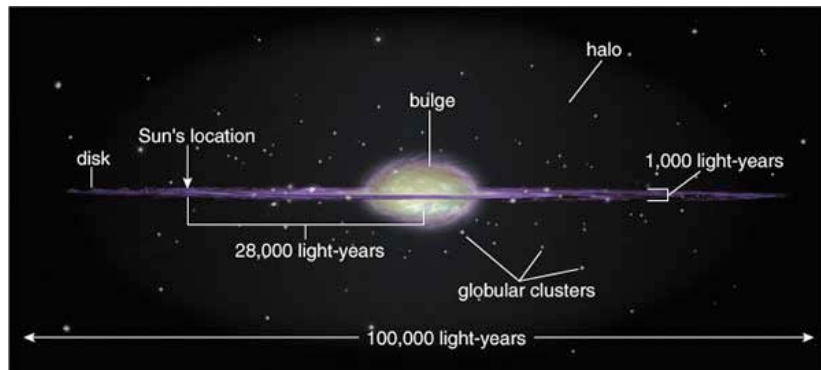


How Many Stars in the MW?



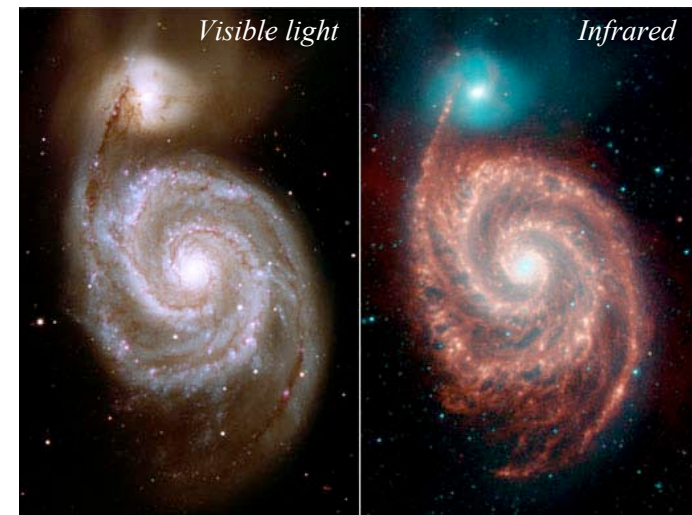
- ~100 billion stars!
- Half of **visible** mass is in the disk
 - Average separation between stars is about 5 light years
- The rest is in the bulge and halo.
 - Density of the bulge is millions of times larger than the disk.

Rotation of the MW

- The Sun is 28,000 light years away from the center of the MW, and orbits about the center at 220 km/s
 - About 1/1400 of the speed of light – fast rotation!
 - Newton's laws imply that mass *inside* the Sun's orbit is about **100 billion (10^{11}) solar masses**.
 - Fast rotation is necessary to balance large gravity.
- How about mass *outside* the Sun's orbit?
 - If there is no matter outside the Sun's orbit, then rotation speed decreases as $1/\sqrt{r}$
 - Observations show that rotation speed remains the same beyond the Sun's orbit, *even beyond the visible edge of the MW*.
 - Mass has to increase as r , but we don't see anything there...
 - **Invisible mass** → **Dark Matter**

Pop!

- Population I (**Pop-I**)
 - “Disk Stars”
 - Atmosphere contains 1-2% of heavy elements (heavier than He)
 - The Sun belongs to Pop-I
- Population II (**Pop-II**)
 - “Halo Stars”
 - Very little heavy elements; Old population
- Population III (**Pop-III**)
 - “First Stars”
 - *No* heavy elements; Primordial population
- Planet formation – which pop would be capable of having planets around?



ISM!

- M51 (Whirlpool Galaxy)
 - Interstellar dust absorbs visible light and emits in infrared
 - These images tell us many things – Pay close attention to differences between two images.

Spiral Arms

- Stars and spiral arms *do not* move together.
 - If they do, we have “winding problem”
- Spiral arms represent “density waves” propagating through the galaxy.
 - Waves do not carry stars or gas with them.
 - When waves hit gas, density of gas increases.
 - In high density gas, stars are born.
 - The spiral arms appear to shine because of these newly born stars.
- Small mass stars (which look redder) escape from the arms, but high mass stars (which look bluer) don’t.
 - Therefore, blue stars appear to follow the arms.
 - Recall the images of M51

Central Black Holes

- It is believed that every galaxy hosts (at least) one black hole at the center.
 - Both spirals and ellipticals.
 - Bigger galaxies host more massive black holes.
 - The black hole at the center of the MW weighs **3 to 4 million** solar masses.
- When black holes are *active*, they are called...
 - Active Galactic Nuclei (AGNs)
 - Quasars (QSOs)
 - The MW’s central black hole is currently inactive.
- How did such giant black holes form?
 - We don’t know.