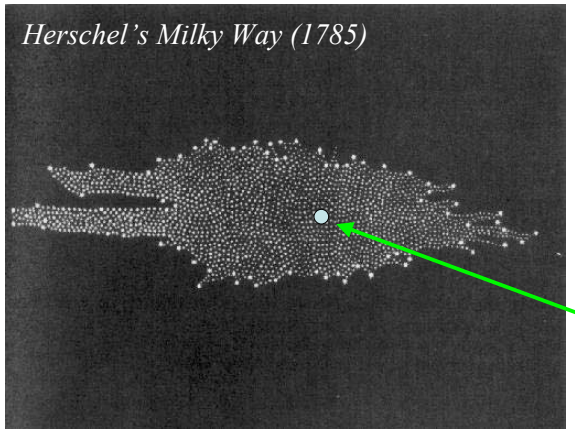
Newtonian Universe

- The Newtonian universe is infinite, but the material world was finite, at first.
  - Empty space is allowed between materials in the universe
  - The space outside of the material world was reserved for Gods
- Correspondences with Robert Bentley in 1692-1693 have changed Newton's view of the universe
  - Bentley pointed out that the material world cannot be finite; if it is, all matter will collapse into a single body
  - Only matter evenly distributed over infinite space can exist without collapse (but this is a highly unstable configuration!)
  - From these considerations, Newton extended the material world to infinitely large, with matter evenly distributed.

Milky Way

- Stars are not evenly distributed!
  - Modification to the Newtonian universe needed
- Thomas Wright (1711-1786)
  - "An Original Theory of the Universe" (1750)
  - Two models accounting for the Milky Way: disk and sphere
  - Many-universe hypothesis: he thought that nebulae were other universes
- Immanuel Kant (1724-1804)
  - Adapted one of Wright's idea: the Milky Way is a *rotating* disk
  - Many-universe: nebulae are other milky ways
- William Herschel (1738-1822)
  - His observations of stars showed that the Milky Way was flat.
  - Famous diagram of the Milky Way (1785)



- Distances to the stars were measured assuming:
  - No absorption or attenuation in interstellar space
  - All stars are similar to the Sun
  - Stars are distributed uniformly in space
- None of the assumptions was correct

How was Herschel deceived?

- Estimated distances were inaccurate because of…
  - Interstellar absorption and attenuation
    - Distant stars look dimmer because:
      - they are farther away, ***and***
      - their lights are attenuated by interstellar dust.
    - He did not know about the attenuation, and overestimated distances toward the center of the Milky Way
  - Stars are different
    - Binary stars (two stars orbiting each other) are at the same distance, but they have different brightness
- Stars are not uniformly distributed
  - The most clouded region does not necessarily imply the most extended region
- After proper corrections, the Sun is not at the center of the Milky Way.

Many or One?

- Pierre Simon de Laplace (1749-1827)
  - One-universe hypothesis
    - only one Milky Way (or galaxy) in the universe, and nebulae are gas clouds forming other solar systems
  - His model remained standard until 1924
- In 1924, Edwin Hubble showed that Andromeda nebula was far beyond the outer reaches of stars in the Milky Way -- the Andromeda is a galaxy, just like the Milky Way.
- Now we know that what they called "nebulae" included both galaxies and gas clouds.
  - Some nebulae are gas clouds within our Galaxy and some are galaxies outside.

Finite or Infinite?

- Current observations show no compelling evidence for the "starry sphere" or the "edge of the universe", within our cosmic horizon.
- However, some people claim that they have found evidences.
  - Example
  - We still don't know if the universe is finite or infinite.
- What do you think? Why?