Weighing NGC3762—9 Nov

- Kepler's Law needs modification since period of sun's motion around Milky Way is 200 Myr.
  - Mass = R^3 / T^2
  - Mass = $R\ v^2$
- Doppler effect for measuring speed.
- Mass of NGC3762
- Friday: Where is the mass?
  - Answer: Mass is not where the stars are.

Most mass here.
not where stars are.

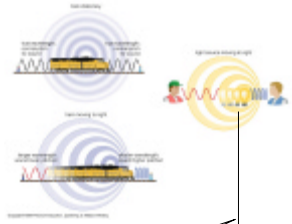
Weighing the Sun

- Measure period T & size R of a planet's orbit to find the mass M
  - Kepler's 3rd Law
  - $GM \propto 4\pi^2 R^3 / T^2$
  - $M = R^3 / T^2$ for R in AU, T in years, and M in solar masses.
    - $M \propto R\ v^2$
      - Measure velocity with Doppler effect. Useful in astronomy.
      - Periods of sun's orbit is 200Myr.
- Under influence of the gravity of a mass, a test object moves a given distance. If the time is short, the mass is ___.

Mass	Test object	Motion	Behavior if more massive
Sun	Earth	An orbit	Year is shorter
Eros			
Earth			
Galaxy			

Doppler Effect: Measuring velocities

- Recall redshift & expansion of U
  - Wavelength changes b/c U expands
  - Wavelength changes if light source is moving
  - $v = c\ (\lambda_{received} / \lambda_{emitted} - 1)$
  - If motion is away (v>0),
    - $\lambda_{received} > \lambda_{emitted}$, redshift
  - If motion is toward (v<0),
    - $\lambda_{received} < \lambda_{emitted}$, blueshift
- Motion across line of sight cannot be measured with Doppler effect. Key idea.



Line of sight

Viewed from here,
λ unchanged.

1. What in the spectrum along the major axis shows different parts of the galaxy are moving at different speeds?
2. Why is the same motion not seen in the spectrum along the minor axis?

NGC 3672, Vera Rubin, Norbert Thonnard, & Kent Ford, jr., 1977, Astrophys. Journal 217, L1.

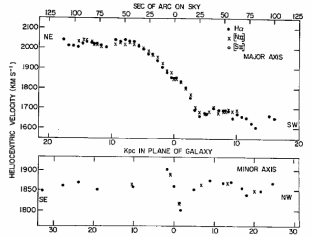


FIG. 3.—*Upper*, major axis heliocentric velocities on plane of sky, as a function of distance from the nucleus. *Lower*, minor axis velocities as a function of distance from the nucleus; note change in scale from upper plot. The steep velocity gradient in nuclear region along minor axis is prominent.