# Astrophysics II – ASTR:3772
# Spring 2015


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- Office hours:
  Tuesday 1:30-2:30 pm,
  Wednesday 9-11 am,
  or by appointment, or drop by.

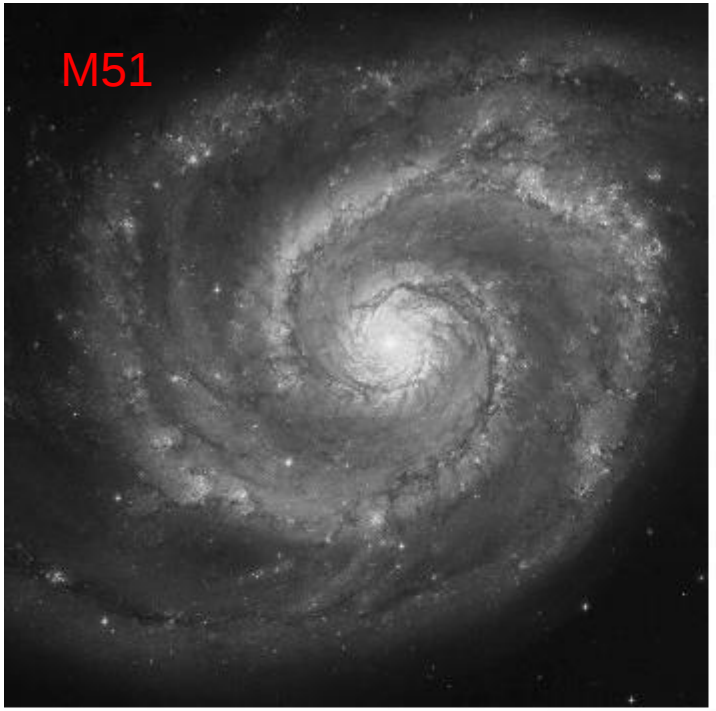
# Nuts and Bolts

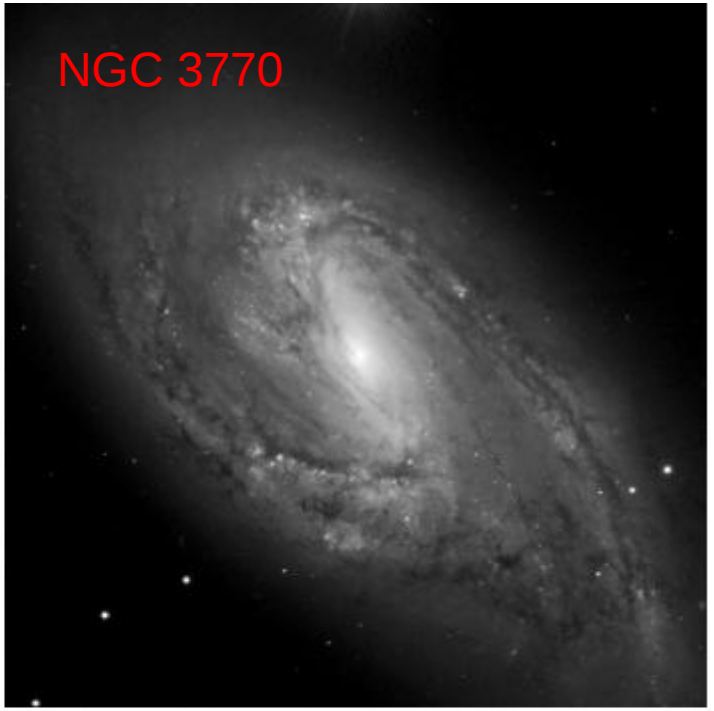
- Lectures are 9:30-10:45 am Tuesdays and Thursdays in 358 VAN.
- The required textbook is *Astrophysics in a Nutshell* by Dan Maoz.
- http://astro.physics.uiowa.edu/~kaaret/2015s_astr3772
- Students are expected to attend all lectures.
- Two in-class exams and a Final.
- Grade:
  - Each one-hour exam - 100 points.
  - Final examination - 120 points.
  - Homework – 100-200 points.
- Homework due at the *beginning* of class. OK to work in small groups, but be sure to understand each problem. Students will be called on to present problems in class and will receive full credit for those problems.

# Spiral Galaxies

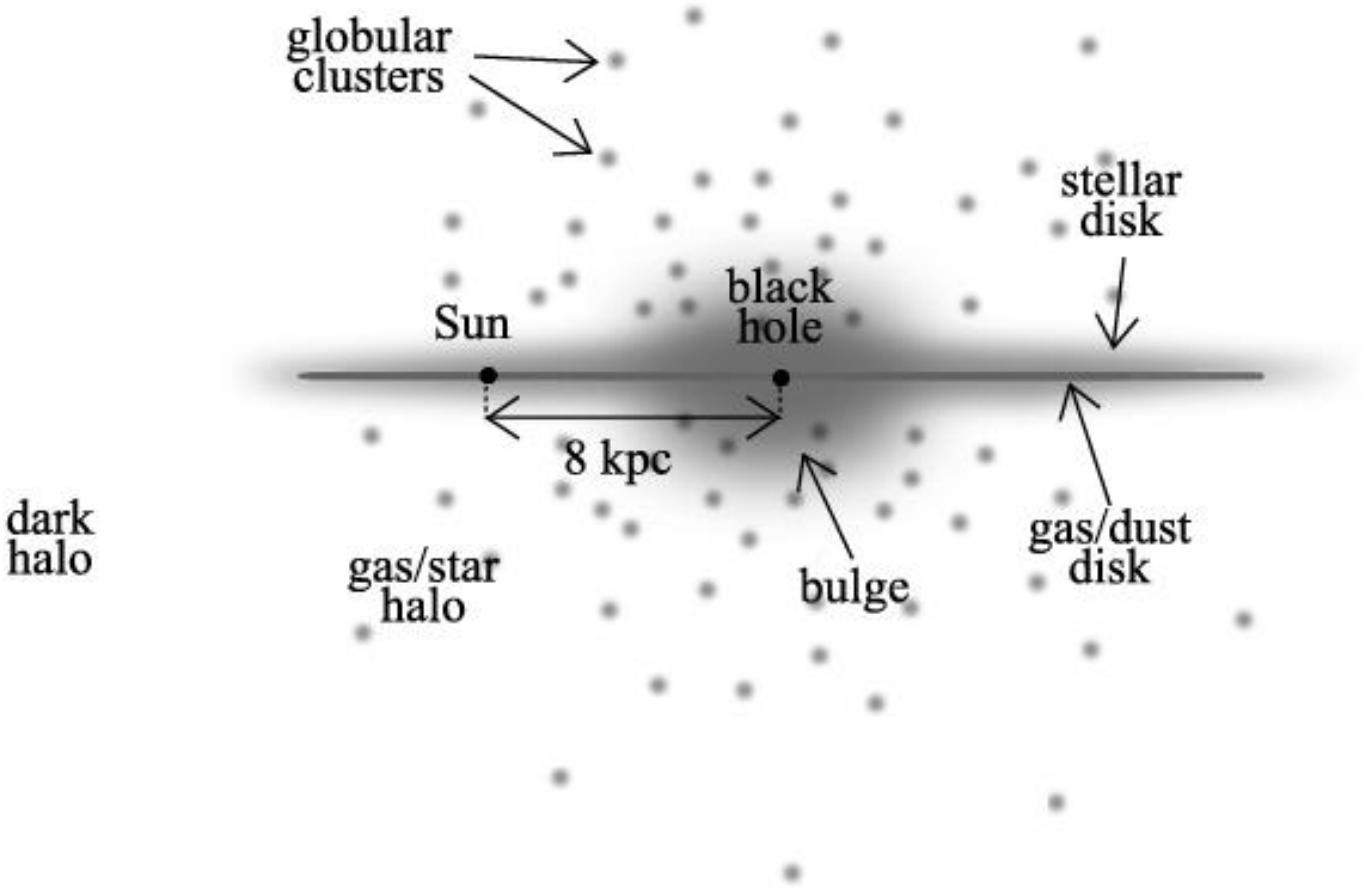
Parts are

- Disk
  - Gas, dust, young stars in circular orbits
- Bulge
  - Old stars in random orbits
- Halo
  - Globular clusters and old stars in random orbits



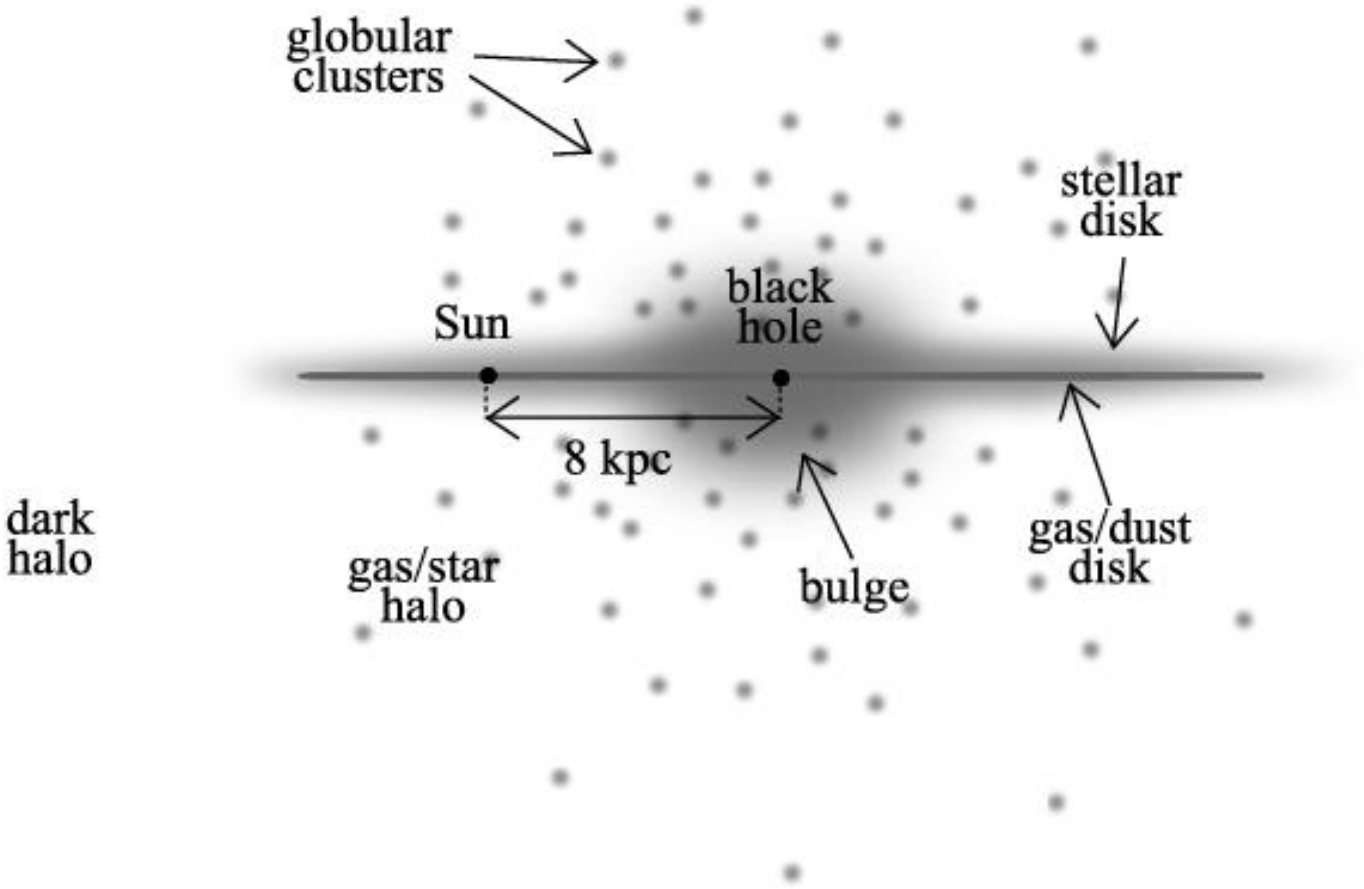

# Milky Way




- Distance from Sun to Galactic center $R = 8.0 \pm 0.5$ kpc.
- Orbital velocity of Sun around Galactic center $v = 220$ km/s.
- Orbital period = $2\pi R/v = 2\times10^8$ years.

- Can we calculate the mass of the Milky Way?

# Milky Way




- Mass of MW internal to Sun = $1.8\times10^{44}$ g = $10^{11}$ solar masses.
- Average mass of stars in MW is ~ 0.5 solar masses.
  - How do we know that?
- About half the mass interior to the Sun is stars, so there are about $10^{11}$ stars interior to the Sun. Other half of mass is dark matter.

# Disk of the Milky Way

- Density profile:

$$\rho(r,z)=\rho_0\left[\exp\left(-\frac{r}{r_d}\right)\right]\left[\exp\left(-\frac{|z|}{h_d}\right)\right]$$

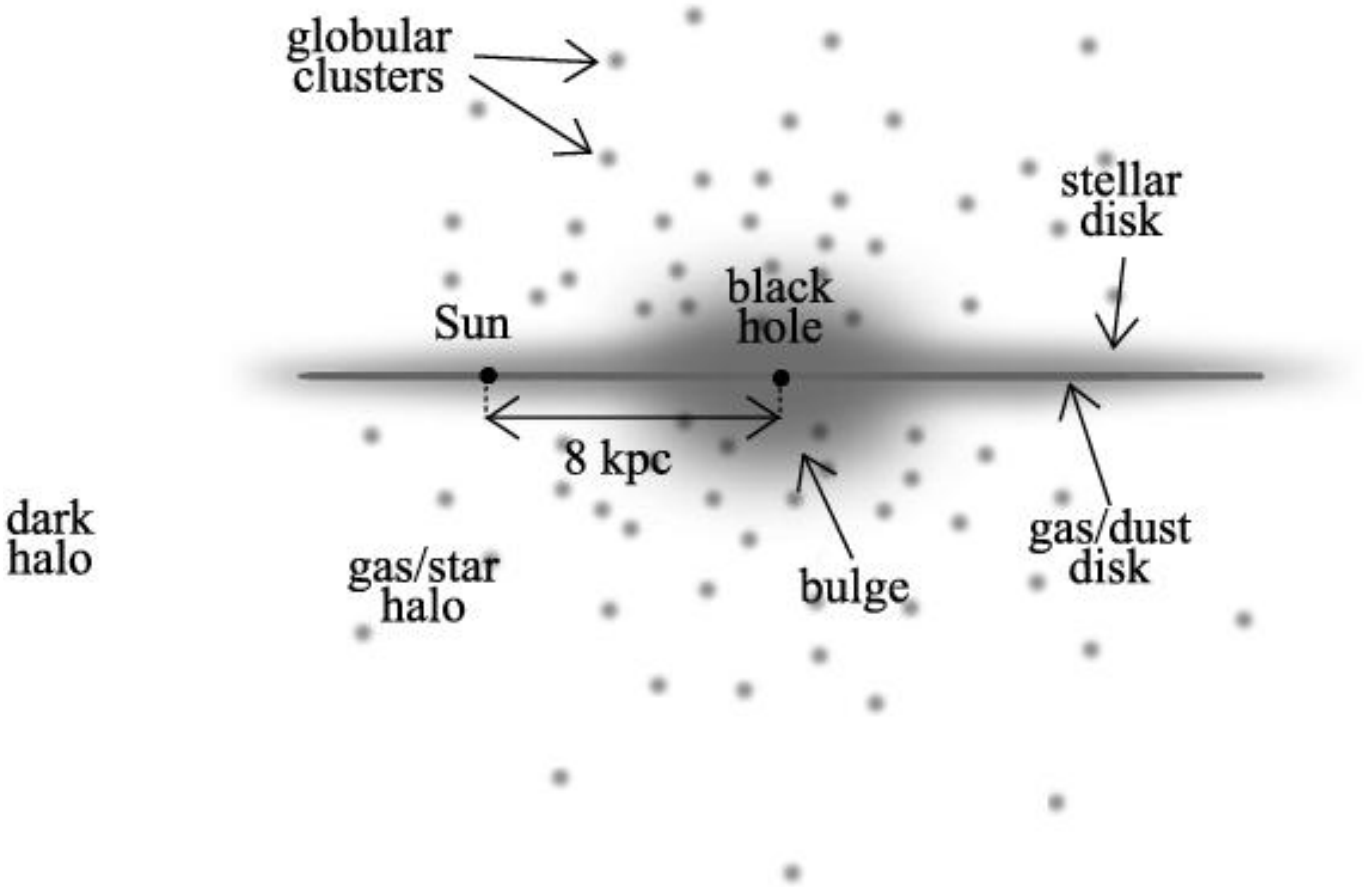
$r$ = radial distance in center, $z$ = distance above/below plane

- Scale length of disk $R_d$ = 3.5 ± 0.5 kpc.
- Scale height of disk $h_d$ = 330 pc for older (solar mass) stars.
- Scale height of disk $h_d$ = 160 pc for gas and dust (why smaller?).
- About $10^{10}$ solar masses with “one scale radius”.
- Estimate stellar density, mean separation, collision rate.

# Spiral Arms

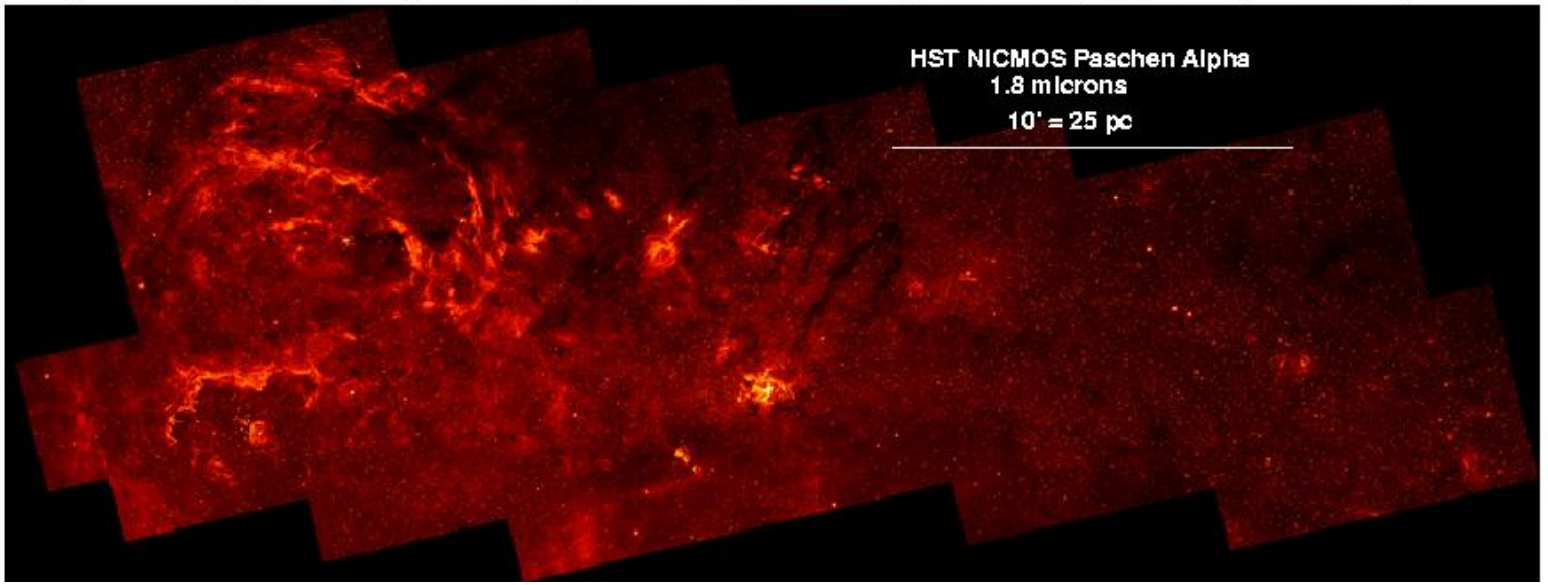
- Spiral arms have enhanced gas density and star formation rate.
- Stars form in arms, move out.  Older stars pass through arms.
- Arms are density waves.

# Spheroid



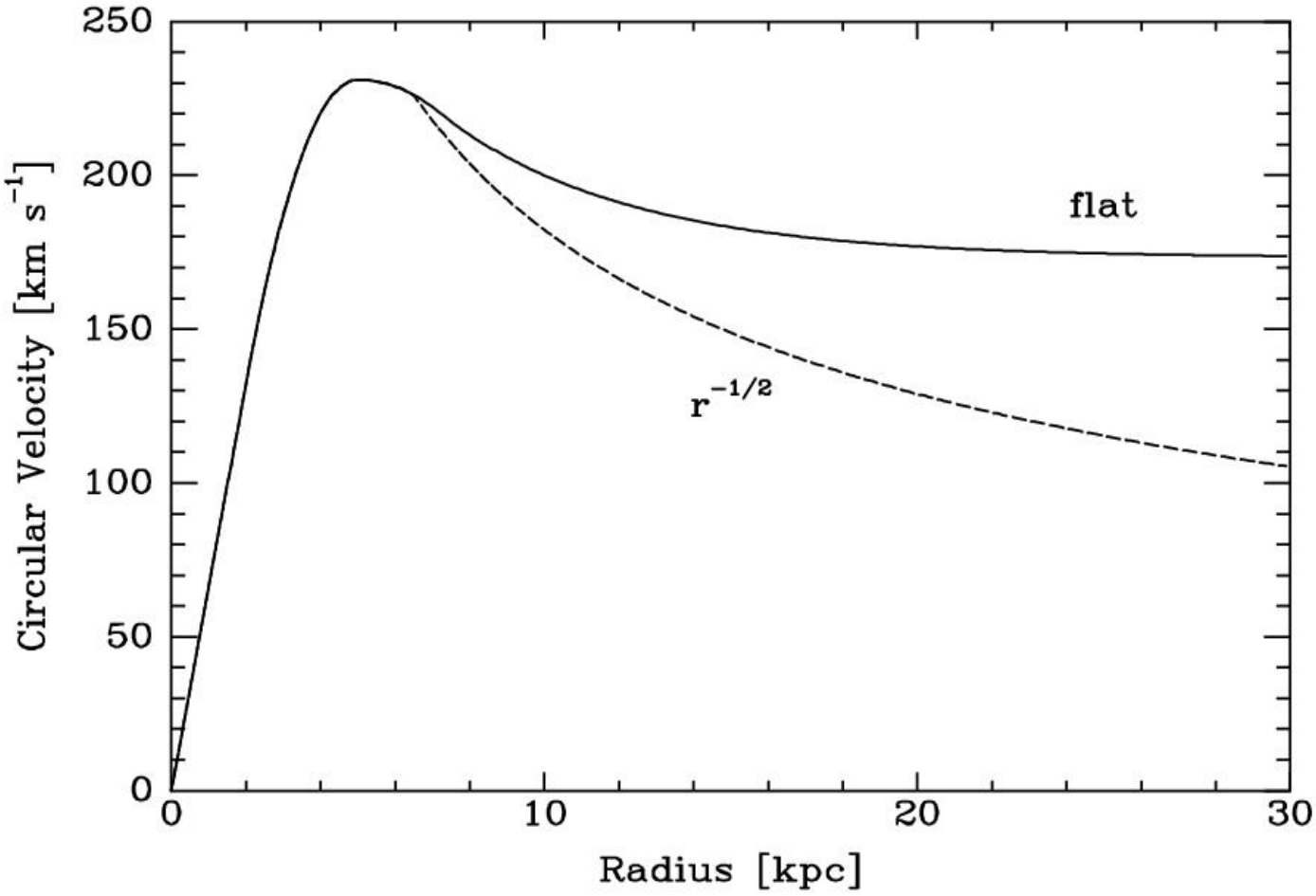

- Bulge radius ~ 1 kpc, density $\rho \sim r^{-3}$.
- Halo radius ~ 50 kpc.
- Age of stars in bulge and halo 10-14 Gyr.
- Spheroid stars have lower metallicity than Sun, as low as $10^{-4.5}$ solar. Why?

# Galactic Center

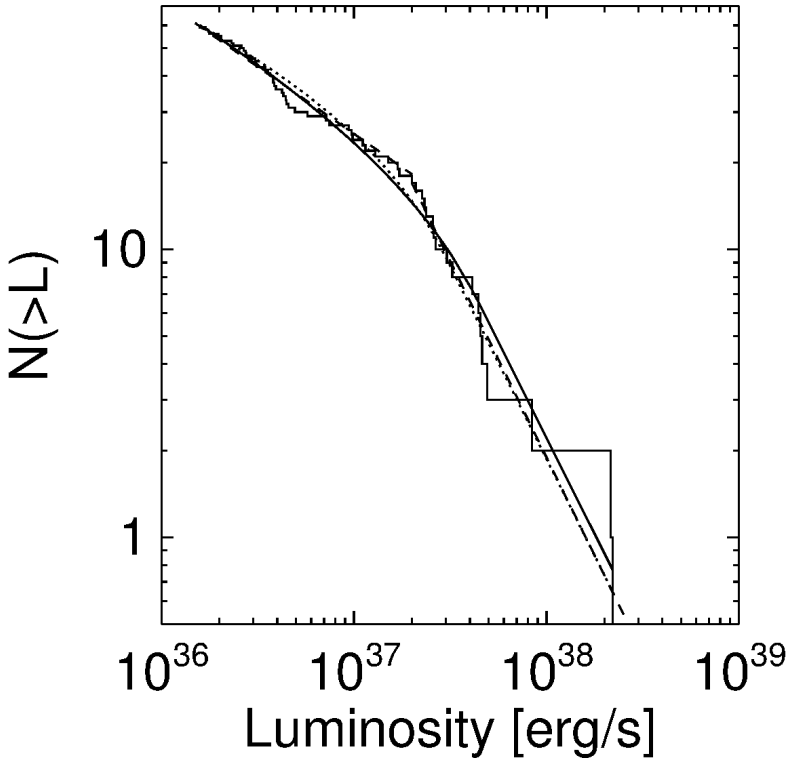

- Lots of stars, gas, dust, and a supermassive black hole.
- Orbits of stars near Sgr A* indicate dark object of $4 \times 10^6$ solar masses.
- Black hole is radio and X-ray source.

# Dark Halo




- Orbital speeds of stars at large Galactocentric radius are larger than expected if orbits are maintained only by gravitational pull of visible matter (stars+gas).
- Need “dark matter”.
- Rotation curve is flat at large radii. What is density profile of dark matter?

# Luminosity Functions




- Luminosity function = $N(>L)$ = number of objects above a given luminosity as a function of that luminosity.
- A similar function can be defined using fluxes, $N(> f)$ = number of objects observed above flux $f$.
- If you have many stars all of the same luminosity, $L$, randomly distributed in space, what is $n$ in $N(> f) \sim f^{n}$?

# Homework

- For next class:
  - Problems 6-1