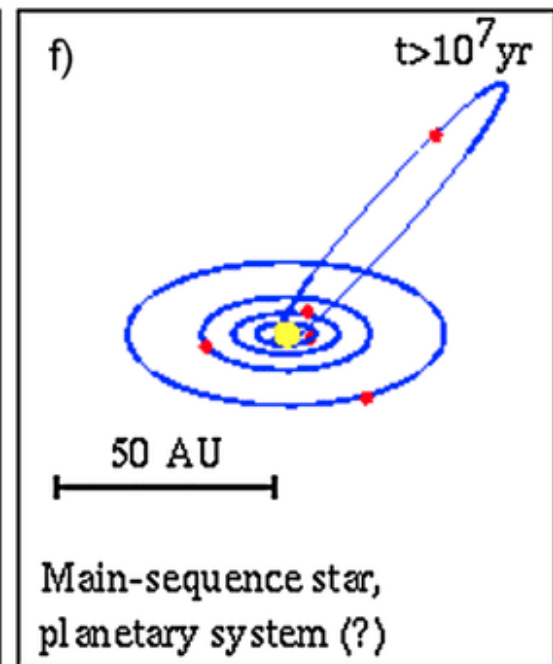
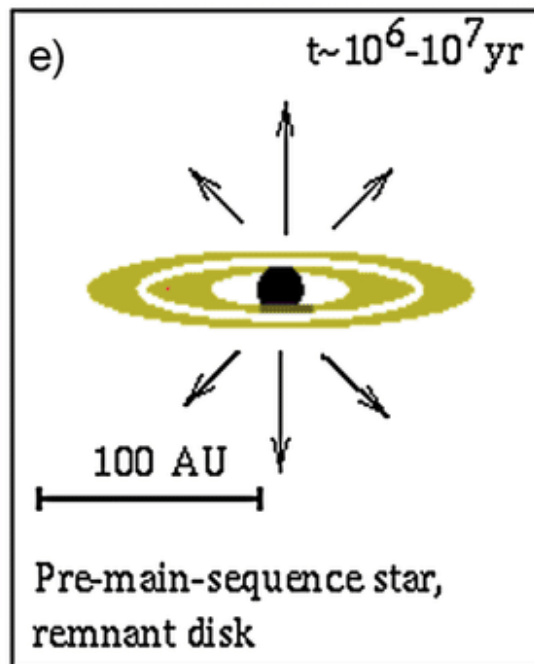
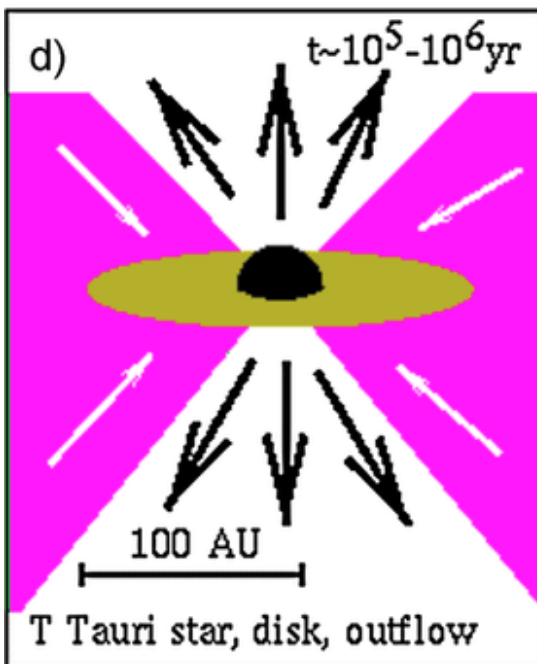
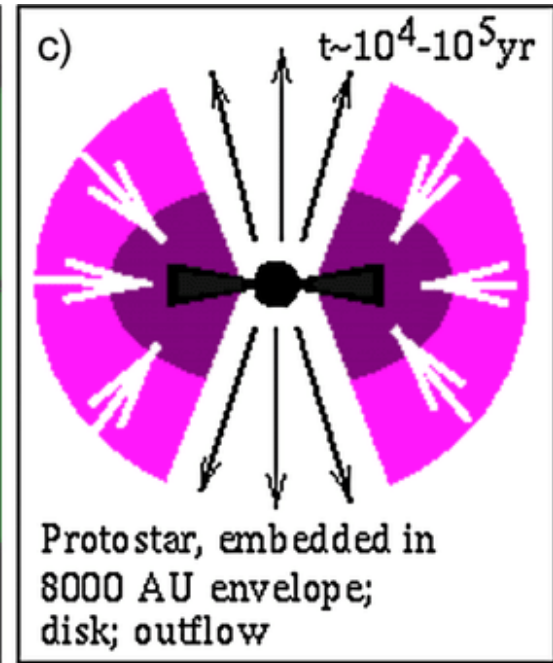
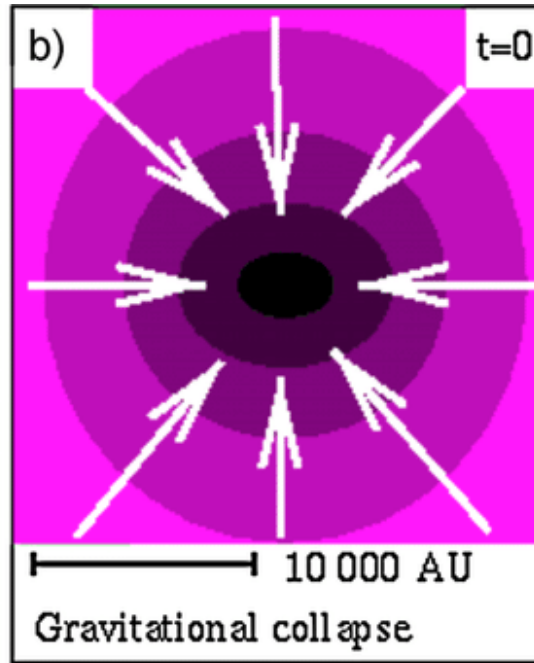
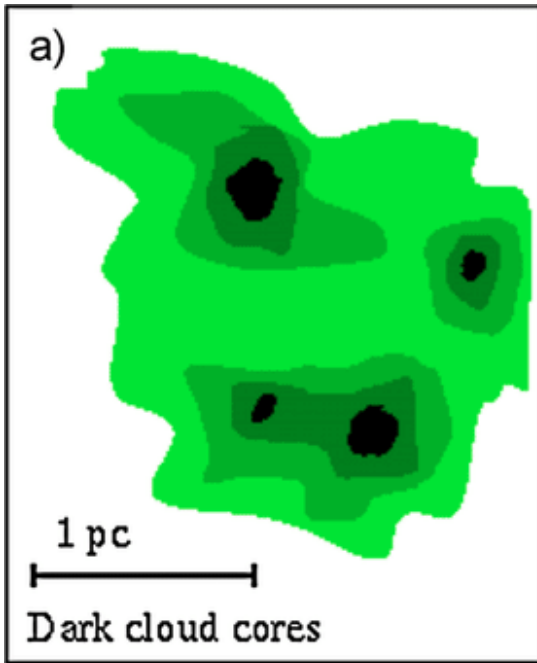
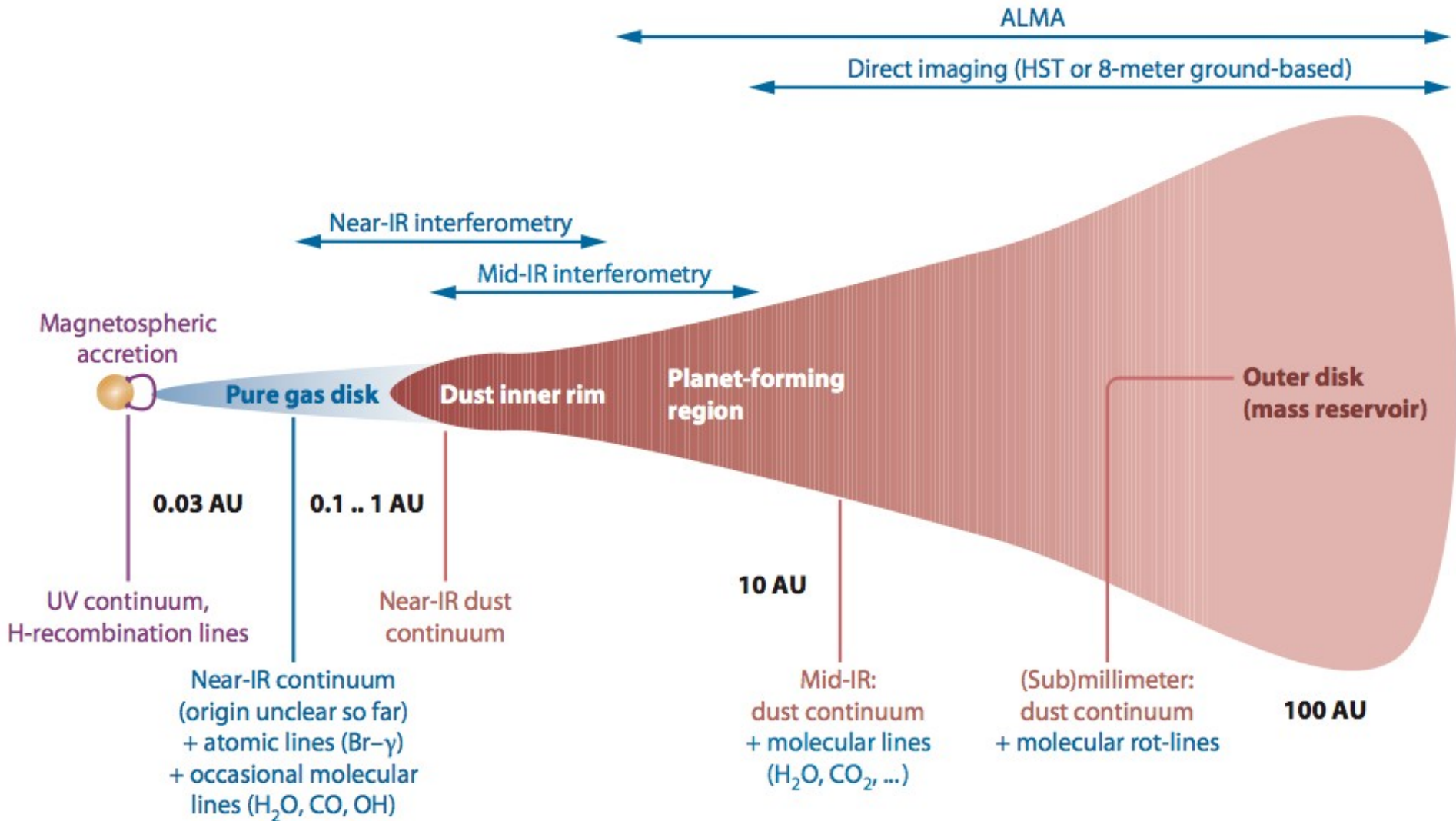


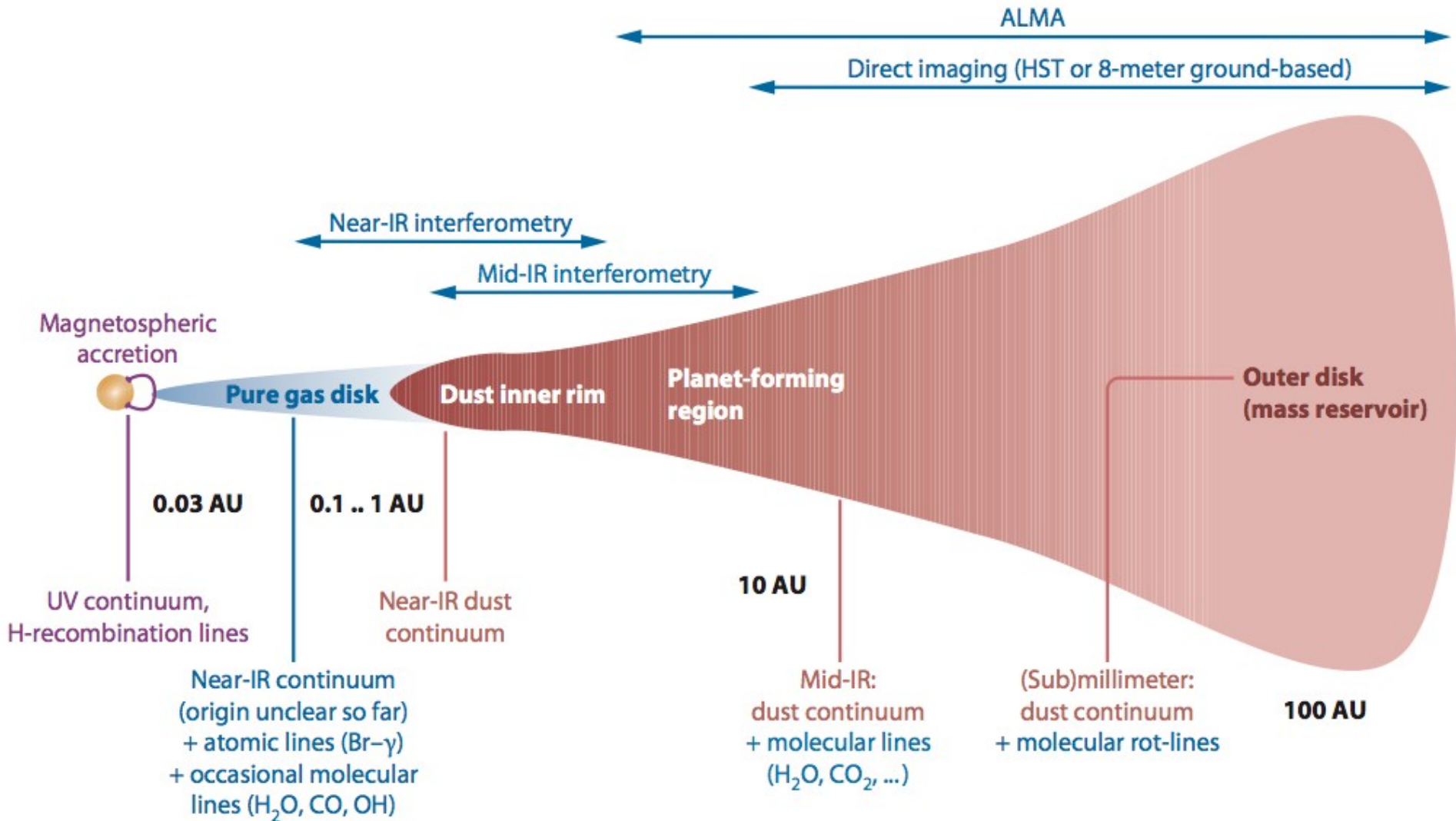
Star & planet formation



Star & planet formation

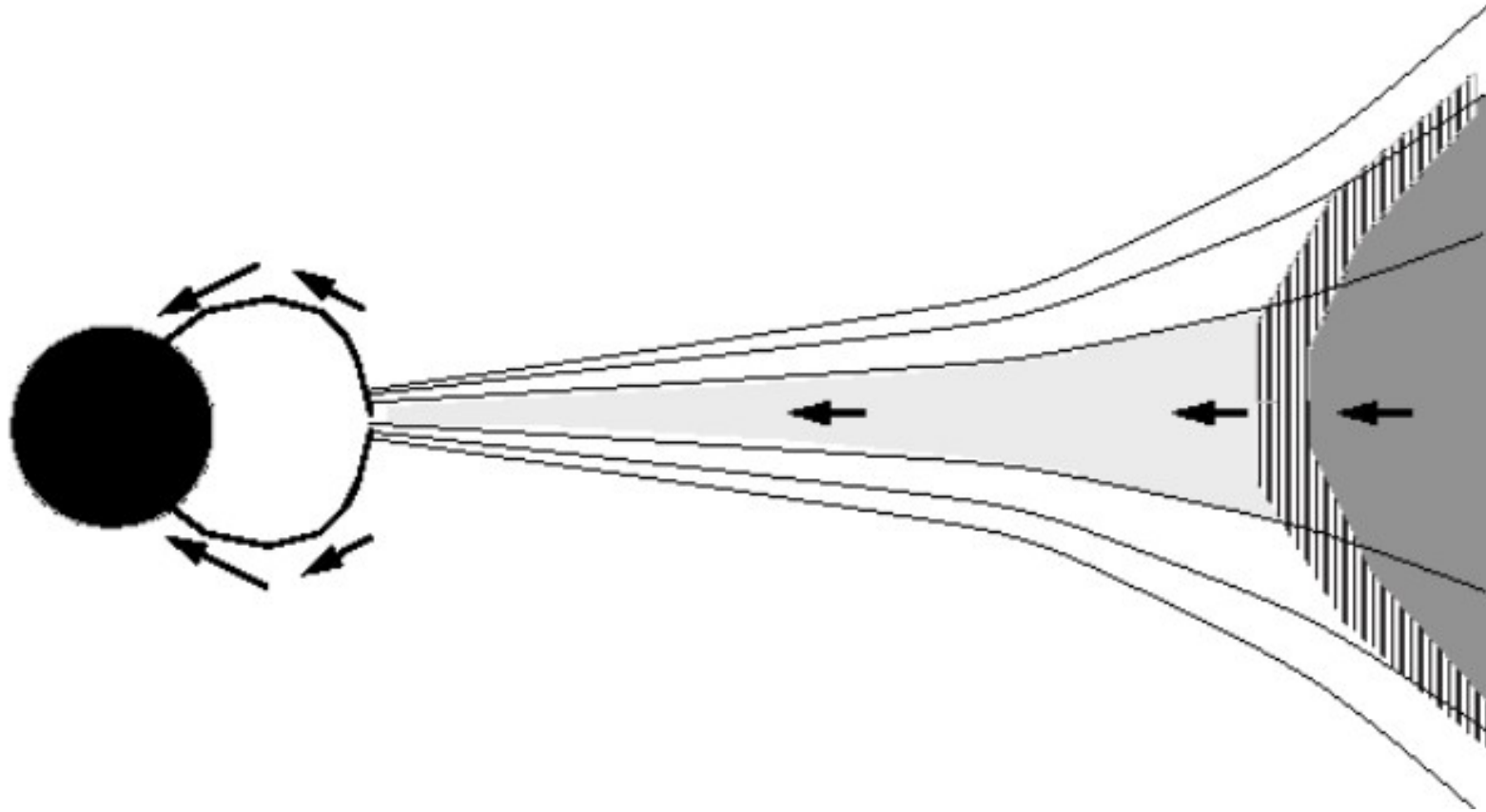


Star & planet formation

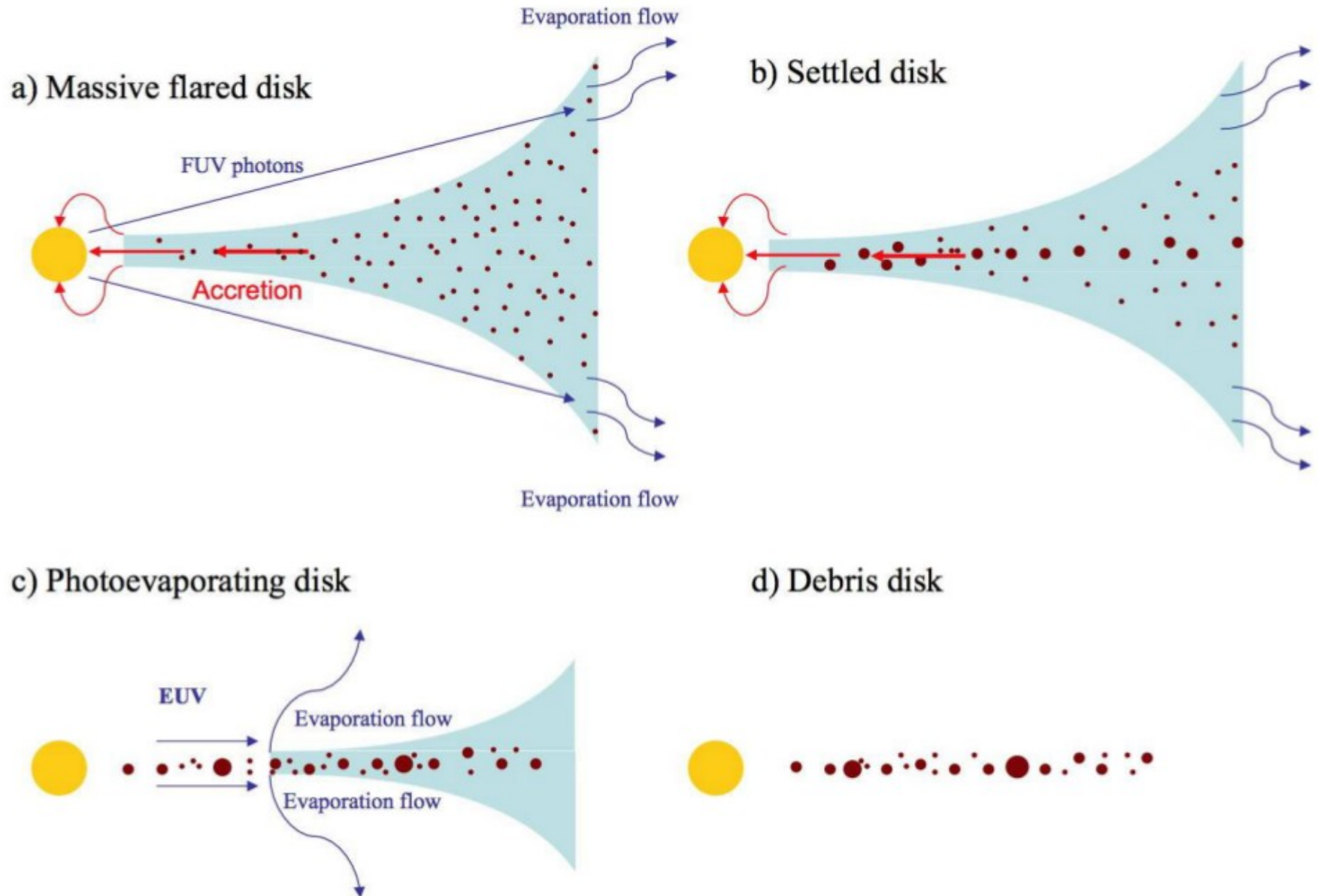


Why pure gas disk?

Accretion of gas onto star



How does dust move inwards?



How does dust move inwards?

2 effects, both in the same direction:

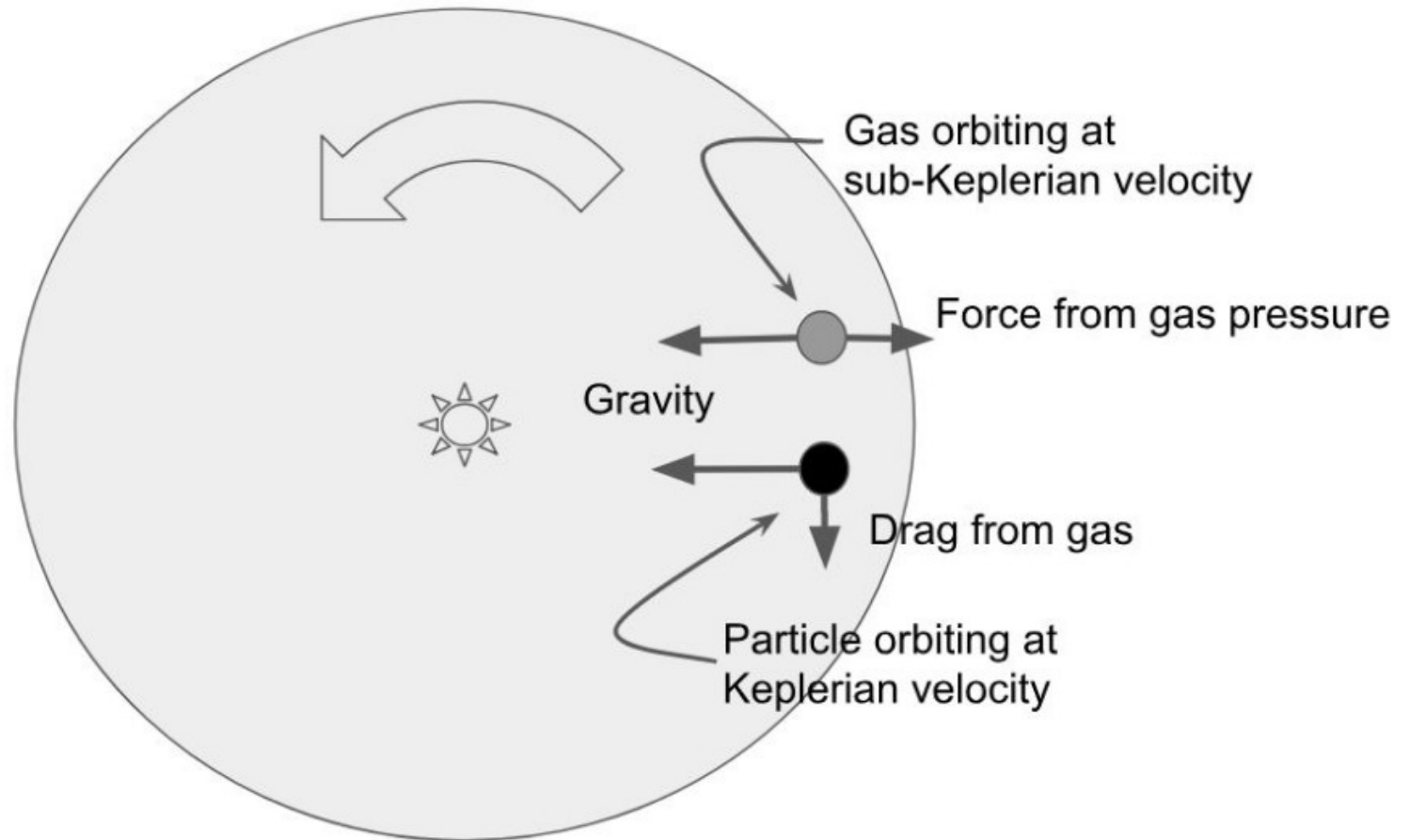
- Poynting-Robertson drag
- Streaming instability

Streaming instability

Equation for tangential velocity difference between gas and dust:

$$\frac{v_{\phi, \text{gas}}^2}{r} = \frac{GM_*}{r^2} + \frac{1}{\rho} \frac{dP}{dr}$$

-Derived from Newton's 2nd law and the definition of circular velocity



Which particles are affected the most?

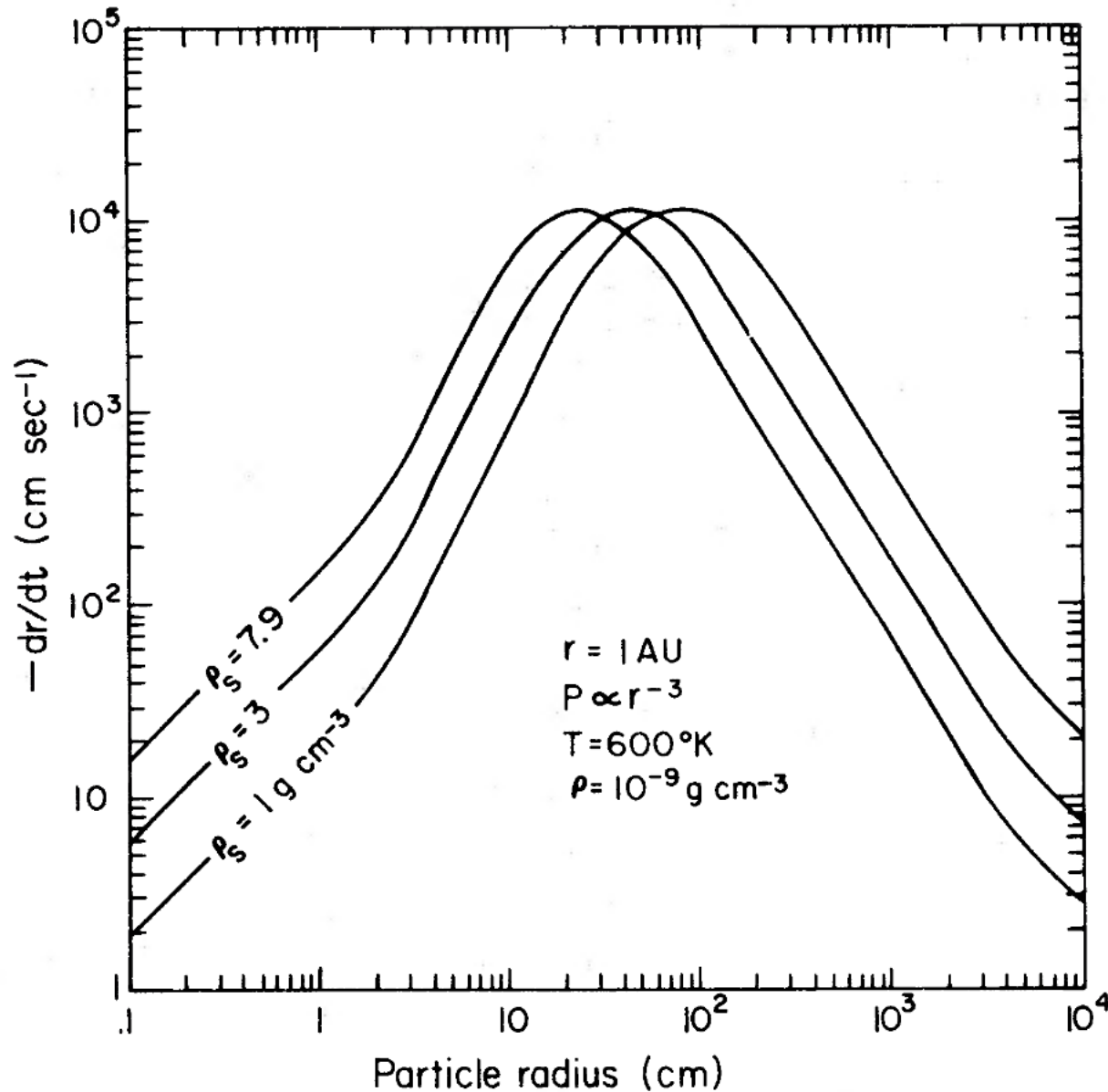
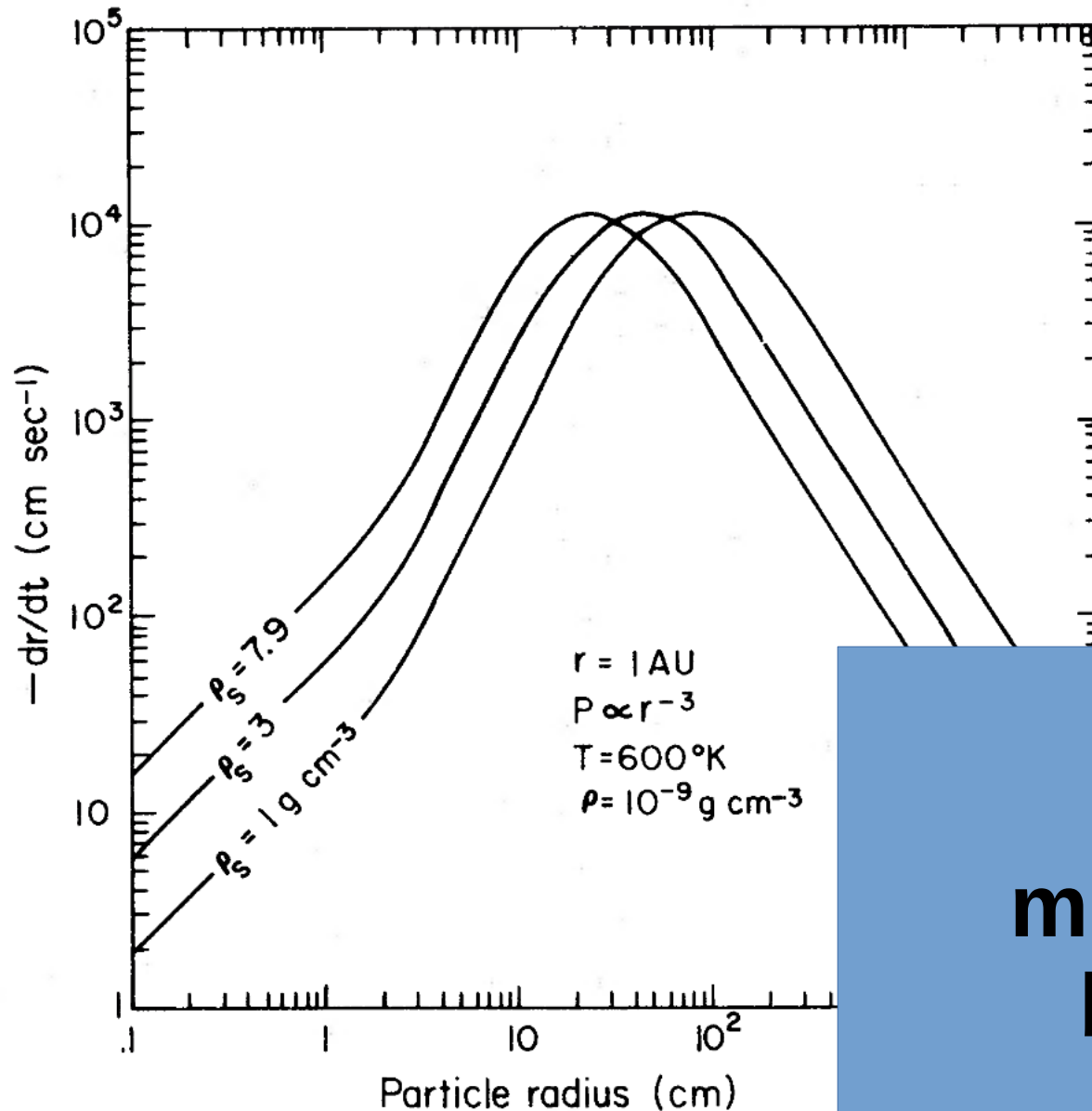


Figure 3. Effect of particle density on radial velocity.

Which particles are affected the most?



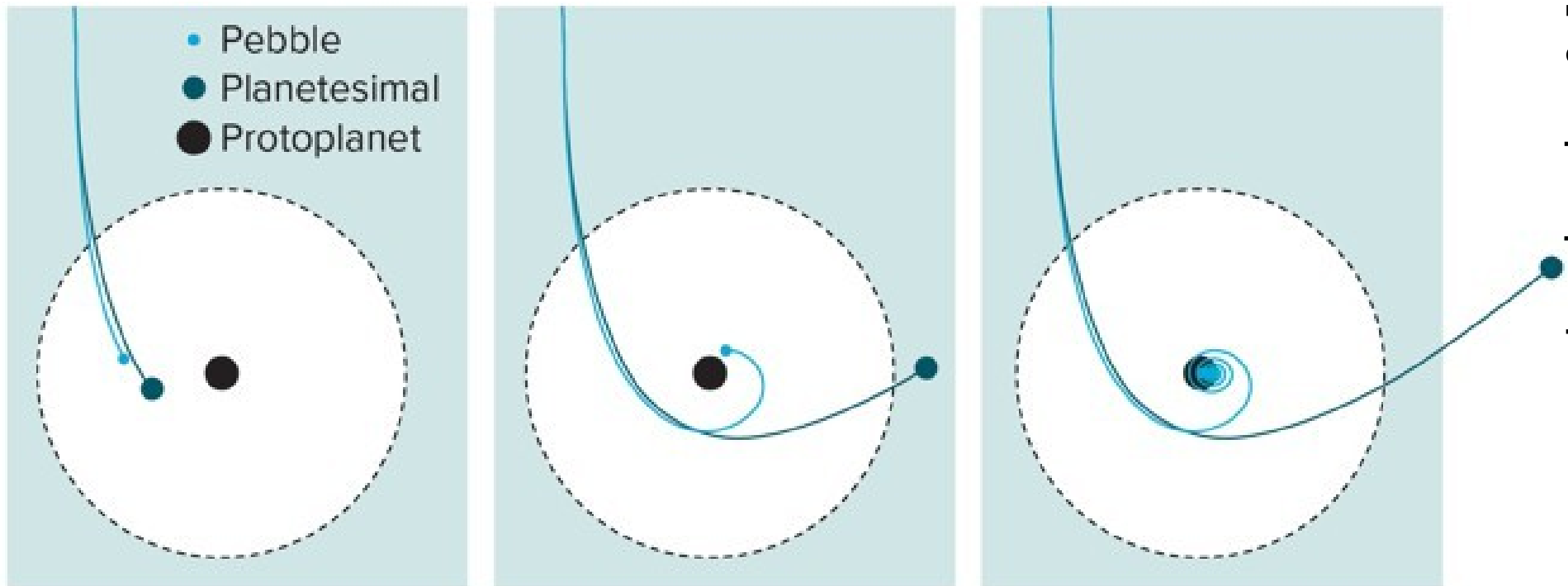
**“The
meter-size
barrier”**

Figure 3. Effect of particle density on radial velocity.

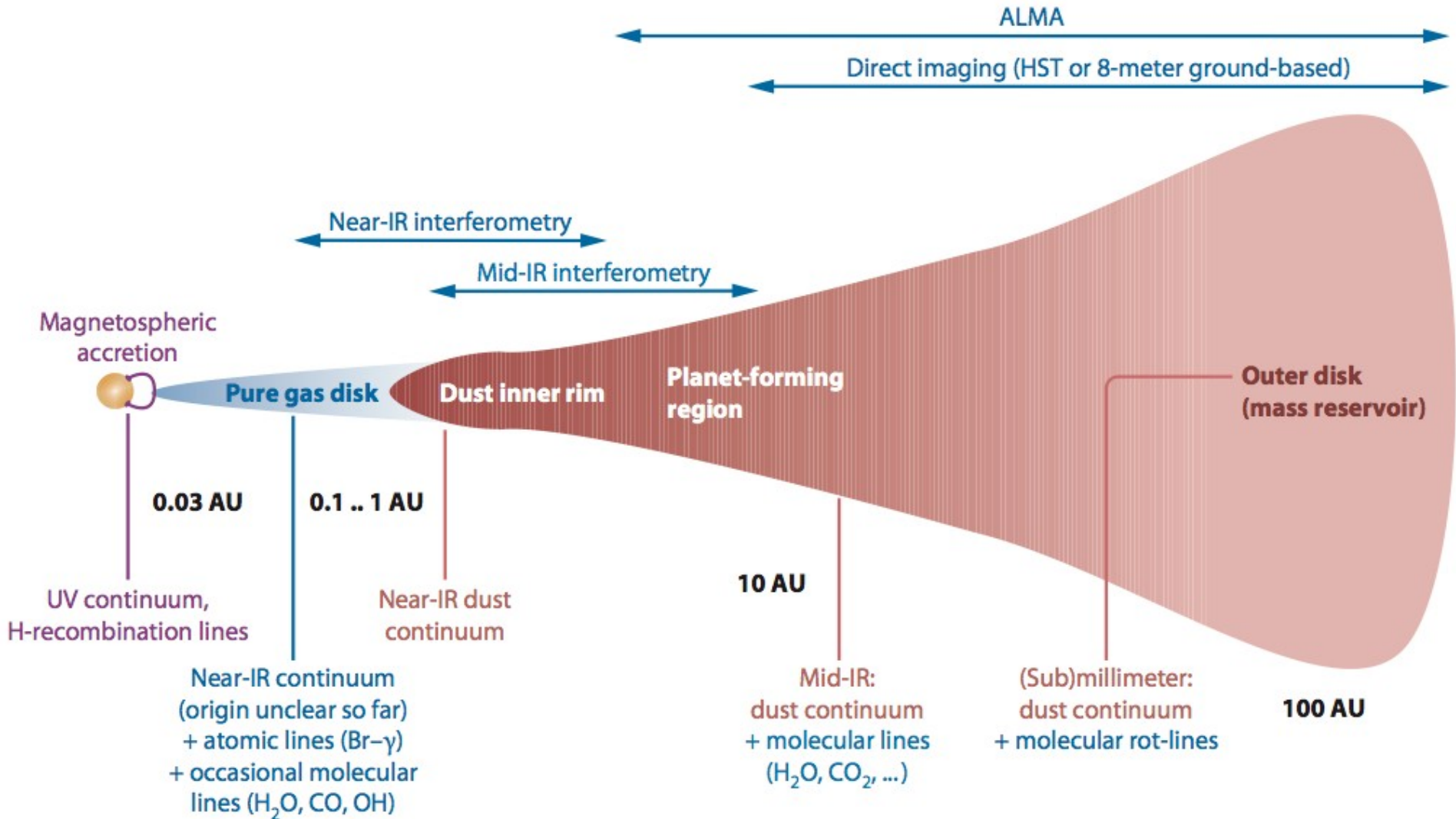
Need to get over meter-size quickly: “Pebble accretion”

A pull on pebbles

A pebble flying past a protoplanetary body is slowed by friction from surrounding gas as it enters the protoplanet’s gravitational influence (dotted line). That slowdown allows the small pebble to be captured by the protoplanet’s gravity and spiral in for a smash-up, whereas a larger planetesimal just zips by. Over time, many pebbles will coalesce with the protoplanet, allowing it to grow large quickly.

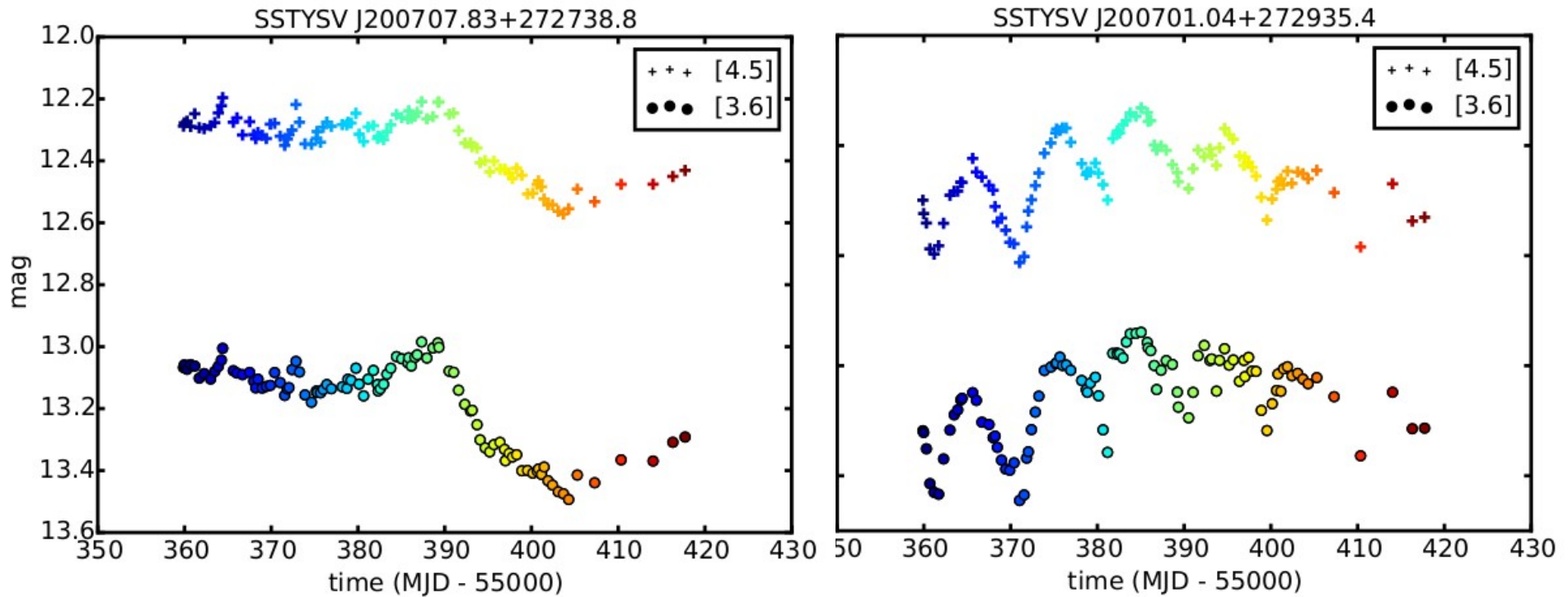


Studying disks observationally



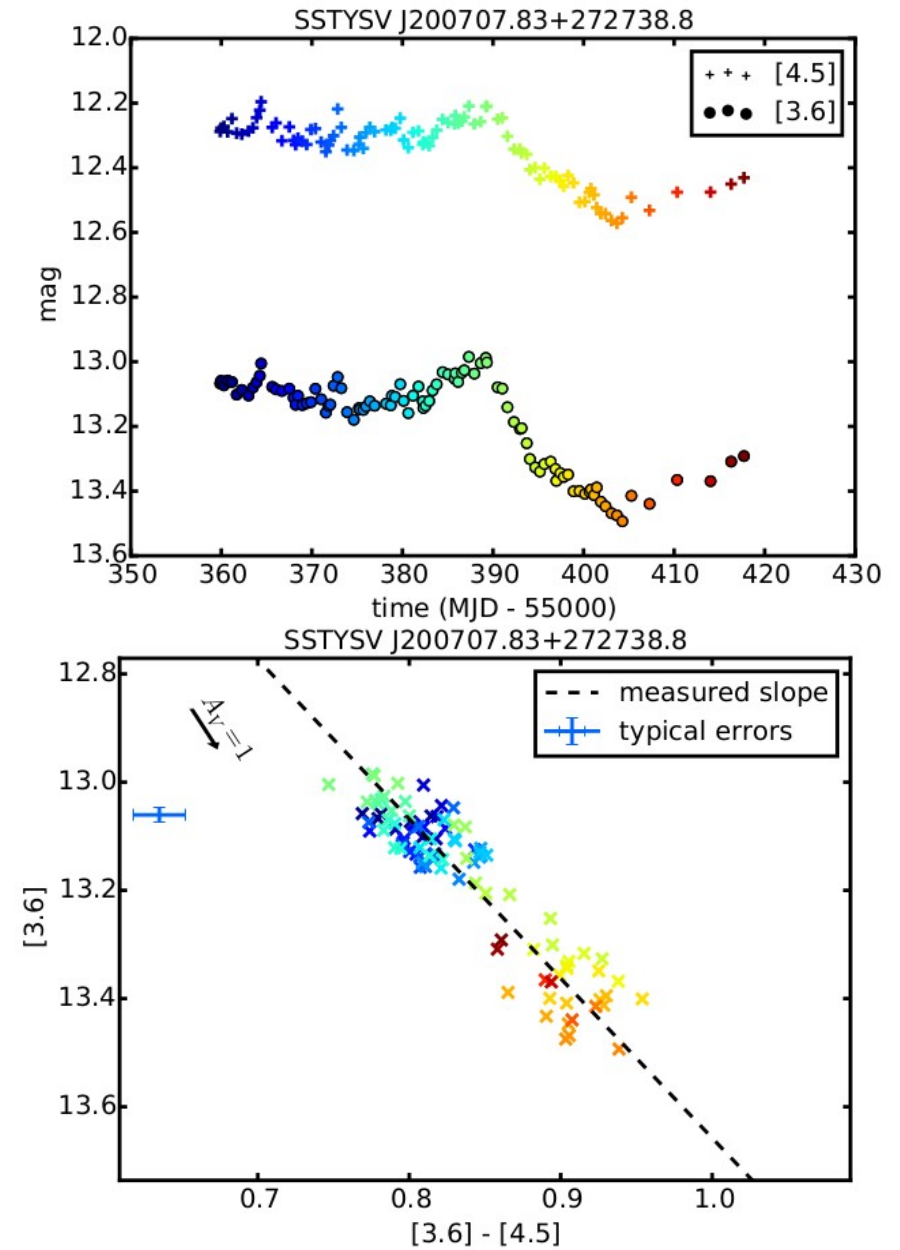
Studying disks observationally

YSOs often too faint to get time series of spectra. Get light curves in 2 or more filters instead!

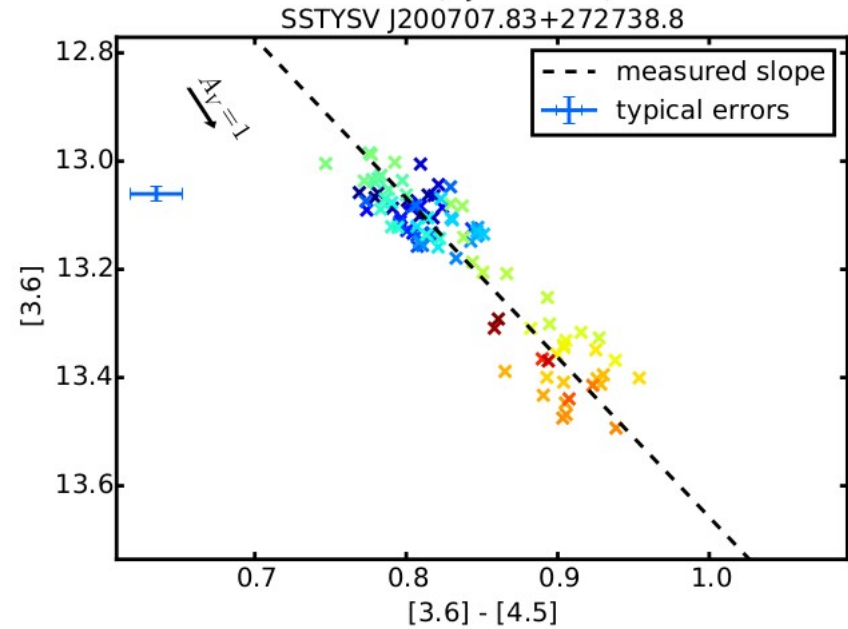
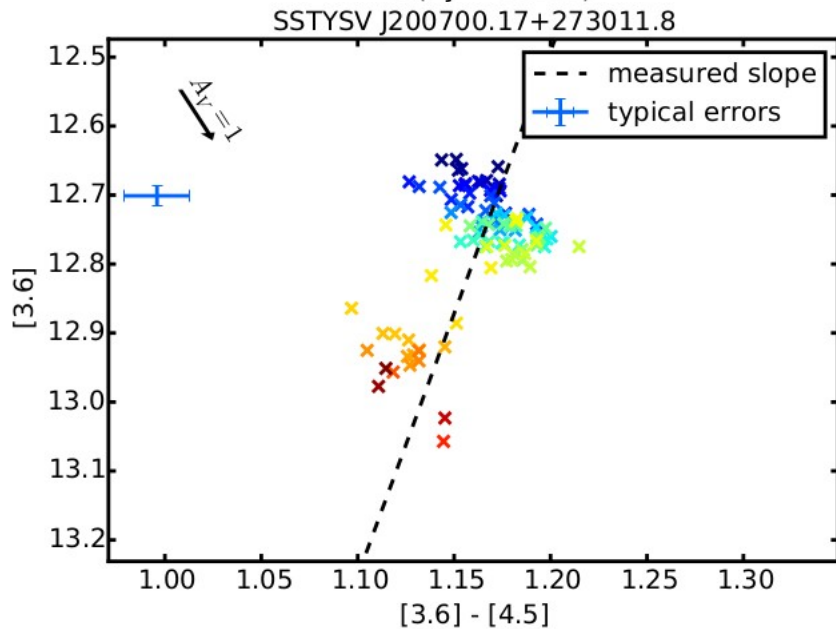
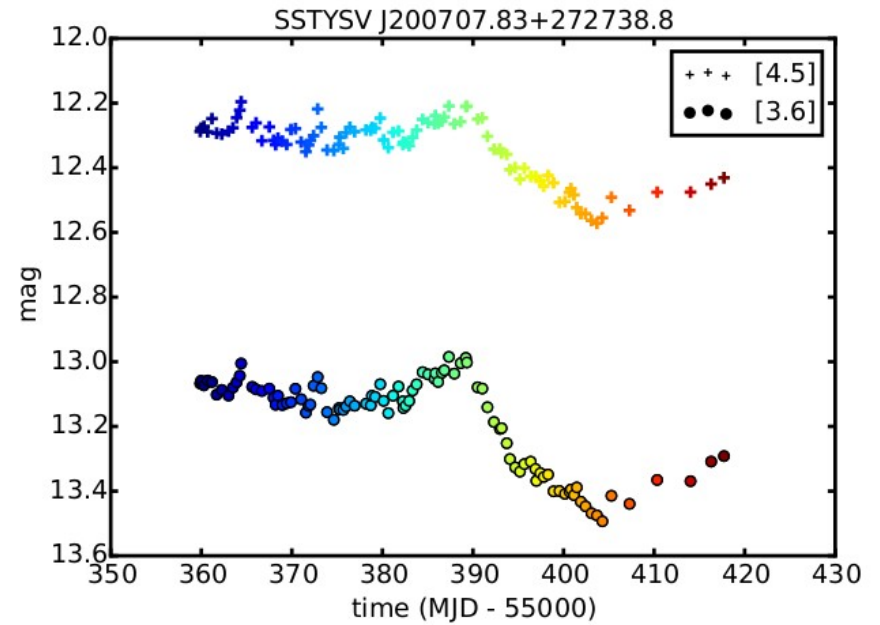
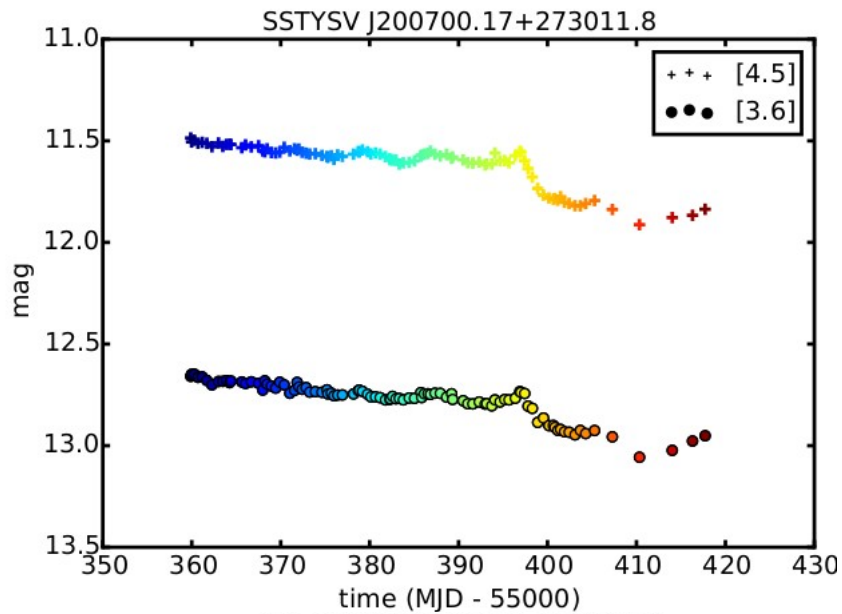


Studying disks observationally

Color-magnitude diagrams



Studying disks observationally

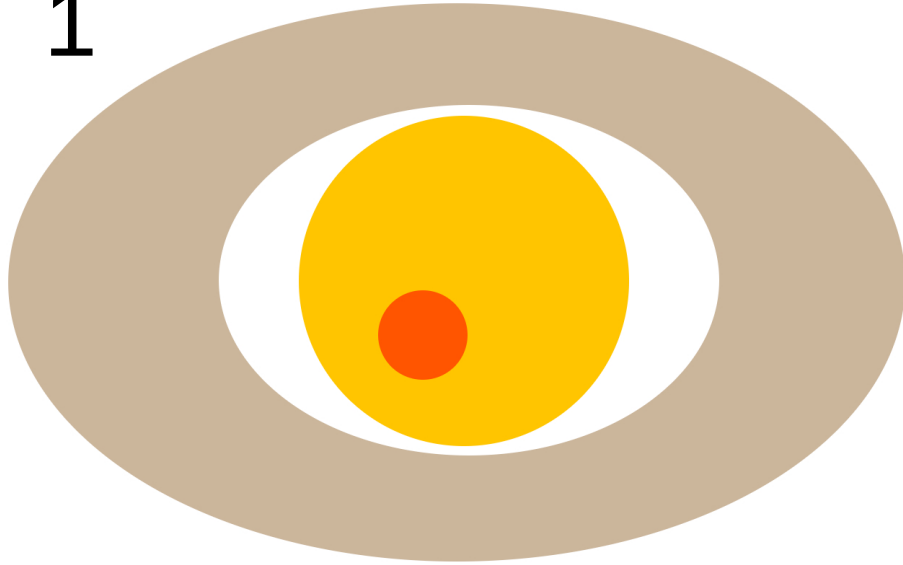


Physical processes and color changes in the infrared

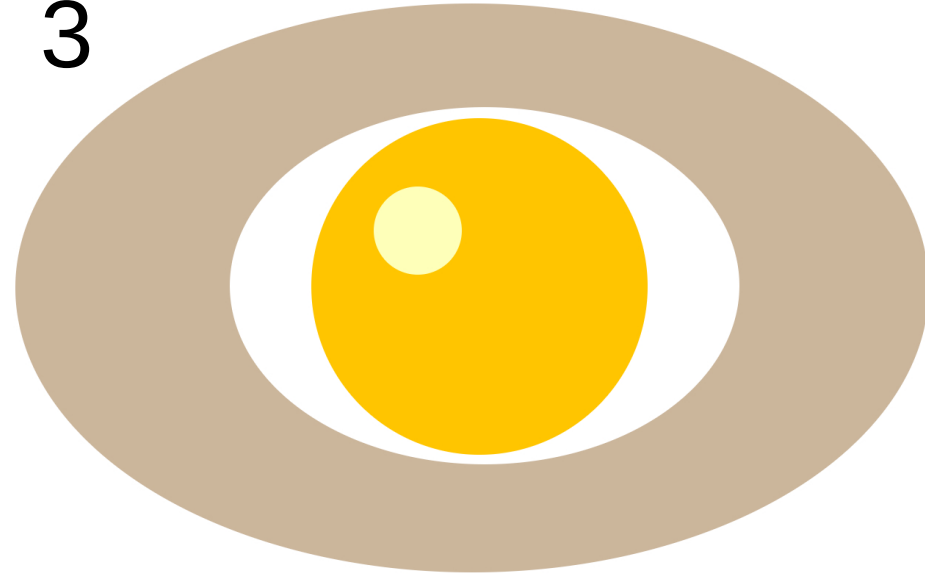
- 1) Star + cool (magnetic) spot
- 2) Star + blob of dust from warped disk
- 3) Star + hot spot from accretion
- 4) Star + hot spot from accretion + disk inner rim moving to larger radius

Physical processes and color changes in the infrared

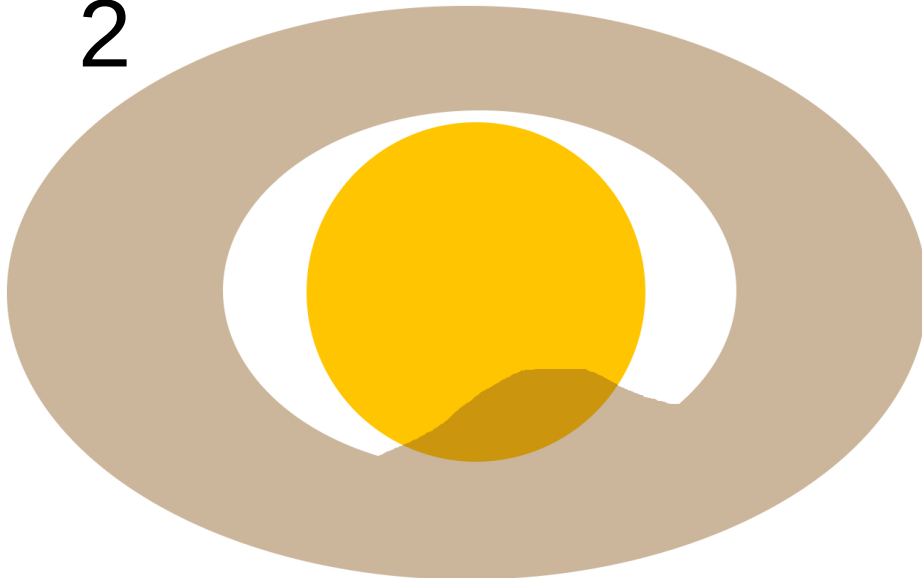
1



3



2



4

