# *Proplyds*

*Modern Research*

*Oktober 20, 2006*

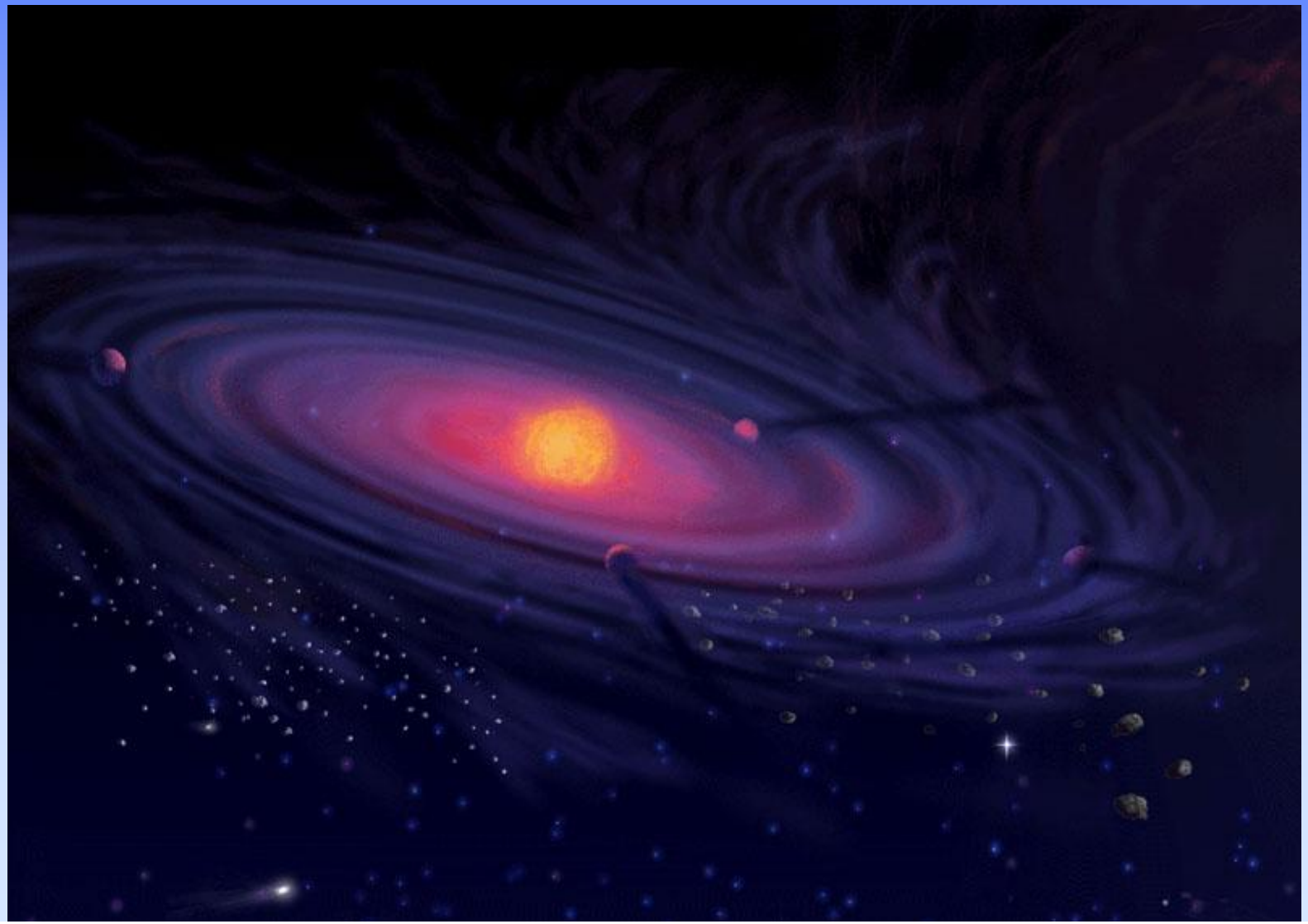
Yorick van Boheemen

# Program

- Introduction
- Observed proplyds
- Evolution
- Conclusion
- A pretty picture

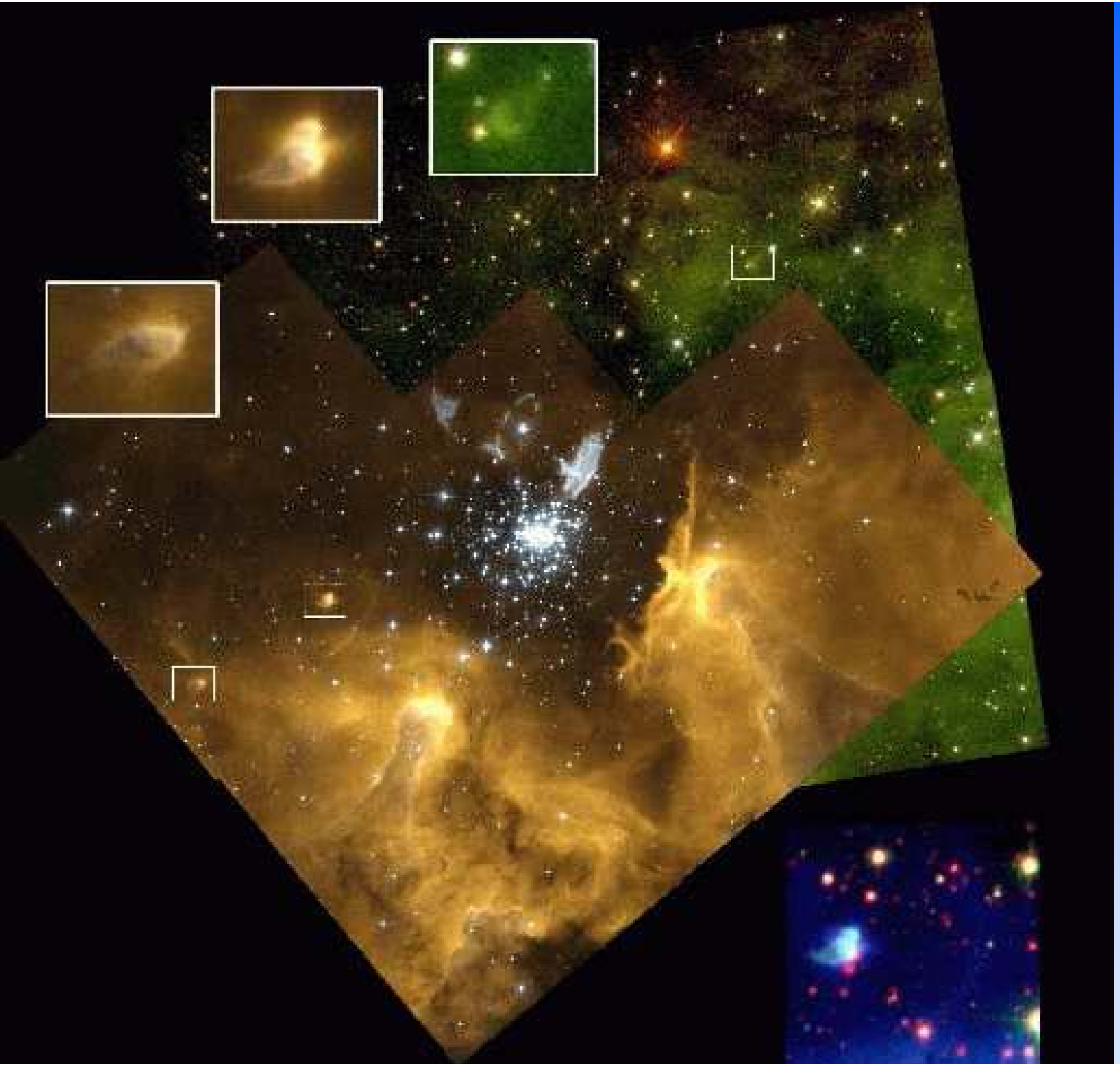
# Introduction: Proplyds

- Protoplanetary disks



# Orion Nebula (M42)

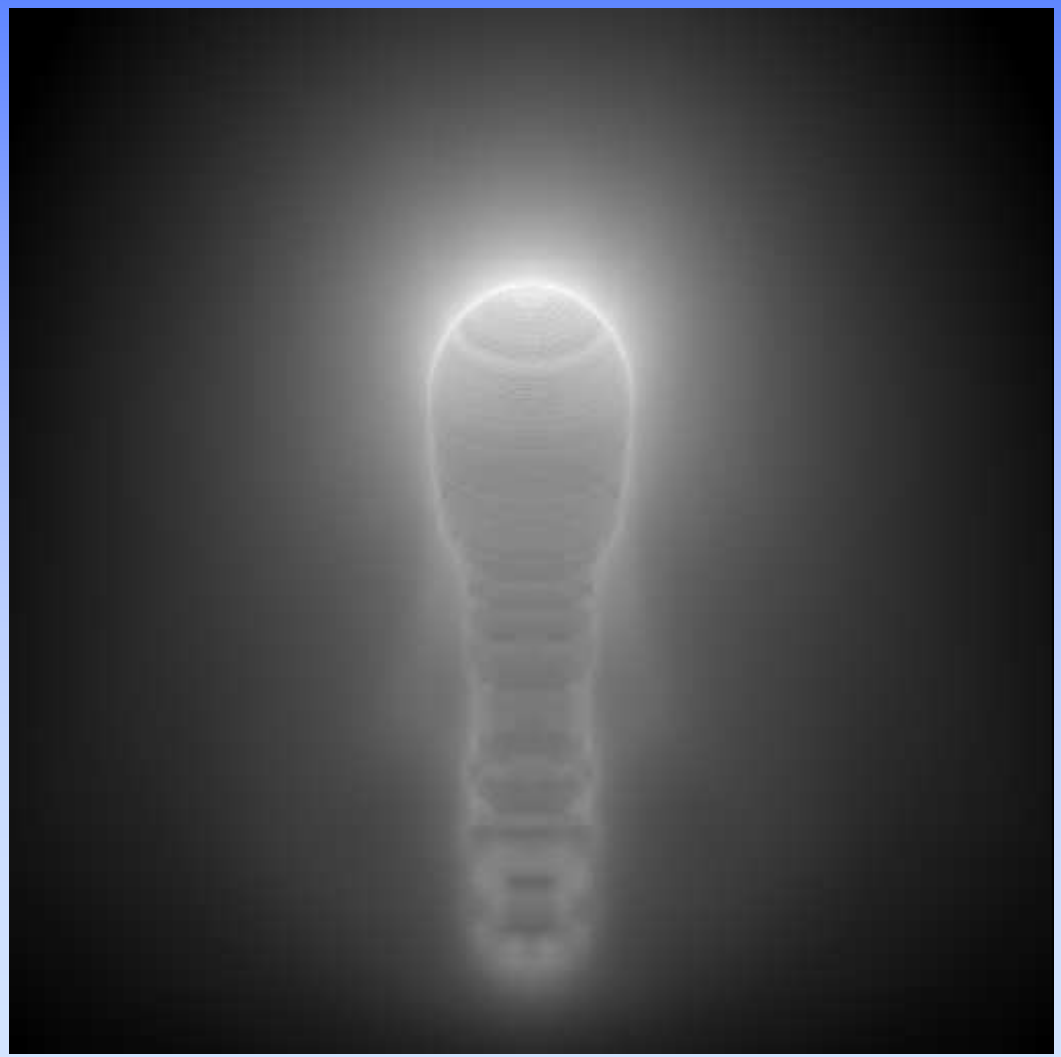
- Shows over 700 stars in evolution
- HST:  ~150 proplyds



NGC 3603

# Discovered proplyds in NGC 3603

- Sizes: 6.000 x 20.000 AU
- Lifetimes: 10^5 yr

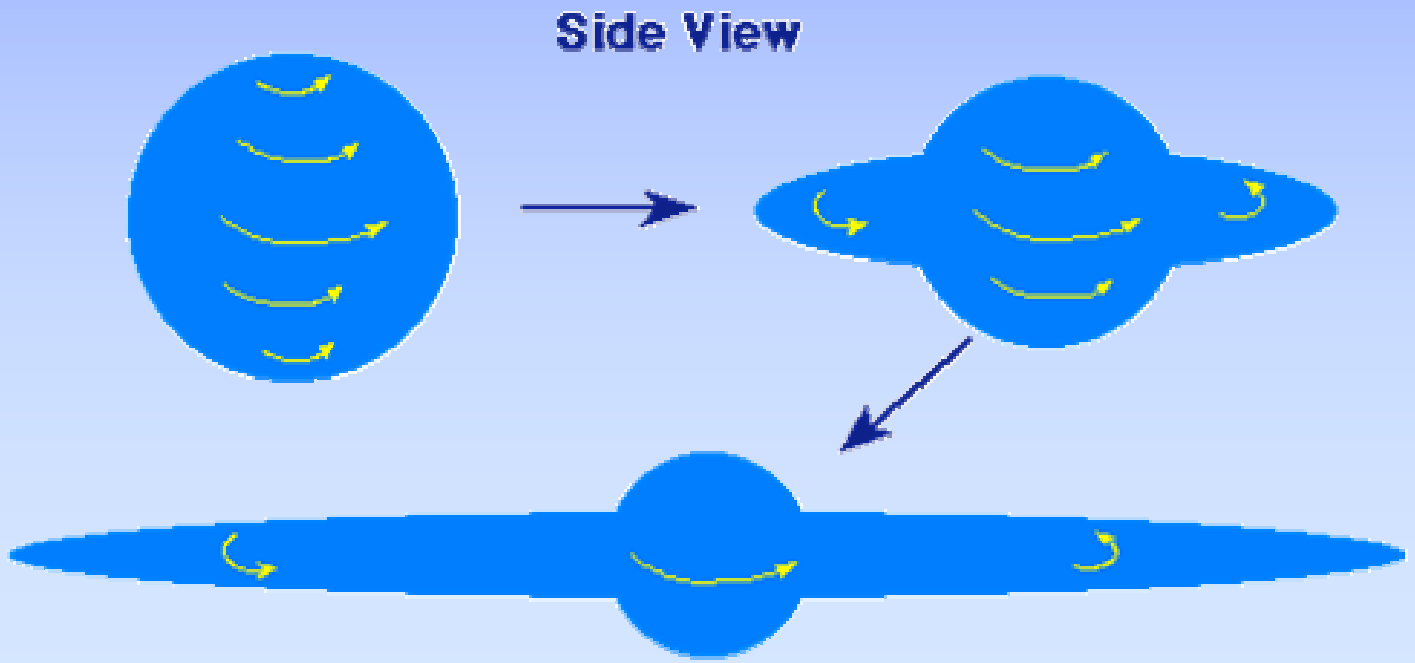


# Evolution: Fases

- Nebula
- Disk forming
- Conditions for planetforming

# Nebula

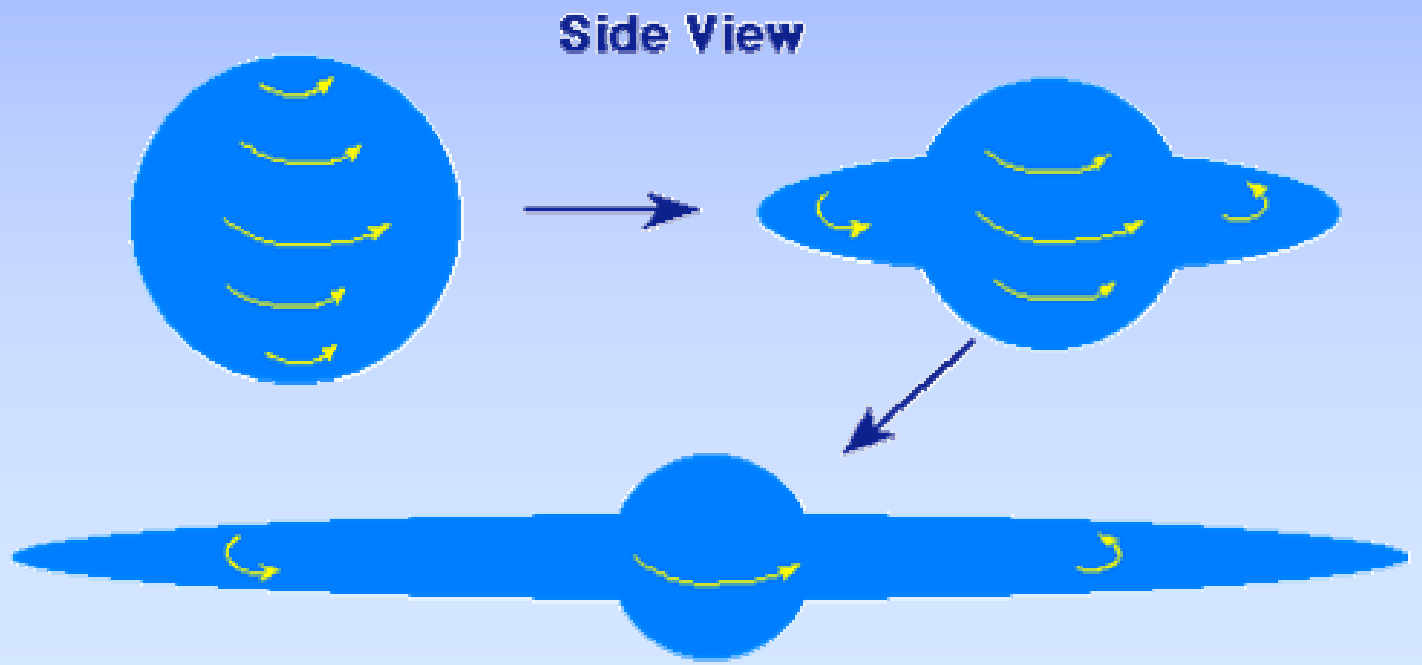
- Star forms core: Nebula around it
- Nebula collapses to a disk



# Nebula

- Star forms core: Nebula around it
- Nebula collapses to a disk

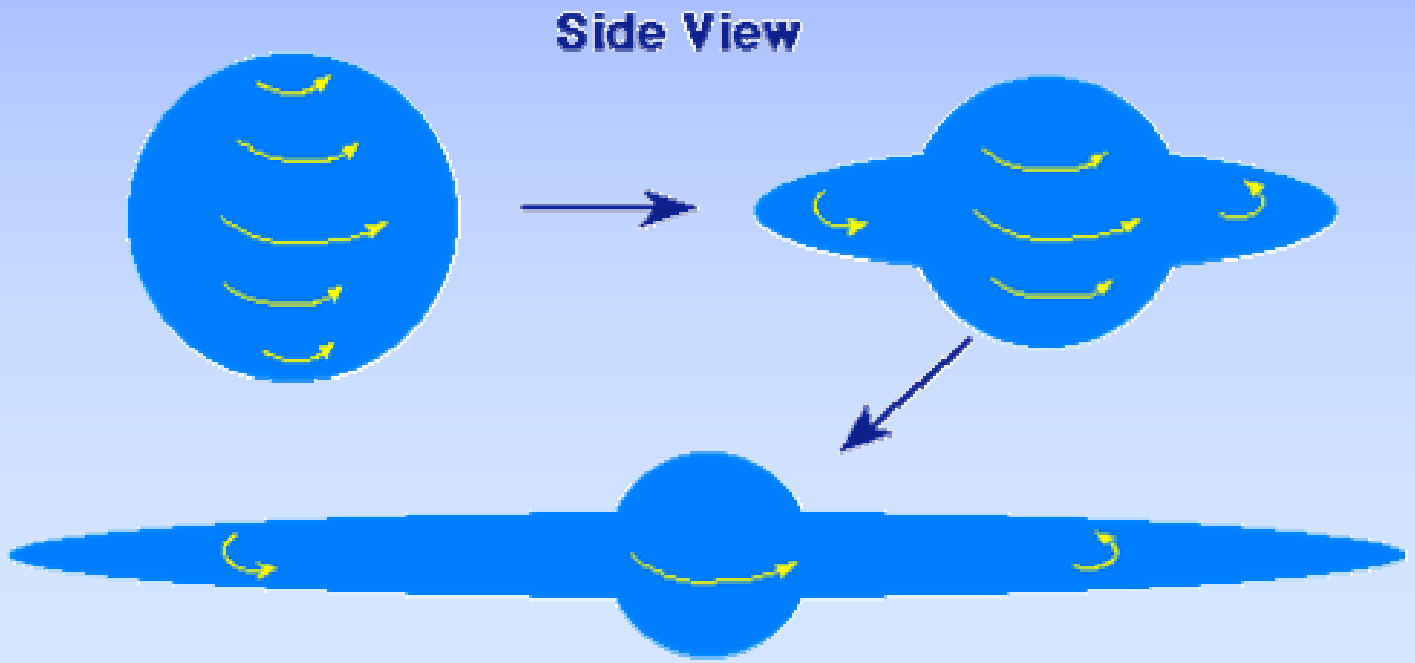
$$R_{CENTR} = \frac{\omega^2 R^4}{GM}$$



# Nebula

- Disk spreads outward because of conservation of angular momentum

$$R_{CENTR} = \frac{\omega^2 R^4}{GM}$$

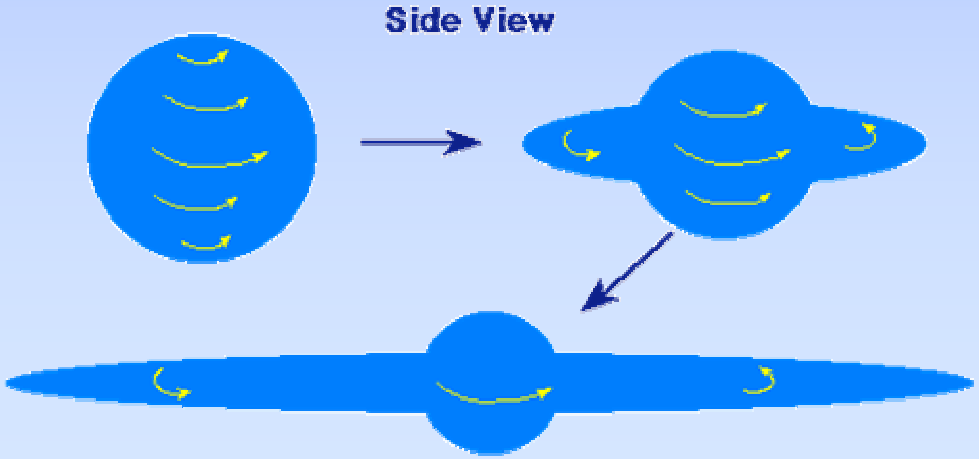


# Angular Momentum

- Because of turbulent viscosity

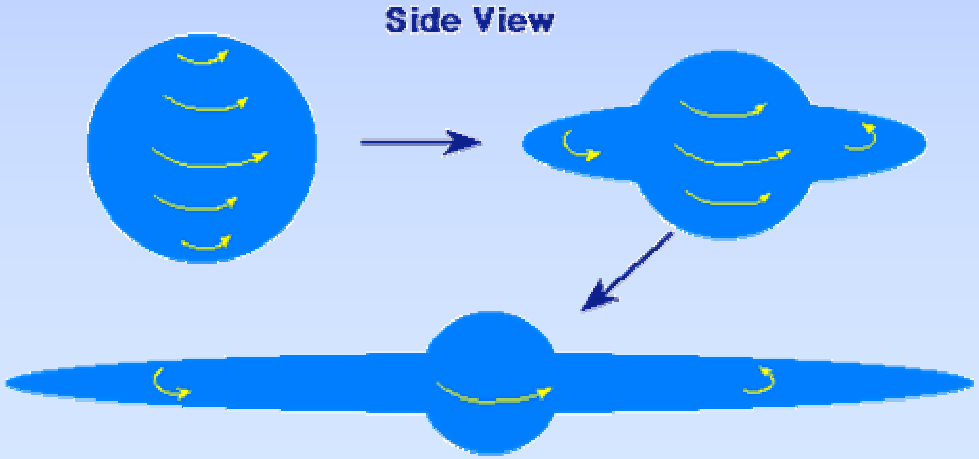
$$\nu = \alpha c_s H$$

- Magnetorotational instability
- Thermal convection
- Instabilities



# Angular Momentum

- Gravitational Instability
- Density waves



# When do planets form?

- Gravitational (in)stability
- Condition
- Two theories:
  - Coagulation
  - Dynamical instability

# Toomre Q

- Stability quantized:

$$Q = \frac{kc_s}{\pi G \Sigma}$$

- Q > 1 stable
- Q <= 1 unstable

# Physical conditions

- Model for global and local cases

$$t_{cool} = \frac{4}{9\gamma(\gamma-1)}\frac{1}{\alpha\omega} \qquad t = \frac{\beta}{\omega}$$

- Disk will fragment for

$$t_{cool} \leq \frac{3}{\omega}$$ » M = 0.1M_star

$$t_{cool} \leq \frac{5}{\omega}$$ » M = 0.25M_star

# Physical causes

- Coagulation
  - Large dust grains
    - Coagulate into larger grains
    - Settle into layer and make it gravitationally instable
- Dynamical instability
  - A part of the disk suddenly collapses
  - Rapid forming of Jupiter sized planets

# Conclusion

- Proplyds well researched
- Many are discovered

- Some physical processes poorly understood