

The Nebular Theory

“theory” implies
explanatory power

“nebula” means cloud.

The solar system formed from a large cloud of gas that collapsed under the force of its own gravity. Its rotation increasing as it collapsed, via the conservation of angular momentum.

This happened about 5 billion years ago, and probably only took a few tens of millions of years.

Nebula collapsing under its own gravity -- spins faster -- why is it flattened into a disk?

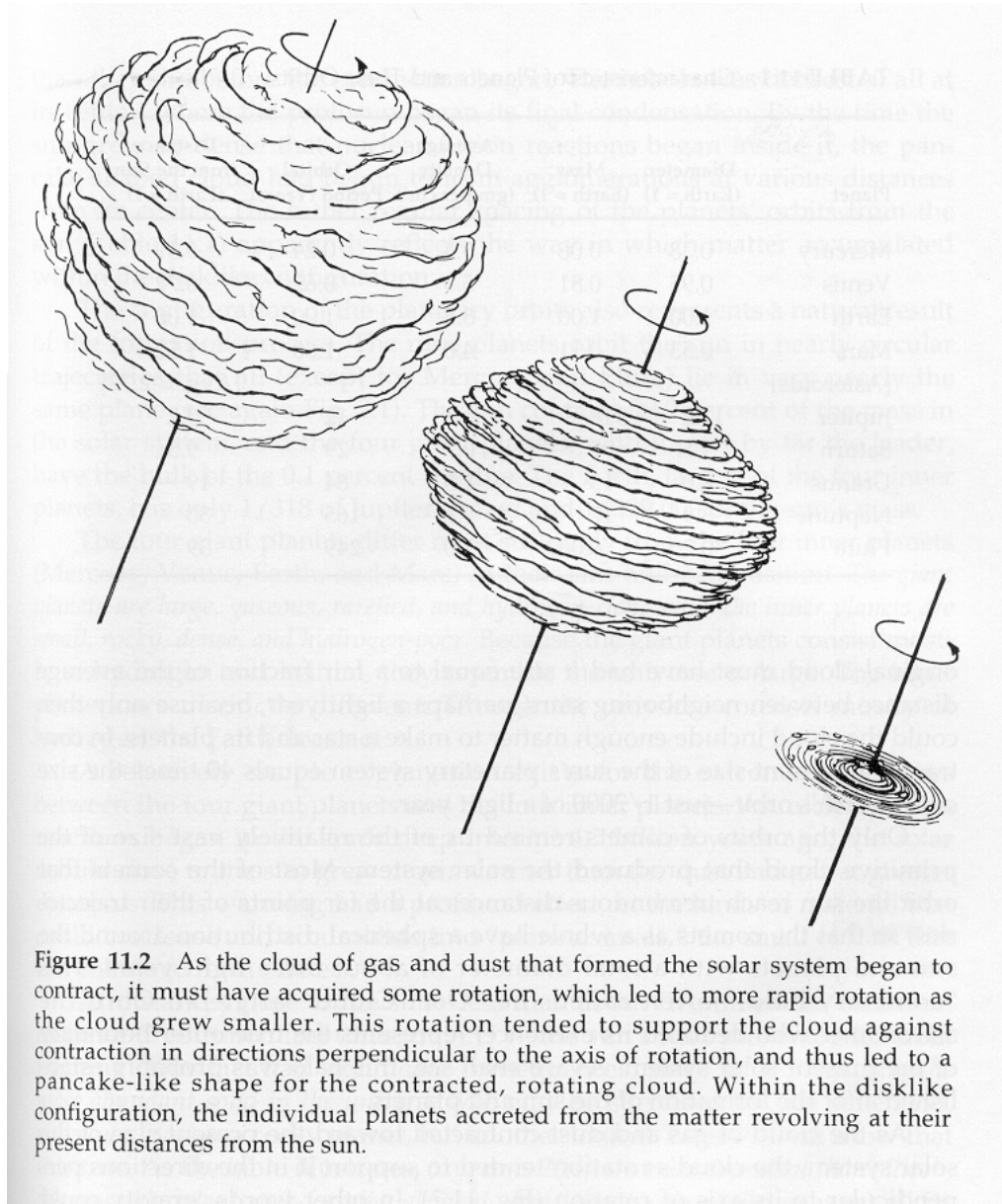
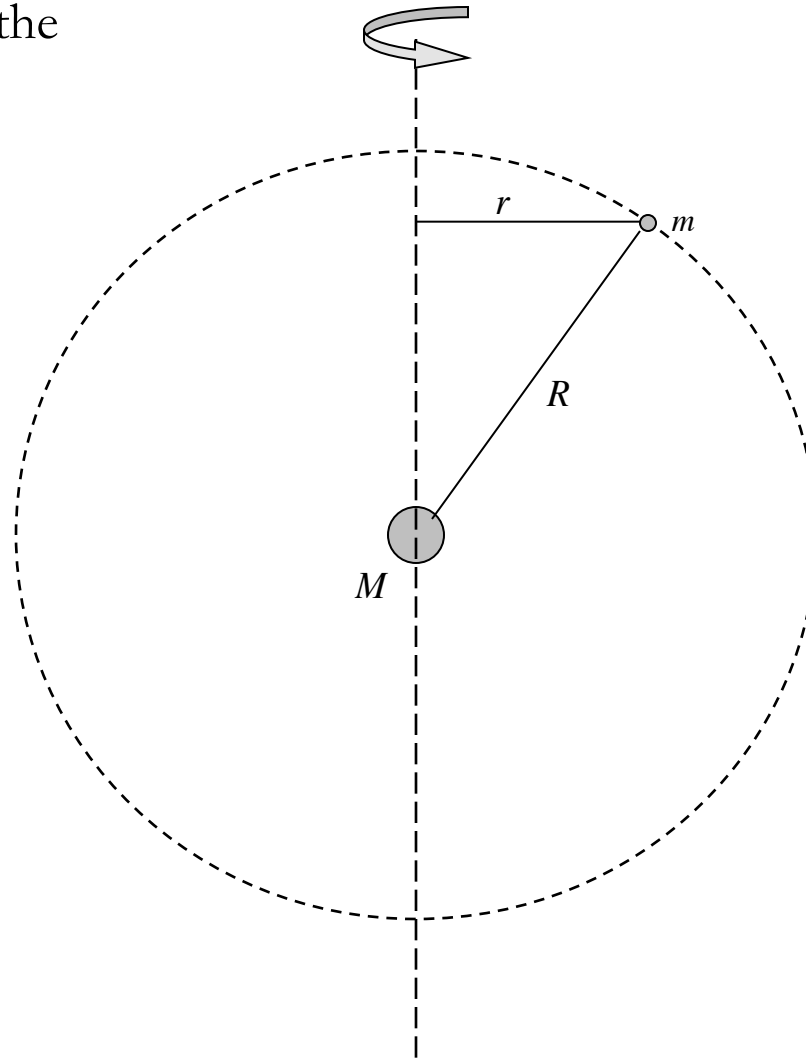


Figure 11.2 As the cloud of gas and dust that formed the solar system began to contract, it must have acquired some rotation, which led to more rapid rotation as the cloud grew smaller. This rotation tended to support the cloud against contraction in directions perpendicular to the axis of rotation, and thus led to a pancake-like shape for the contracted, rotating cloud. Within the disklike configuration, the individual planets accreted from the matter revolving at their present distances from the sun.

you can treat the whole
gas cloud as one test
particle, mass m , and “the
rest”, mass M

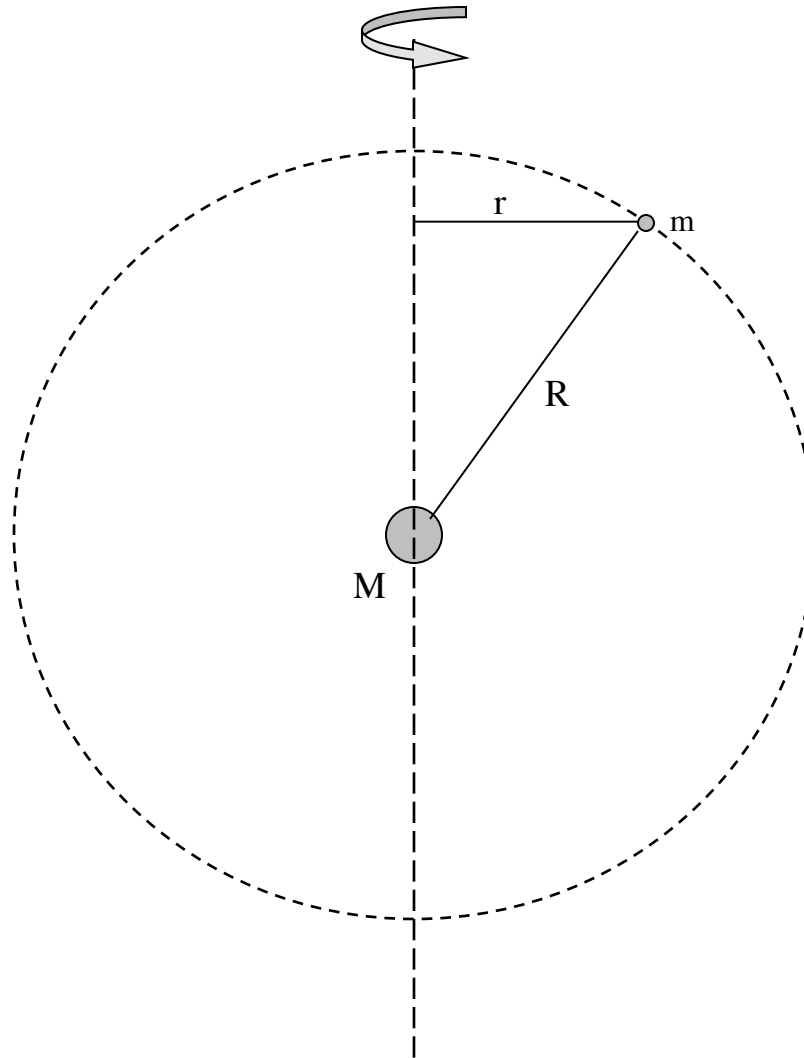


gravity is the prime
mover

$$F_{grav} = \frac{GMm}{R^2}$$

Particles have a property related to their rotation that is fundamental, like their energy

This rotational momentum, or angular momentum is conserved; it cannot be created or destroyed



velocity (into the screen)

$$\vec{L} = mvr$$

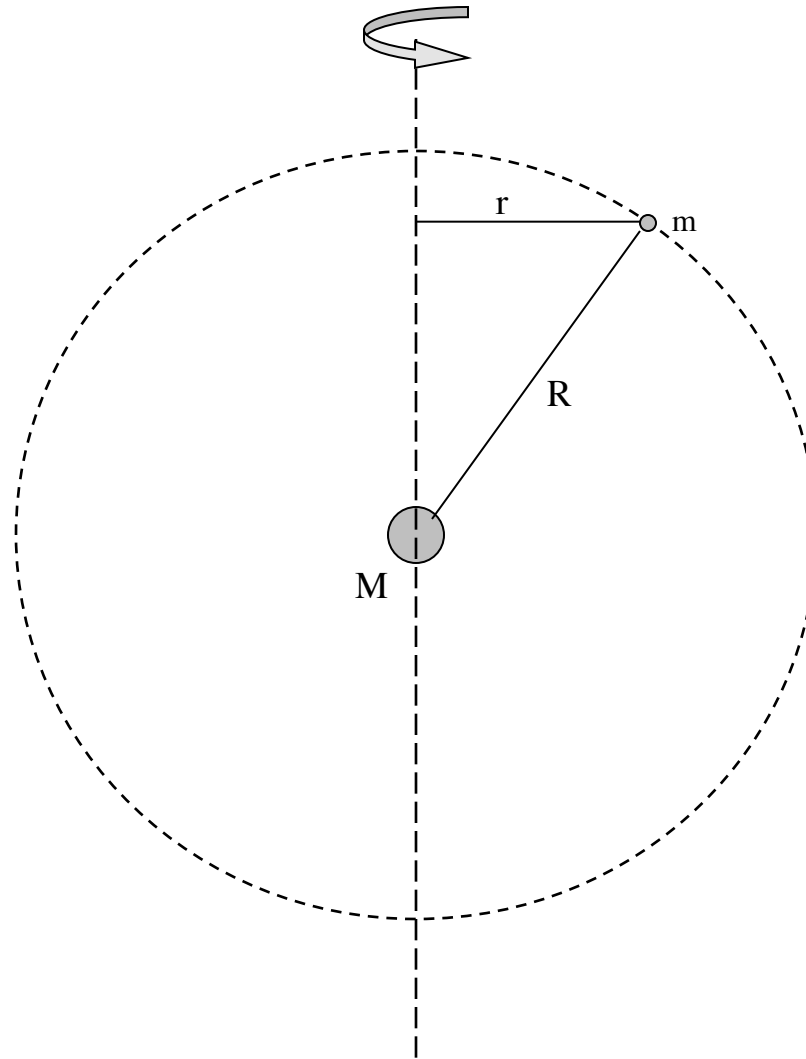
mass

distance from the *rotation axis*

as gravity from M pulls
particle m inward, not
just R but also r gets
smaller

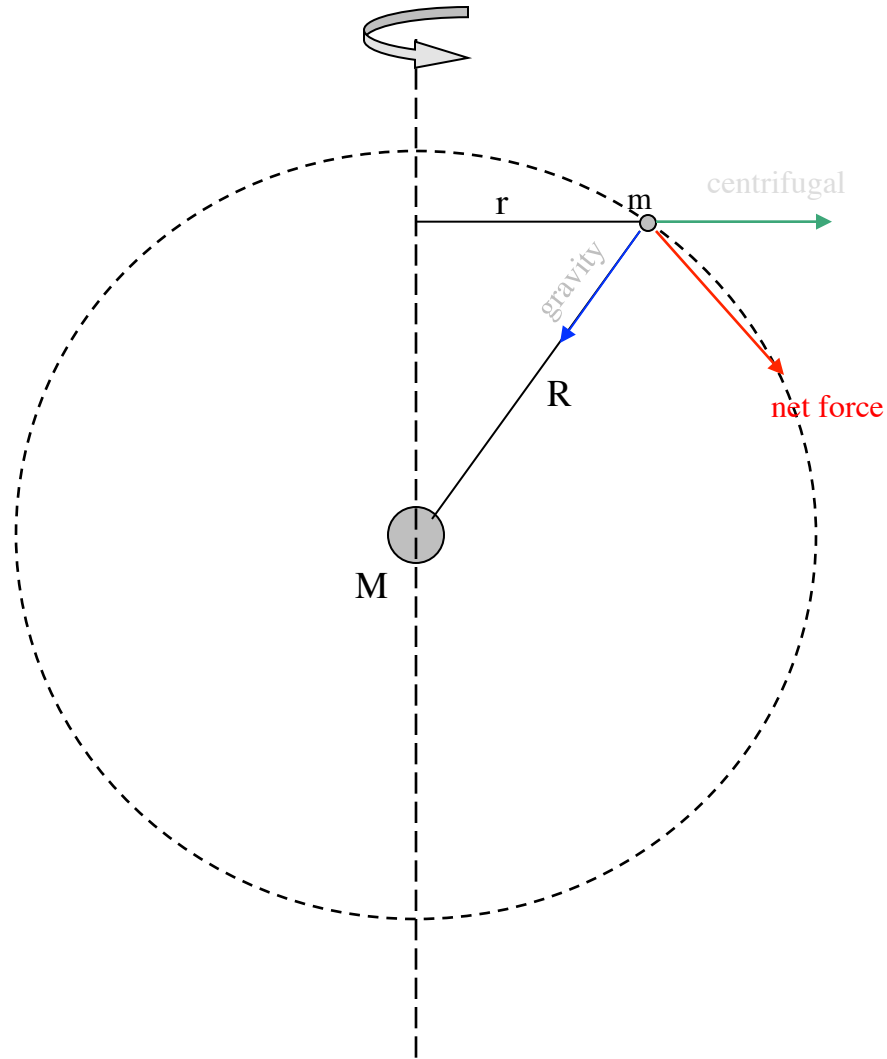
$$\vec{L} = mvr$$

if the angular
momentum is to stay
the same while r
decreases, then **v must
increase...**

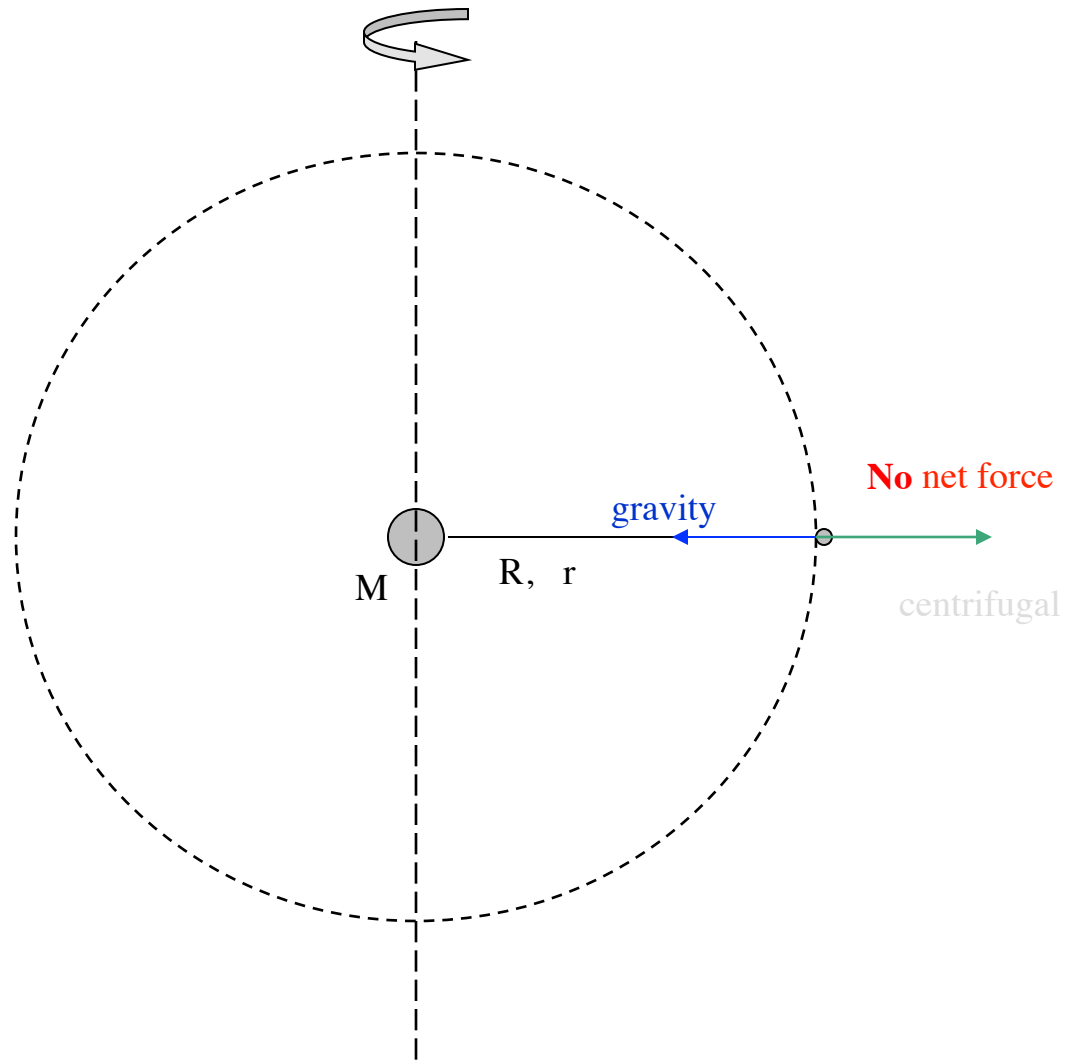


the particle must revolve faster about the axis

But a rapidly spinning object wants to fly apart due to the **centrifugal force** – the centrifugal force doesn't directly oppose gravity. The net force is toward the equator.



The only place the particle can be and have the net force go to zero – in other words, have gravity and the centrifugal force balance – is in the **equatorial plane**



Nebula collapsing under its own gravity -- spins faster – It is naturally flattened into a disk.

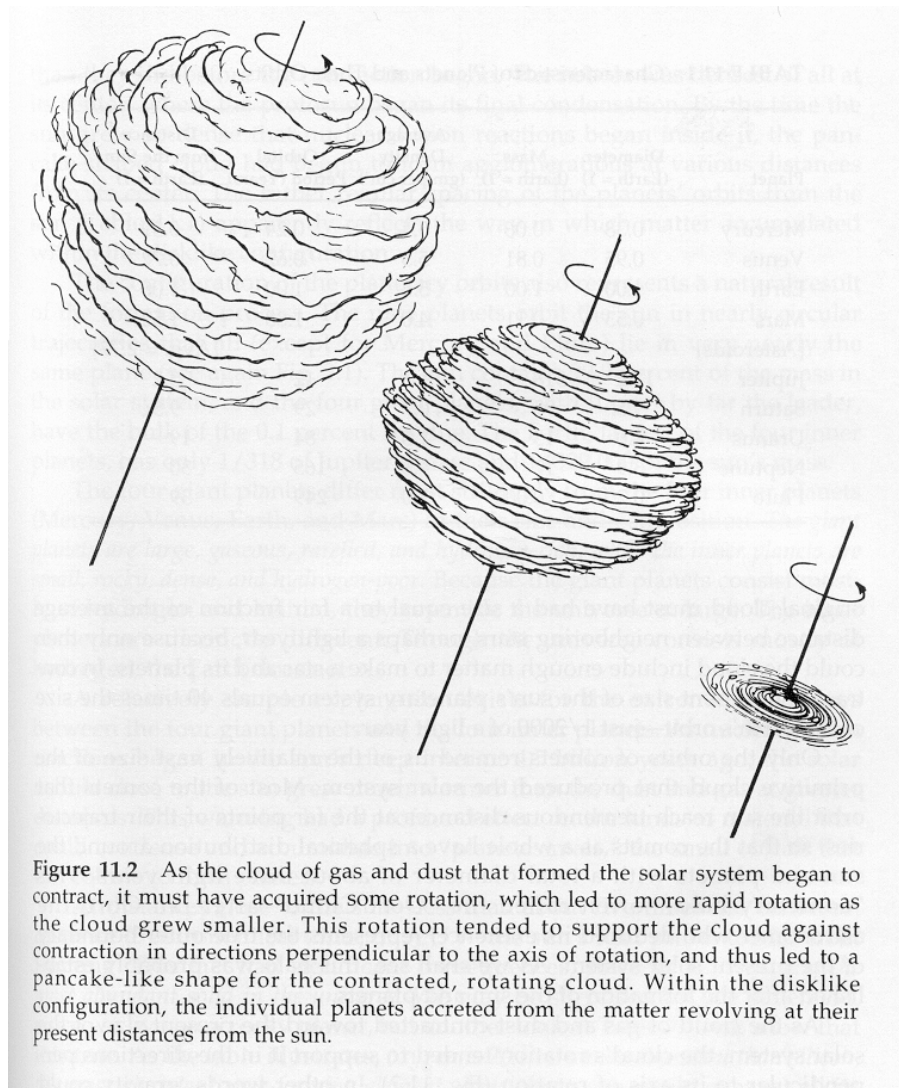


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