Disk Structure and the Formation of Young, Massive Stars

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Low-Mass vs High-Mass Star Formation

The formation of low-mass stars, 2x the mass of the sun (solar masses) or less, is well-known (see Figure 1). There are many low-mass stars visible in our local field of view and formation timescales are long!

Figure 1: How a low-mass star is formed, simplified
Large cloud of gas → gas collapses at dense point → star forms → gas keeps falling on star in the form of a spinning disk → star grows! → gas runs out, but disk remains → disk clumps together to form planets and solar system!

High-mass star (8 solar masses or greater) formation is more tricky to determine. Massive stars are much less populous. They form very quickly and radiate so much energy that they die quickly as well. They form so fast that they are still completely surrounded by gas and dust (called the envelope) when they are born. Thus they are practically invisible in most observable wavelengths. Radio observations would work, but waves are so big they produce unresolved (blurry) images of small objects….

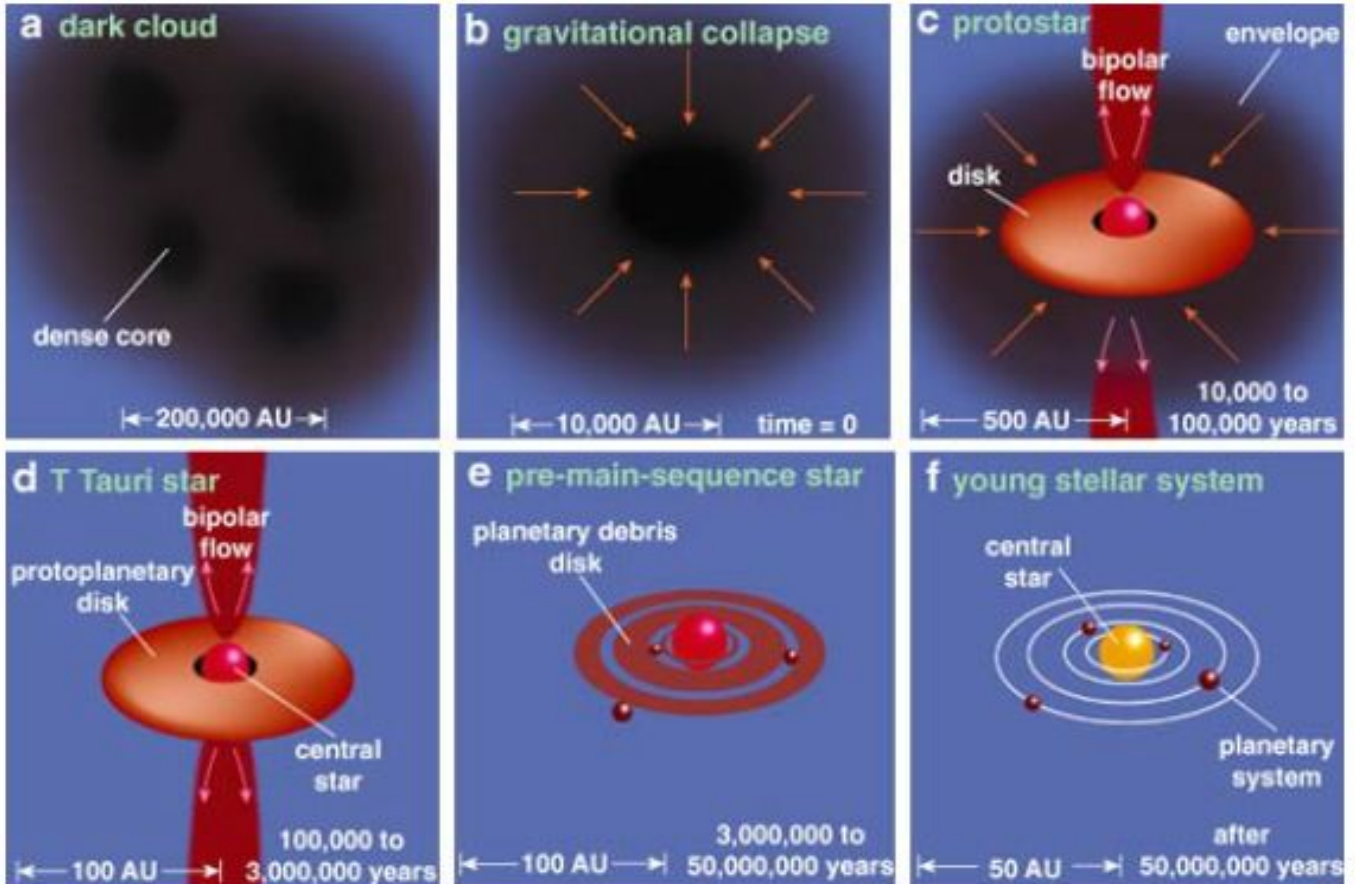

Figure 1: Evolutionary sequence of star formation (from Greene, 2001).

Amazing ALMA

ALMA to the rescue!

Radio interferometers such as the Atacama Large (sub)Millimeter Array (ALMA) use many antennae and can produced resolved images of small, distant radio sources. ALMA began observing in 2011 and many objects were now visible that could not be resolved before.

My Project:

1. Use ALMA archive data to look at a sample of disks surrounding young massive stars
2. Determine many properties: temperatures, densities, velocities, disk shapes, stability, and sizes
3. Determine if massive stars form with similar disks as their low-mass counterparts

Figure 2: Image of the Atacama Large (sub)Millimeter Array (ALMA) from eso.org

My Results and Future Outlook

My Project Results:

1. Nine objects produce six different disk types
   a. Two disks were deemed to be the stable, Keplerian disks (i.e. following Kepler's 3rd law of motion) that are seen around low-mass stars!
   b. Several showed aspects of the expected shape and rotation, but it is clear that there are many variations.
   c. Are the variations a result of different formation routes? Or maybe are the disks in different stages of evolution? Much more research is needed!

FIGURE 3: Emission images of four different high-mass sources, produced from ALMA archive data. Only the central point represents the star, while the surrounding regions are the disks. It can be seen that they come in many different morphologies and regions.

A "Bright" Future:

This field of study has really picked up since the development of interferometers such as ALMA. Many findings have occurred only within the last 5-10 years! Much more is yet to come, and hopefully this mystery of the Universe will be solved in the upcoming years.

FIGURE 3