GENESIS SEARCH FOR ORIGINS FACT SHEET

Protostars

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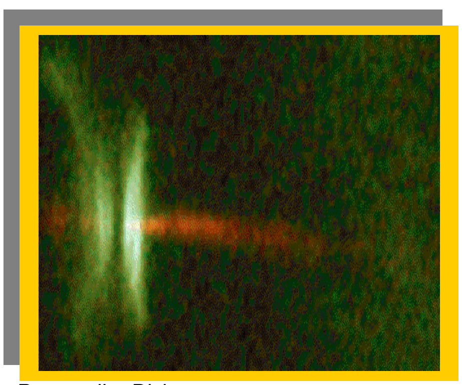
Stars begin their lives inside **molecular clouds**, or regions of gas in interstellar space that can range from a few to several hundred **parsecs** across. (One parsec is a distance equal to 3.26 light years.) Typical densities inside these clouds are about 10^6 particles per cubic centimeter (about a million times denser than usual interstellar space) and where temperatures are 10-20 °K. In these conditions the most common element in the universe, hydrogen, is in the form of hydrogen molecules, or H_2, and more complex molecules like CO (carbon monoxide) and H_2O (water) can exist. **Interstellar dust**, or microscopic clumps of hundreds to hundreds of thousands of atoms, are also common.

Two competing forces exist inside molecular clouds: gravity and pressure. Gravity caused by the mass of the particles pulls molecules and dust grains together, while pressure, caused by the motion of the particles, tends to push them apart. The crowded and cool conditions in molecular clouds allow the molecules and dust grains to gravitationally attract one another. Crowding particles together means there is more of a chance they can collide and stick together. Low temperatures mean the particles inside the cloud are travelling slower than they would be at higher temperatures. Particles that collide will tend to stick together instead of flying apart immediately.

Molecular clouds are not uniform. They are affected by gravity from stars and other clouds as they rotate around the galaxy; they are hit by stellar winds and supernovae explosions. These forces stir up molecular clouds, causing high density pockets of materials. In these dense regions, gravity is high enough and the temperatures (and corresponding pressures) are low enough that a molecular cloud begins to gravitationally contract. A molecular cloud can be on the verge of collapse for many millions of years, before an outside force that causes parts of the cloud to contract disturbs it.

Molecular clouds tend to fragment when they collapse, forming multiple **protostellar cores**. A single molecular cloud can have many young stars forming--anywhere from tens of stars in some small clouds to hundreds of thousands of stars in the case of **giant molecular clouds** like those found in the constellation of Orion.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Protostellar Disk

Molecular clouds are not stationary. The molecules rotate around the core of the cloud. Thus when cloud cores collapse into **protostars**, the gas does not fall in a straight line onto the young star; instead it tends to collect in a rotating flat disk that slowly spirals into the star. The star builds up most of its mass on a time scale of a few million years (which is short compared to the lifetime of most stars which is many billions of years).

As the protostar gains matter by gravitational attraction, some of this material interacts with the developing magnetic field. It shoots out from the center as outflows of gas perpendicular to the spinning disk. These outflows disrupt the molecular cloud, and are believed in part to help regulate star formation inside the cloud. If enough stars form initially, the winds and outflowing gas from developing protostars can churn up and break apart the cloud, preventing more stars from forming. These outflows can also disrupt the flow of gas into the rotating disk around the protostar. They provide a possible self-limiting mechanism by which protostars can only grow to be so big.

As a star gathers most of its gas, the gas and dust left over in the disk rotating around the core can begin to form planets. In fact, we have observed such proto-planetary disks surrounding over 100 young stars in Orion.