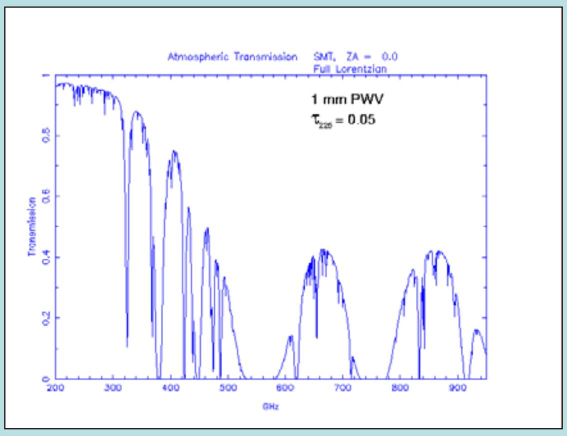
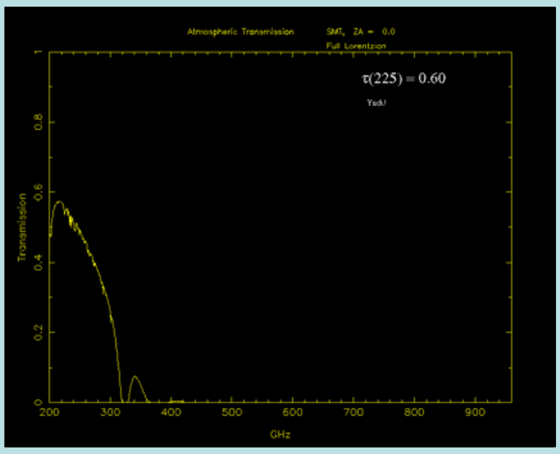
Why is this so difficult?

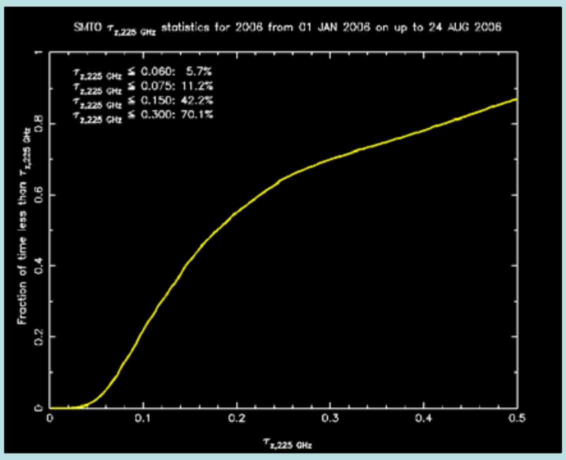
Submillimeter astronomy is a few decades old, it is the last wholly unexplored wavelength frontier.

The atmosphere is opaque at submillimeter wavelengths:

Absorption of submillimeter light by water vapor (and to a lesser extent, O_2 and O_3 molecules) in the atmosphere leads to a perpetually "cloudy" submillimeter sky. Minimizing this absorption by building observatories at the highest and driest sites, such as Mt. Graham (Arizona), Mauna Kea (Hawaii), the Atacama desert in Chile, and the South Pole allows us to observe "windows" of partial transparency at submillimeter frequencies during periods of good weather. Below is a plot of the transmission of the atmosphere (0=totally opaque, 1.0=totally transparent) for excellent submillimeter conditions at a very dry site. The dryness of a site is measured in millimeters of Perceptible Water Vapor (PWV). 1 mm of perceptible water vapor means that if you could condense all of the water vapor above you into an ocean, it'd be only 1 mm deep! This is typically 10-20 times drier than a summer day in the American Midwest, for example. Such weather is realized 10-30% of the time during winter months at sites like Mt. Graham. (Source from SORAL website)







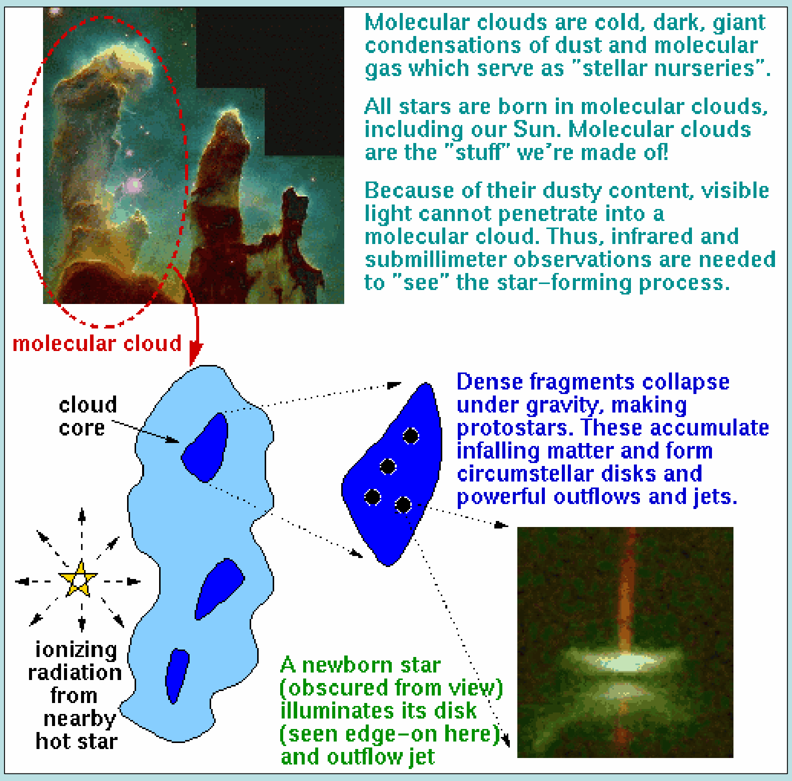
Atmospheric transmission is measured by a taumeter, a receiver device that points straight up at sky to measure tau, or optical depth, which is a measure of how much light is absorbed over a certain distance, tuned for 225GHz. The data recorded by the taumeter goes to a computer program that calculates the percent of submillimeter signal coming through the atmosphere into a value of tau. The middle plot shows when the value of tau is bad, that is the atmospheric conditions are opaque to certain frequencies in the submillimeter. The plot on the left shows our average tau for half of the 2006 year.

An Example of Submillimeter Science

Molecular Clouds and Star Formation

Among the most pressing of these questions is how stars are formed. Stars are born from the material between other stars. In some regions of space, the density of gas and dust is much higher than the norm, and atoms are sufficiently shielded from destructive high-energy photons to interact with other atoms to form simple molecules. In the highest density central regions of such *molecular clouds*, material is so well shielded that delicate, complex molecules can form. It is from these molecular cloud cores that new stars (including our own Sun) and planets are born. These are the places of creation; understanding them may help astronomers understand the conditions from which the Earth, and *life* has evolved.

Because the star forming process occurs behind so much intervening dusty material, visible-light telescopes cannot see what is happening. By moving to the infrared, sub-millimeter and millimeter wavelength regions, where the effects of this obscuration are nearly negligible, astronomers can begin to directly probe regions where stars are actively being born. Understanding the star forming process has many astronomical consequences. Knowing what physical conditions are needed to form molecular cloud complexes is important in understanding the star-forming evolution of galaxies, both in the current age and, perhaps most importantly, when galaxies were first forming. The understanding of how a single star forms from a molecular cloud, then, has even cosmological implications.



The current working model for star formation may be represented by four conceptually distinct stages of development that are the culmination of the last several decades of theoretical and observational efforts. Within molecular clouds, there are cores of material which are denser than the surrounding cloud. Dense molecular condensations form within these molecular cores as the loss of magnetic support through ambipolar diffusion allows gas and dust to contract gravitationally. Eventually these condensations become sufficiently centrally concentrated to undergo dynamical collapse; the inner regions form an evolving protostar and surrounding disk while the outer regions form an extended in falling envelope of material (the arrows). At some point, a bi-polar wind breaks out along the rotational poles of the system, while material continues flowing inward along the equatorial regions. The visual extinction toward the central protostar is typically tens to thousands of magnitudes at this point, effectively obscuring it from scrutiny at optical wavelengths. Over time, the angle occupied by the wind broadens, removing surrounding material and halting the inward flow of material. At this point, the system becomes detectable at near-infrared and even optical wavelengths as a star plus a disk, commonly recognized as a T Tauri system.

Molecular clouds themselves harbor a number of fundamental mysteries which submillimeter data and analysis is expected to shed light upon. Our understanding of the evolution, and (kinematics/chemical) structure of a giant molecular cloud is incomplete. Submillimeter measurements will uncover the warmer, denser components of a molecular cloud as well as the UV-illuminated "surfaces" of clouds where the delicate interplay and feedback between massive stars and molecular clouds can be explored. This will be crucial to improving our understanding of how molecular clouds form and are disrupted by their environments (i.e. the stars they give rise to). (Source info from http://soral.as.arizona.edu/submm-science.html)