Submillimeter Observations of Dust and Lines in Distant Galaxies

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The Universe today displays complexity on all scales. Understanding how this complexity arose from initial simplicity is a major challenge for astronomers in the next decade. Although the broad outline is clear–primordial density fluctuations, now observed as anisotropy in the the cosmic background radiation, eventually collapse into familiar structures, i. e., galaxies–the details of this process remain obscure. It is also clear the initial generation of star formation, with the attendant nucleosynthesis of metals, must have had a profound effect on subsequent events.

The most distant galaxies are seen at redshifts corresponding, for standard cosmologies, to a few percent of the age of the Universe. The exisitence of these objects alone constrains the duration of the epoch of initial star formation. Moreover, these objects are frequently ultraluminous, either because of a (merger induced) burst of star formation or because of an active nucleus. Both possibilities imply significant evolution has already occured.

Submillimeter and millimeter wavelength observations will be crucial for discovering the details of galaxy formation and evolution in the early Universe. Galaxies consist, by and large, of stars. Star formation in the local Universe is intimately related to dust and molecular gas in dense interstellar clouds. There is every expectation this is also true in the early Universe.

The bulk of the energy released by newly formed (O) stars ends up reradiated by dust at far infrared and submillimeter wavelengths. Submillimeter continuum observations, which measure the dust content and temperature, thus probe the star formation rate in galaxies. By directly observing dust, submillimeter wavelength surveys avoid any bias against high extinction objects that may limit other (optical) techniques.

Molecular rotational and atomic fine structure lines, e. g., CO, CI, and CII, are significant cooling paths for interstellar clouds. They provide important diagnostics of physical conditions in the the interstellar medium of early galaxies.

Submillimeter observations with present telescopes (JCMT, CSO, etc.) have begun the study of gas and dust in distant galaxies. Spectroscopic observations have identified molecular gas in some of the most distant objects know. Continuum surveys have identified a population of distant sources, many previously unknown. Currently known examples of these galaxies are instrisically ultralumnious and further amplified by gravitational lenses. Future telescopes (MMA/LSA) promise more, perhaps reaching down to the parent populations.