The Background-Limited Infrared Submillimeter Spectrograph (BLISS) for SPICA

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Abstract

With the advent of new large-format far-IR / submm arrays, imaging surveys are revealing hundreds of thousands of dusty galaxies from the first half of the Universe's history when the bulk of star formation and black hole growth likely occurred. The key to studying these objects is spectroscopy in the rest-frame mid- to far-IR. Fine-structure and molecular transitions in this waveband are largely unaffected by dust extinction and the suite of lines provides redshifts and reveals the properties of the embedded stellar and black-hole energy sources. We have developed BLISS to provide a breakthrough capability for far-IR survey spectroscopy at wavelengths between JWST and ALMA. SPICA's large cold aperture allows mid-IR to submm observations which are limited only by the natural backgrounds, and BLISS-SPICA is 6 orders of magnitude faster than the spectrometers on Herschel and SOFIA in obtaining full-band spectra. The sensitivity allows study of galaxies at all epochs back to the first billion years after the Big Bang (z∼6), making BLISS-SPICA the ideal platform for spectroscopic follow-up for the wide variety of sources now being discovered with far-IR and submm imaging.

BLISS provides instantaneous coverage from 38–433 μm using ten grating spectrometer modules coupling 2 sky positions in 5 wavelength bands. The instrument is cooled to 50 mK for optimal sensitivity with an on-board magnetic refrigerator. The detector package is 4224 silicon-nitride micro-mesh leg-islolated bolometers with superconducting transition-edge-sensed (TES) thermistors, read out with a cryogenic time-domain multiplexer. All technical elements of BLISS have heritage in mature scientific instruments, and many have flown. We are now engaged in a design study to optimize performance while accommodating SPICA's constraints, including the stringent cryogenic mass budget. We present our progress in all key aspects: 1) science requirements and the opto-mechanical instrument architecture, 2) detector and readout approach, and 3) sub-K cooling approach, including mitigation of magnetic interference.

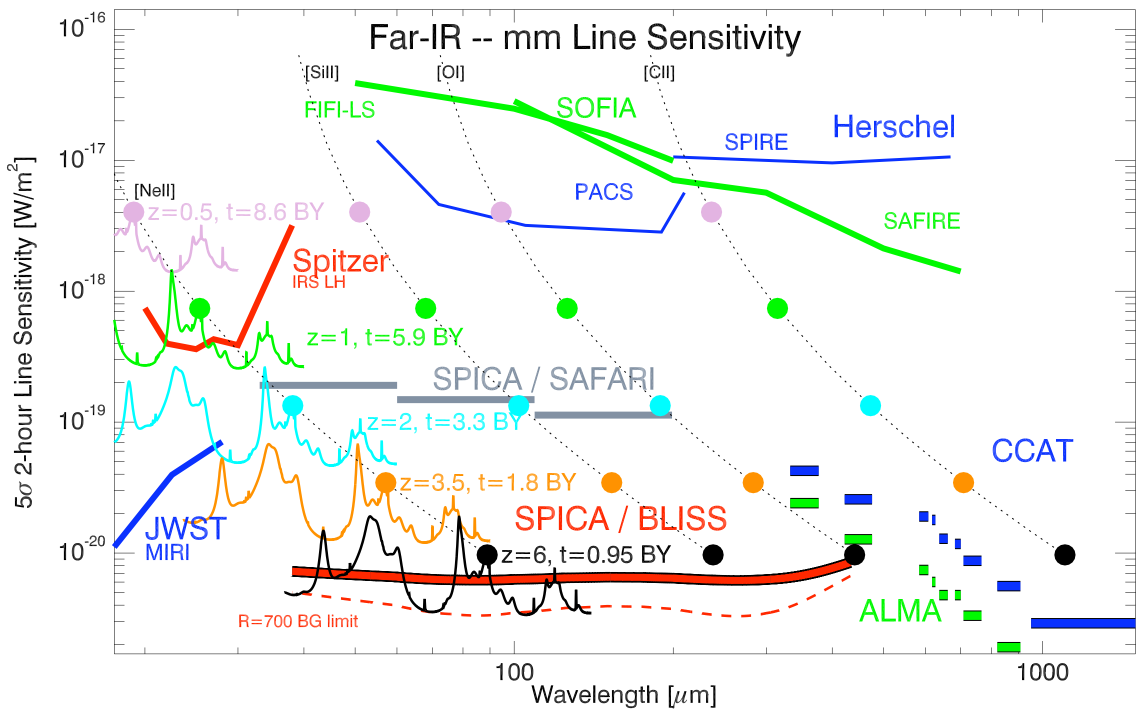

Figure 1. BLISS-SPICA is 100–1000 times more sensitive than present-day far-IR facilities for spectroscopy. Observing speed scales as the inverse square of the plotted sensitivity. The dashed curved at bottom is the photon background limit, the heavy curve above it is the BLISS design sensitivity. Fine-structure line intensities are shown as dots colored to denote redshift (and age of the Universe), assuming $L_{\rm line}$=$10^9 L_\odot$. BLISS also has excellent sensitivity to broad features such as the PAH bands—a redshifted L=$10^{12} L_\odot$ galaxy template is plotted, with flux scaled to show the BLISS sensitivity when binned to R=60.