CASIMIR: the Caltech Airborne Submillimeter Interstellar Medium Investigations Receiver

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***Abstract*— CASIMIR, the Caltech Airborne Submillimeter Interstellar Medium Investigations Receiver, is a far infrared and submillimeter heterodyne spectrometer under development for the Stratospheric Observatory For Infrared Astronomy, SOFIA. CASIMIR will carry out observations in the frequency range from 500 GHz up to 1.4 THz, with extremely high spectral resolution, of order 10^6. Capitalizing on recent advances in SIS mixer development, CASIMIR will cover this region of the spectrum with unprecedented sensitivity. CASIMIR is extremely well suited to observe the warm, ~100 K, interstellar medium, particularly water lines, in both Galactic and extragalactic sources.**

I. Introduction

FAR infrared and submillimeter wavelengths are extremely important for investigations of the warm (T~100 K), interstellar medium, both in the Galactic sources and in other galaxies. The warm ISM is heated by shock waves or UV radiation, phenomena often associated with star formation or other high energy events, e. g., supernovae or active galactic nuclei. The excited material then re-emits both continuum from the dust and spectral lines from the gases. Because of tropospheric water vapor, however, much of the far infrared cannot be observed from ground based telescopes. From an airborne telescope in the stratosphere, on the other hand, observations in the far infrared and submillimeter can study the fundamental rotational transitions of many astronomically significant hydride molecules and other species.

II. Instrument Characteristics

CASIMIR, the Caltech Airborne Submillimeter Interstellar Medium Investigations Receiver, is a very high resolution, heterodyne spectrometer for far infrared and submillimeter wavelengths. It is under development as a first generation, Principal Investigator class instrument for the Stratospheric Observatory For Infrared Astronomy (SOFIA). Initial observations with CASIMIR on SOFIA are expected to begin in 2011 and the instrument should be available to guest investigators soon thereafter.

Five bands will cover the frequency range of 500 GHz up to 1.4 THz in. The instrument has two cryostats that each hold two single polarization mixers. Hence any four bands can be observed on a given flight and any one of those four bands can be software selected at anytime during the flight, without mechanical adjustment or physical access to the instrument.

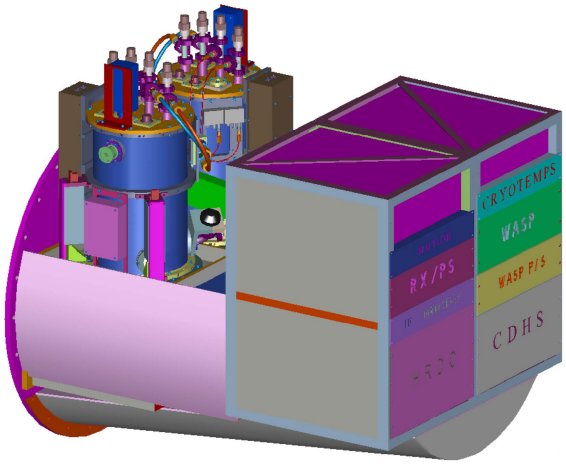
All bands use advanced Nb/AlN/NbTiN Superconducting-Insulator-Superconducting (SIS) mixers fabricated at JPL. Ongoing development aims to significantly improve the noise temperatures of these devices compared with present receivers at these frequencies. This development should achieve double side band noise temperatures of around $3hv/k$ for devices operating below 1 THz and $6hv/k$ above 1 THz. Eventually, the useful frequency range of SIS mixers may extended up to 1.6 THz. The planar mixers are quasi-optically coupled, with twin slot antennae bonded to antireflection coated hyperhemispherel lenses. Relay mirrors direct the beam through a cryostat window to the telescope.

The tunerless solid state local oscillators (LOs) for all bands are driven from a single, commercial 26–40 GHz microwave synthesizer. They are mounted to the sides of the cryostat and the signals are injected through a side window and coupled to the mixers with beam splitters.

The 4 GHz wide intermediate frequency (IF) band is centered at 6 GHz. This wide frequency range will enable observation of broad extragalactic lines. An FFT spectrometer processes the IF signal and provides a channel resolution as fine as 250 kHz.

The two cryostats are mounted on top of an optics box that contains the relay optics coupling the instrument to the telescope beam, an internal calibration system, and an optical boresight telescope. Bias electronics and warm IF components are mounted on the cryostats. Electronics racks hold the FFT spectrometer, ancillary electronics, computers, and power supplies.

CASIMIR embodies a versatile and modular design, able to incorporate future advances in mixer, LO, and spectrometer technology.



CASIMIR instrument configuration.

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