Superconducting Integrated Submm Spectrometer for Laboratory Applications

Specification:

- Input frequency range: 200 – 700 GHz (covered by four exchangeable sensor modules each one covering range of about 100-150 GHz);
- Output frequency (IF) range: 1–2 GHz
- Receiver noise temperature: below 500 K (direct detection sensitivity better than $10^{-13}$ W);
- Spectral resolution: better than 1 MHz;
- Cryogenic module is designed as a 50 mm diameter insert that fits into a transport liquid helium vessel or a special refrigerator;
- Dedicated PC-based acquisition system is available for computer control of the spectrometer operation (optional).
- Estimated price of the spectrometer set including cryogenic insert, one sensor module, PLL electronics and bias supply is about $50,000
- Estimated price of a sensor module is $5,000

The spectrometer can in situ detect radiation from a coolable rf source (4–100 K) within frequency range of 200 - 700 GHz placed in vacuum at the distance of about 5 cm from the Superconducting Integrated Receivers (SIR).

The SIR chip is a superconducting integrated circuit comprising a quantum-noise-limited SIS mixer and a tunable Josephson local oscillator (LO). We have developed a series of lightweight and compact ultra-sensitive submm SIRs [1] with low power consumption (typically less than 50 µW), which are beneficial for imaging applications in radio-astronomical research and remote monitoring of the Earth atmosphere. SIRs are very attractive for laboratory studies as well; the integrated receiver has been developed and tested demonstrating noise temperature below 300 K at 520 GHz.

It is known that frequency stabilization of a LO is necessary for accurate detection of narrow-band submm wave emission. To realize stability better than 1 ppm of the center frequency, the LO of the SIR has to be phase-locked to an external reference source.


Such phase locking of a superconducting submm FFO with continuous frequency tuning is demonstrated for the first time for ANY type of Josephson oscillator) over a wide frequency range (up to 700GHz) with a resolution given by the phase noise of the reference oscillator. These results are the basis for the development of 550-650 GHz integrated receiver for the Terahertz Limb Sounder (TELIS) intended for atmosphere study and scheduled to fly on a balloon in 2005. We propose to use the achievements of the TELIS project to develop a sensitive laboratory-purpose integrated spectrometer for the detection and spectral study of radiation from a variety of superconducting oscillators. We hope that this development will be a beneficial step towards wide use of superconducting receivers in many research laboratories and universities.

To develop such spectrometer into a commercial product a two-year research project with total funding of about $ 150 000 is required.

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