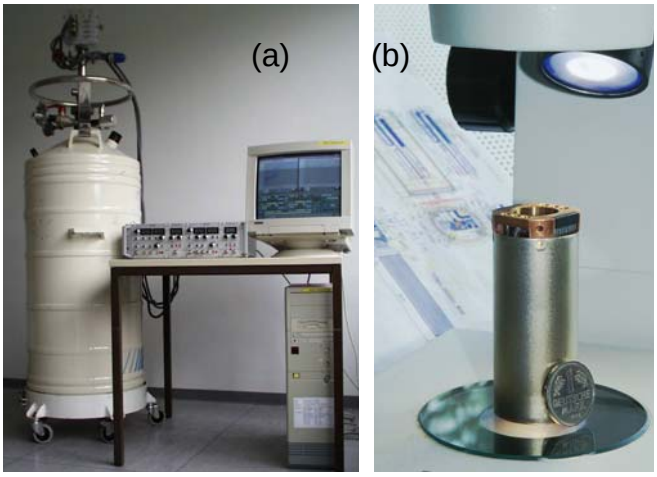
Superconducting Integrated Submm Spectrometer for Laboratory Applications

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).



Prototype of the Integrated spectrometer (a). Photographs of exchangeable receiving head (length 76 mm and diameter 32 mm); the input aperture and connectors are seen on the top (b). This receiver has been successfully used for detection of the radiation from cryogenic submillimeter source. The receiver does not need a separate local oscillator as a Gunn oscillator or a BWO, since an ultra-compact Superconducting Integrated Receivers (SIR) [1] chip contains its own internal electronically–controlled local oscillator.

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.

[1] V.P. Koshelets, S.V. Shitov, “Integrated Superconducting Receivers”, Superconductor Science and Technology, **vol 13**, p. R53, (2000)

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