Development of THz Superconducting HEB Receiver Systems for Balloons, Aircraft, SmallSats and Future Large Missions

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We describe the on-going development of several classes of receiver systems based on superconducting hot-electron bolometer mixers. We target four general platforms, listed in time order, from immediate to long-term: high-altitude balloons (ASTHROS), aircraft (e.g., SOFIA), SmallSat and a future flagship mission (OST). Each platform has its own advantages and disadvantages in terms of resources and capability, and these have guided our multi-pronged effort to develop systems that can be suited for these opportunities.

For the near term, we are developing a receiver system for the ASTHROS mission. A low-power cooler capable of reaching 4 K operating temperature that consumes only 200 W allows us to use NbN-based waveguide mixers of modest array size (~8). These mixers are pumped by an array of frequency-multiplier chains image to the mixer array. The small number of pixels is compensated by the long duration of the flight, which is not limited by boil-off of helium as in other cryogenic balloon experiments.

An aircraft such as SOFIA can provide very generous power resources, and an instrument designed for it can be made very aggressive. We have proposed an instrument called SHASTA, which ultimately would have a 128 pixel array targeting the 1.9-2.1 THz band. As part of this effort, we are developing a modular NbN-based 16-pixel waveguide mixer arrays that could be tiled together in a future instrument. This system would use local oscillator arrays that permit horn-to-horn imaging between the mixer and LO arrays. To permit observations at higher frequencies target other spectroscopic lines, our development effort includes a 16-pixel 5 THz waveguide mixer array that is pumped by a single quantum-cascade laser source.

A SmallSat experiment is likely to be only feasible if a 20 K-class cooler is used. We are developing MgB2-based mixers, both in quasi-optical and waveguide configurations. Such a system can be pumped by FMCs for frequencies < 3 THz or by QCLs > 2 THz. We are currently developing a brassboard utilizing a commercial 20-K class cooler.

Finally, with a look into the future, a concept for a highly integrated mixer focal plane array is being developed. This would involve coupling low profile micro-machined silicon lenslet arrays fed by a planar array of balanced HEB mixers. The rf and lo port would be opposite sides of a flat mixer package, with LNAs integrated in proximity of the mixer and the IF signals fed out laterally.

We will present status on the development of all four systems.

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