Wide RF band mixer -block design for waveguide-type HEB mixer

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A superconducting hot electron bolometer (HEB) mixer is the most sensitive heterodyne mixer above 1 THz, and it is now being used for astronomical observations thanks to various developmental efforts during the last decade. For example, it was employed for the Herschel space telescope, and was used to observe many spectral lines of various fundamental atoms, ions, and molecules in the THz band, which give us rich information about chemical and physical structures of interstellar clouds. For further observations with ground-based telescopes at a higher angular resolution, our group has been developing superconducting HEB mixers for the 0.9 and 1.3-1.5 THz band.

The HEB mixers can be classified into the two types by a coupling method to the incoming radiation; one is a waveguide type and another is a quasi-optical type. We employ the waveguide-type coupling because of its well-defined beam pattern and future extension possibilities for sophisticated receiver systems like a 2SB receiver. As a drawback, the RF bandwidth of waveguide-type mixer is generally narrower than that of quasi-optical type. In order to mitigate this weak point for the waveguide-type HEB mixer, we have tried to expand the RF bandwidth as much as possible by optimizing the mixer design.

It is thought that the HEB mixer element can be treated as a resister for the RF signal input. Hence, the design of the waveguide mixer block and the IF matching circuit is easier than other mixer elements such as an SIS element, although actual fabrication of the THz HEB mixer is quite difficult due to very small dimensions. In order to observe the 0.9, 1.3 and 1.5 THz atmospheric windows with a single mixer, we have tried to design a mixer block which has a sensitivity in 0.9-1.5 THz range by using a computer simulation. The simulation is carried out by using the commercial software HFSS. At first, we fixed the width of waveguide so as that the basic mode can only propagate through it for the above frequency range. In order to reduce the frequency dependence of choke filters, we have adopted Hammer filters instead of conventional quarter-lambda filters. Then, I have tuned the impedance by changing the shape of the bow-tie antenna to match the impedance of the HEB element. As a result, we have found that the waveguide HEB mixer sensitive to the RF signal from 0.9 to 1.5 THz is indeed possible. Actual testing of this mixer is in progress.