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Wideband Corrugated Horns and Orthomode Transducers for 67-116 GHz (ALMA band 2+3) and 275-500 GHz (band 7+8) Heterodyne Receivers for Radio Astronomy

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Recently, radio astronomy heterodyne receivers at mm and sub-mm wavelengths are pushing the limits of wideband performance in the context of future receiver development for the ALMA and related telescopes. Wide RF bandwidth performance would allow to reduce the total number of receivers to cover a given bandwidth, simplifying operation and maintenance of telescopes. It would also offer new science cases, since it would allow observations with a single receiver of spectral lines which would be otherwise observed by two different receivers, with different performance and calibrations. For this purpose, NAOJ has been collaborating in recent years with other institutes in the development of receiver prototypes to cover the 67-116 GHz and 275-500 GHz frequency bands. These correspond to ALMA band 2+3 and band 7+8, respectively.

The first subsystem of the receiver, the receiver optics, is of key importance to efficiently bring the RF signal from astronomical sources from the telescope antenna to the first LNA or mixer in the receiver, and to perform polarization discrimination. For a wideband heterodyne receiver, wideband waveguide component designs, such as corrugated horns and orthomode transducers (OMTs), are thus necessary.

Direct fabrication of sub-mm waveguide components is very challenging due to the very small dimensions to be fabricated and the required accuracies of a few micrometers. In order to validate design concepts and novel components, it is practical to firstly attempt fabrication of mm-waveguide components. This also allows a step-by-step establishment of fabrication methods from mm-wave to sub-mm-wave dimensions.

Recently, we have demonstrated good measured performance of conical corrugated horns and waveguide OMTs for ALMA band 2+3 (67-116 GHz), and have successfully completed designs for band 7+8 (275-500 GHz), which are currently being manufactured. All components in this paper are fabricated by direct machining in aluminum following fabrication processes established during the production of ALMA band 4, 8 and 10 receivers at NAOJ. Corrugated horns are fabricated in a single block, whereas OMTs are fabricated as split-blocks in 2 pieces.

In this paper, we will report on the designs and measured performance of wideband ALMA band 2+3 and ALMA band 7+8 conical corrugated horns and OMTs, which to our knowledge show some of the best reported performance over such large bandwidths at mm and sub-mm wavelengths.