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Comments on the document "ALMA Optics," of A. Baryshev and W. Wild

A. R. Kerr, 28 Jan 2000

The diagram in the document "Alma Optics" shows a single Martin-Puplett interferometer, adjusted to divide the LO power equally between two SIS mixers while coupling the USB signal from the telescope to one mixer and the LSB signal from the telescope to the other mixer. Although this scheme separates the two sidebands, it does not terminate the unwanted image frequency at each mixer properly in a cold load. To achieve low noise operation in such a sideband separating receiver, each mixer must see a cold termination at the image frequency. The noise temperature of the image termination adds directly to the receiver noise temperature. In the receiver depicted in the diagram, the image termination of each mixer is the LO source, which is unlikely to look like a 4 K cold load. A simple DSB receiver, in which the image is terminated in the antenna temperature, would probably give superior overall sensitivity, albeit with half the useable bandwidth.

There are two ways to modify the receiver as depicted to achieve sideband separation without degrading its sensitivity; each involves inserting an additional quasi-optical device in the LO path to provide the desired cold image termination.

(i) A ~20 dB coupler and 4 K load can be inserted inside the Dewar in the LO path before the signal/LO combining grid. This presents a cold load to both mixers at their image frequencies, but requires ~20 dB more LO power.

(ii) An additional tunable MPI and 4 K load can be inserted inside the Dewar in the LO path before the signal/LO combining grid. This would provide the desired cold image terminations near the sideband center frequencies, but at the ±3.5 GHz band edges would only give 3.5 dB isolation from the LO source, which is probably not adequate. The bandwidth over which good low-noise operation could be obtained would then be ~3.5 GHz.

For reference, compare the proposed receiver with a simple DSB receiver using a ~20 dB beam splitter for LO injection. The DSB receiver requires only a single mixer and IF amplifier per polarization, and has a bandwidth limited only by the IF amplifier and possibly by the IF circuit of the mixer. For spectral line work, the image temperature of the DSB receiver is the antenna temperature + a component due to LO source leakage through the LO beam splitter.

Alternatively, compare the proposed receiver with a simple DSB receiver using a MPI for efficient LO injection. This DSB receiver requires only a single mixer and IF amplifier per polarization, and has a bandwidth of 3.5 GHz at 0.52 dB signal loss and 9.5 dB LO-to-signal leakage — half the bandwith of the proposed SSB receiver. For spectral line work, the image temperature of the DSB receiver is the antenna temperature + a component due to LO source leakage through the MPI.