Design of IRMA III, the latest Infrared Radiometer for Millimeter Astronomy

David A. Naylor, Brad G. Gom, Robin R. Phillips, Ian M. Chapman
Physics Department, University of Lethbridge, Alberta, Canada

The performance of astronomical interferometer arrays operating at (sub)millimeter wavelengths is seriously compromised by phase distortions resulting from rapid fluctuations in atmospheric water vapor content. Unless corrected, these phase distortions, which vary rapidly in time and from antenna to antenna, greatly reduce the sensitivity and image quality of these arrays. The Atacama Large Millimeter Array (ALMA) interferometer, with 64 antennae and multi-kilometer baselines, will present a very difficult phase correction problem. This talk presents the productions model design and anticipated performance of IRMA III, a third generation Infrared Radiometer for Millimeter Astronomy, which we propose as a potential phase correction solution for ALMA. Building on the success of two initial prototypes (IRMA I and II), two IRMA III devices have been built and will be deployed for testing a Llano de Chajnantor, the future ALMA site in the Atacama desert of Chile. Since there is presently limited infrastructure at the Chilean site, the design must pay careful attention to all aspects of remote operation.

The challenging phase correction requirements for ALMA necessitate special instrumentation and modeling techniques. The IRMA III system is based on a cryocooled, 20 μm MCT detector system which monitors a large number of water lines in a well defined band near the peak of the Planck curve. Due to the high brightness of the 20 μm sky, this approach provides extremely high sensitivity with a small, relatively inexpensive, passive instrument. IRMA III system consists of a compact cryocooler and detector unit, Ethernet enabled embedded microcontroller, custom data acquisition electronics, calibration source, and 100 mm off-axis parabolic reflector, all in a weather-proof enclosure roughly the size of a toaster. The two initial test systems will include Alt-Az mounts, and will be positioned on a 300 m baseline to allow novel turbulent layer height and speed measurements, as well as correlation studies with the existing NRAO 12 GHz test interferometer. Members of our group have also developed an atmospheric model which has been used to verify the results from the first prototypes, and to predict the performance of IRMA III at the ALMA site.

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