Vector Beam Pattern measurements of a 850 GHz wide field Microwave Kinetic Inductance Detector camera

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Abstract— We present vector beam pattern measurements of a large field of view Microwave Kinetic Inductance Detector camera at 850 GHz. The angular and position dependent optical response of a receiver, its beam pattern, is given by the E-field of the detected radiation and as such is a vector with both amplitude and phase. Amplitude only measurements, even if taken in multiple optical planes, will be an incomplete description of the optical response. As such they will miss subtle phase errors and so not describe how a full instrument will operate in its final scientific operation configuration on sky. With the phase information, the full E-field is described, allowing the beam to be numerically propagated in either direction to investigate the optics or optical coupling between components. This allows testing at subcomponent level or in the near field of the full instrument, which can then be used to determine and understand the final deployed far field on sky performance. Phase and amplitude measurements are now standard procedure for phase sensitive heterodyne instruments, such as used in ALMA. However, vector beam pattern measurements have only recently been shown to be possible with direct, power-only sensitive, detector arrays: the lack of an intrinsic phase response, high pixel count and low detector speed make it more difficult. Additionally, with large field of view cameras the optics become more complex so making this technique more relevant. Measurements are presented from a wide field camera with a test array of lens-antenna coupled Kinetic Inductance Detectors. The vector beam patterns are measured using a dual optical source modulation scheme, using multiplexing electronics allowing around 400 pixels to be simultaneously characterized. Properties across the field of view can be investigated, including defocus and Gaussian beam coupling, that would not otherwise be available from an amplitude only beam pattern. An added advantage of the technique is that standing waves off the source can be corrected for, important for single frequency measurements. Finally, the dual source modulation scheme means the dynamic range for a given modulation depth is the square of that given by a single source amplitude only measurement. This has opened up much weaker features on the beam pattern for investigation, placing a limit on the residual in-detector-chip stray light and allowing characterization of the radiation scattering in the optical chain.