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Modal Analysis and Experimental Study of High-Order Mode Contribution to Standing Waves in Quasi-Optical Systems

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In many submillimeter-wave optical systems performance is in some way affected by the presence of standing waves. Usually these effects are studied empirically or only modeled to first-order by assuming a quasi-sinusoidal variation with distance and wavelength. In this paper we present an analytical technique to calculate the coupling between two corrugated horns including the total transmission and reflection properties. In our model we have combined the waveguide mode matching technique with a Gaussian beam mode description of the free space propagation. We illustrate the approach for the case of two coupled corrugated horns as the distance between them is varied. We furthermore present experimental test results confirming that multiple reflections do not always result in a classical periodic standing wave pattern. In particular when the horns are close together and the fields are not well matched, high Q cavity effects are observed resulting in irregular standing wave patterns. These cavity effects can be attributed to high-order modes which get trapped between transmitting and receiving horn. We finally discuss the consequences of our observations for a few examples of typical quasi-optical arrangements illustrating that the presented effects can have important consequences for submillimeter-wave optical systems.