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A Broadband Resonant Half-Waveplate for Compact Far-Infrared Grating Spectrometers with Continuous Wavelength Band Division

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***Abstract*—Future astronomical space missions in the far-infrared will utilize compact and wideband grating spectrometers. These grating spectrometers are inherently sensitive to a single polarization, enabling an efficient bandsplitting scheme, without spectral gaps, providing a large continuous wavelength coverage. The key component required is a broadband half-waveplate. In this paper we present our results of a broadband resonant halfwave plate, which satisfies the needs for such spectometers.**

I. Introduction

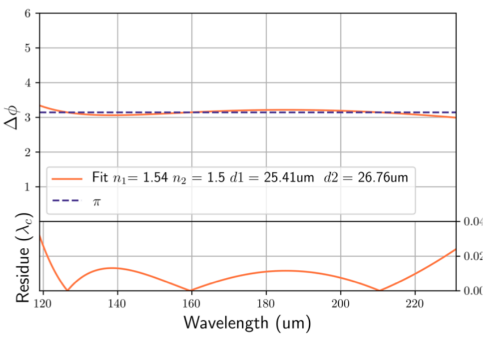
The next generation of far-infrared space instruments for astrophysics will most likely take advantage of wide-band background limited large-format detector arrays and deeply cooled telescopes. The primary tool for addressing the key science questions will be spectroscopy, and a very compelling science case concerns the study of the evolution of galaxies over cosmic time. Instruments proposed to answer questions in this field of astronomy will be based on low-resolution (R~few hundred) grating spectrometers with long slits providing mapping spectroscopy[1].

To cover a large instantaneous wavelength band with as many pixels as possible, the design of such instruments for space is extremely challenging. Broadband, and at the same time very compact, grating spectrometers push the optical design into a limit where the angles of incidence become relatively large, and the grating efficiency becomes dominated by only one polarization. However, this opens up the possibility to use detectors sensitive to single polarization, for example Kinetic Inductance Detectors (KID's) [2], and split the full wavelength range into one octave grating modules by using polarizing grids and dichroics in a continuous fashion, without spectral gaps. Such grating spectrometer architecture does require however a broadband device, which rotates the polarization by 90 deg, without rotating the slit or field image.

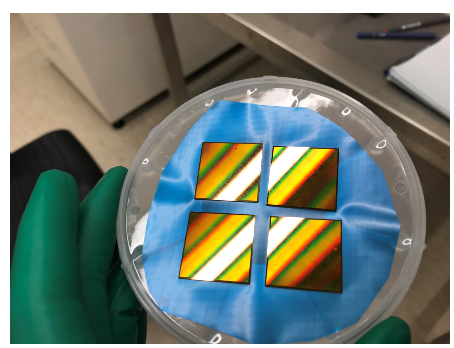
In this paper we present the design, fabrication method, and preliminary experimental results of a broadband resonant half-waveplate enabling this instrument concept. Our design is inspired by a paper of Zhou et al [3], where our design takes the leap from their X-band microwave demonstration into the far-infrared and THz regime. We will describe our simulation results and optimization of the design, the selection of suitable dielectric materials, their characterization by THz-TDS and DFTS techniques, the fabrication method of our THz device, and experiments towards a proof-of-principle.

II. Results

The figure below shows the simulation performance of our design. The design gives a phase difference between the horizontal and vertical polarization components of about π over almost one octave of bandwidth, with a residual phase error less than λ/40.



We recently fabricated a demonstrator, which is shown below. The design is based on deposition of Au strips, sandwiched in between spin-coated polyimide, terminated by an Au groundplane. In our paper we will present details of our design, measurement of the dielectric films, and initial measurement results of the demonstrator.



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