Design Concept of ASTE Polarimeter (APol)

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***Abstract*—Atacama Submillimeter Telescope Experiment Polarimeter is an integrated module that enables magnetic field imaging on the 10m dish telescope. APol works in combination with a transition edge sensor bolometer camera covering 245 to 370 GHz. Herein we introduce the design concept and latest progress.**

I. Introduction and Background

MAGNETIC field plays a crucial role in star formation. How does the B-field topology evolve as molecular clouds form and as clouds contract to form stars have puzzled astronomers for decades. Through polarization of stellar dust thermal emission, we could probe magnetic field topology at various scales [1]. At submillimeter wavelength where dust emission peaks, atmospheric absorption of the emission is significant and crucial to the depth of observations. To observe B-field in coreless cloud where nucleosynthesis has yet to begin, we propose to build a polarimeter for ASTE telescope at Pampa la Bola in Atacama desert where submillimeter transmission is superb [2] [3].

A. Principles of rotating half-wave plate

APol consists of a rotating half-wave plate (HWP) driven with torque motor and a wire grid. The HWP modulates the polarisation vector (angle) of the incident electromagnetic wave by 2θ where θ is the rotated angle of the HWP. Through the rotation, the polarisation angle ϕ of the observed target can be obtained via the Stoke's parameters shown as followed.

$$Q = I(0^\circ) - I(45^\circ)$$
$$U = I(22.5^\circ) - I(67.5^\circ)$$
$$\phi = \tan^{-1}\frac{Q}{U}$$

where the angles are specified in terms of θ

Assuming the atmospheric emission is mostly unpolarised, through the subtraction of intensities $I(\theta)$, the common mode which is the atmospheric noise contribution is removed automatically. This method is the underlying principle of the noise cancellation technique APol employs. It also relies on the assumption that the intensities are obtained within a time frame where the atmosphere can be assumed as stationary. A further study of the fluctuation time scale of the atmosphere at the submillimeter wavelength is currently under progress.

B. Design of the half-wave plate

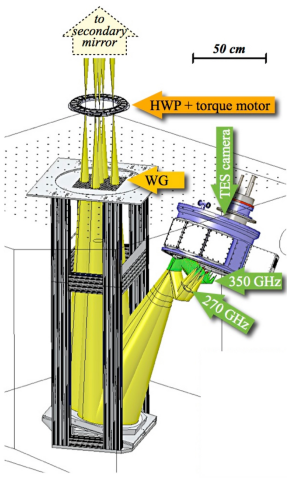

Fig. 1. CAD drawing of APol in ASTE Receiver Cabin

The HWP is designed for the Cassegrain focus of ASTE to avoid physical conflict with existing components when ASTE TES bolometer camera is in operation. As incident rays converged at Cassegrain focus, the diameter of the HWP required to cover the whole field of view (FOV) is also minimised. A smaller diameter can only be obtained by installing the HWP into the cryostat which is unfeasible due to the extra thermal load on the cryogenics system. The size of the HWP required to cover 7.5' of FOV is determined to be 25cm using physical optics propagation in Zemax.

Our HWP is designed and built in collaboration with Pisano based in Cardiff University according to [4] using metal meshed plates. Transmission is expected to be $> 90\%$ across the bandwidth at room temperature.

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