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Initial results from Harvard all-sky optical SETI

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Abstract

We report initial results from the Harvard/Planetary Society all-sky search for pulsed optical signals from other civilizations, which saw "first light" on 11 April 2006 after 6 years of planning and construction. To survey the northern sky ($-20° < \delta < +70°$), our 1.8-m spherical $f/2.5$ optical telescope images a $1.6° \times 0.2°$ patch of sky on two matched focal planes with a total of 1024 photomultiplier tube pixels. Each pair of pixels images the same 2.3 square arcminute patch of sky, and fast electronics filters the incoming visual band light for nanosecond pulses. Coincident optical flashes in a pair of pixels triggers one of 32 PulseNet full-custom chips to record the pulse profiles at nanosecond resolution. This experiment is an all-sky, kilopixel evolution of our targeted search. Its meridian transit survey mode requires ~ 150 clear nights to cover the northern sky with 1-min dwell time per source point. Focus in this talk will be given to describing the capabilities of the all-sky search instrument, the first few months observations, and constraints that these observations place on the density of pulsed optical signals in the galaxy.

Keywords: Extraterrestrial intelligence; Astrobiology; Instrumentation; Detectors

1. Introduction

We report initial results from the Harvard all-sky optical search for extraterrestrial intelligence (SETI). This paper is a companion to "Challenges in the first all-sky optical SETI" by Mead et al. [1], which also appears in this volume. The reader is strongly encouraged to read that paper first since it describes the all-sky telescope, observatory, and instrument, as well as other experimental details. Similar descriptions can also be found in [2]. Readers are refered to [2–4] for general descriptions of SETI and optical SETI, respectively.

This paper focuses on measurements made to calibrate the all-sky telescope and instrument, and on an initial set of observations and their implications. It extends to sky surveys the optical SETI data analysis techniques developed in [4] for targeted observations. The result of this analysis is a constraint on the density of pulsed optical transmitters in the galaxy, as a function of transmitter repeat time. The all-sky observations reported here total 17 h over three nights. While these totals are small compared with the targeted search (~ 2400 h over 5 years), the wide field of view and large number of pixels mean that it has already observed significantly more stars and sky area than the Harvard targeted optical SETI (see [4]). The initial observations also provided a way to develop general observing procedures and to plan for automated observations.

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2. Calibration and sensitivity measurements

2.1. Calibration of telescope position

Before observing, it is important to know precisely where in the sky the telescope is pointed. The all-sky telescope and camera were calibrated by observing a transit of the Moon. In the lunar transit depicted in the two panels of Fig. 1, the center of the Moon crosses the local meridian with a declination of d_0 at a time t_0. (The right ascension $\alpha_0 = t_0$ because it is a meridian transit.) As depicted in the left panel of Fig. 1, the Moon's leading limb grazes the left edge of a photomultiplier tube (PMT) at time t_1. Measurement of t_1 yields the offset between the midline of the PMT array and the local meridian via Eq. (1), which is derived by inspecting Fig. 1:

$$\Delta t = t_1 - t_0 + t_{\mathrm{M}} - t_{\mathrm{PMT}}, \tag{1}$$

where t_{M} (Moon's radius) and t_{PMT} (the distance from the PMT edge to the vertical midline of the PMT array) are measured in drift time.

A similar analysis of the telescope declination d_1 (which is set through the telescope drive controller) that aligns the bottom limb of the Moon with the top of a PMT yields the offset between the horizontal midline of the array and the telescope declination:

$$\Delta d = d_1 - d_0 - d_{\mathrm{M}} - d_{\mathrm{PMT}}, \tag{2}$$

where d_{M} is the Moon's radius.

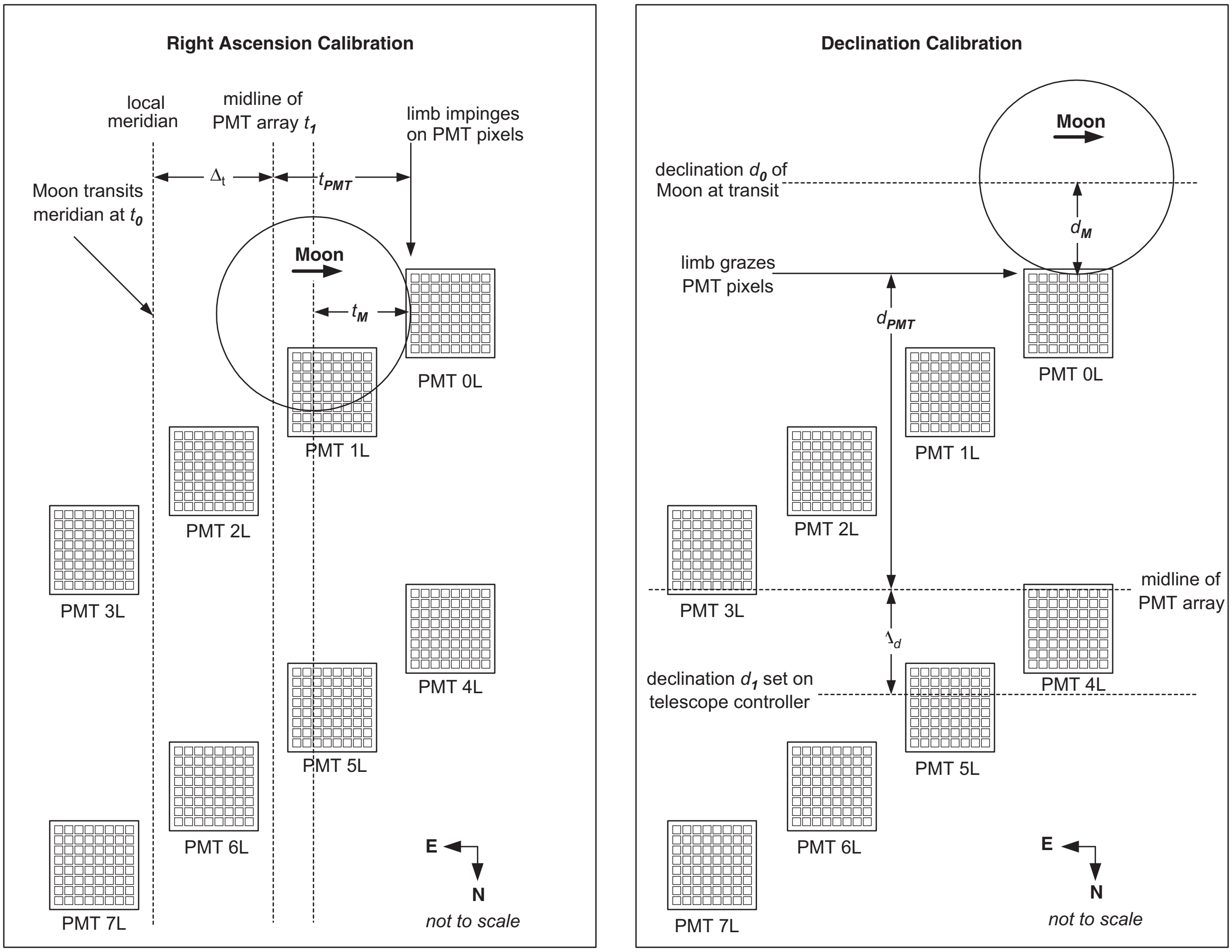

Fig. 1. Calibration of telescope position using PMT 0L. Each panel depicts the Moon moving through the eight PMTs in the left focal plane. The left panel shows calibration of right ascension (α) by measuring the time t_1 that the right edge of the Moon impinges on the edge of the PMT 0L. The right panel shows calibration of declination (δ) by recording the telescope declination d_t for which the bottom edge of the Moon impinges on the top edge of PMT 0L.