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Optical SETI at Lick Observatory: A Status Report

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Abstract. Optical SETI at Lick Observatory is characterized by its robust approach to initial detections. Our three-detector system has distinguished itself by successful rejection of nearly all false positive signals. We present observational progress, discuss use of data analysis procedures such as FFTs and analysis of double coincidences, and mention plans to upgrade our instrumentation.

1. Introduction

The Lick Observatory targeted optical SETI program has been operating routinely for well over a year. Since we have previously described our hardware (Wright et al. 2001), we will merely give a brief summary here. Light from the 1-meter Nickel Reflector passes through a large aperture, then is separated by beam splitters into approximate thirds, which feed each of three sub-nanosecond photomultipliers. Custom-designed ultrafast circuit boards set discriminator levels in order to control count rate in each of the three channels. Photons are counted for each channel, and coincidences of arriving photons between data channels are counted. Data acquisition software written by one of us (R.T.) for Leuschner Observatory's former two-channel system has been adapted to three detectors and integrated with standard Lick Observatory telescope control software.

Data are recorded in FITS format for subsequent detailed examination. In addition to the usual information about time and telescope position, seven channels of data are retained for each object. For the given integration time (typically 100 ms), total number of counts are recorded in each of channels 1, 2, and 3; number of double coincidences taken pairwise between channels 1 and 2, 2 and 3, and 1 and 3; and finally (and most important for our search) any triple coincidence between all three channels (1, 2, and 3). Should a triple detection occur, an audible alarm alerts the observer, confirmed by a written message on the terminal.

2. Observing Strategy

Our supposition is that, for reasons of energy economy, an incoming light beam will be tightly collimated. Thus, a targeted search presupposes deliberate effort on the part of the sending society to gain our attention. The closer the senders are to us, the more likely they will know we are here (whether "we" means our budding technological civilization, or just a potentially habitable planet). Primarily for this reason, our initial list of stars to examine is limited to objects within 200 light-years of Earth. We anticipate that a deliberate signal will not be subtle, but instead will be designed to be easily recognized. Repetitive short bursts of energy, perhaps varied to indicate a non-natural origin (analogous to the familiar Morse code SOS signal) seem most likely to us, although of course we have no information whatsoever as to likely repetition frequency. It could as well be months as microseconds. Since we have no reason to anticipate any special repetition rate from the sending society, we have chosen to observe each object for ten minutes. This interval allows us to observe a reasonable number of stars per night with a reasonable observer workload.

With declination limits dictated by geometrical constraints of latitude and telescope construction, we searched the Hipparchus Main Catalogue for stars with a B-V color index between 0.3 and 1.5 (corresponding roughly to spectral types between F, G, K and mid-M) within 200 light-years of Earth. This yielded 5038 stars, which became our initial object list. As of May 2002, we have observed 2068 of these stars. In addition, we observe stars of special interest. These have included, for example, stars in Earth's ecliptic plane (Castellano 2000), and the solar system analogue 47 UMa (Fischer 2002).

3. Detection

In case of a triple detection, our strategy is to check for and eliminate possible local sources of error, look for a repeated signal, and then confirm by simultaneous observations with widely separated equipment. Equipment checks include: high voltage for detectors is nominal, digital to analog converter (DAC) settings are appropriate for the star being observed, and the count rate is not too high due to clouds, bright moon, or accidental or deliberate illumination of dome. If a spurious cause for the triple is immediately apparent, we fix it and confirm with a repeat observation. If no cause is apparent, we monitor the object with high priority, looking for a repeated signal. If the detection is repeated, we will make the soonest possible arrangements to conduct simultaneous observations with two independent and geographically separated receivers; our own, and similar equipment located at Leuschner Observatory, about 100 kilometers north of Lick Observatory. We hasten to add that this highly anticipated circumstance has yet to arise.

In addition to simple repetition of a pulsed signal, any obvious signal content will result in immediate efforts to confirm with simultaneous observations. Low false positive rates from our triple detector system results in a large advantage over routine simultaneous observations: confirmation is the only circumstance which requires use of two telescopes. Otherwise and to date, the two University of California Optical SETI programs (Lick and Leuschner) operate completely independently, benefit from different search strategies, observe nearly twice as many objects per night, and are not interdependent for such factors as weather and operational status.

4. Data Analysis

Our first and most important analysis occurs as the data are read out: has a triple coincidence occurred? Since our false positive rate is low, these rare events receive immediate attention. However, it is possible that lower intensity signals may lurk in our data. We examine the frequency of simultaneous two-channel triggers ("doubles") in our data, looking for obvious outliers in the distribution. In order to find low-level periodic signals, fast Fourier transforms are applied to the summed data from all three channels. The power spectrum of every star so far observed has been examined. We have learned to recognize occasional data difficulties from the power spectra, but have seen nothing attributable to a real signal.

A major weakness with this approach is that we are presently binning the saved data up to 0.1 sec time bins. It is perhaps unlikely that within this slow time domain, we will happen upon a signal which has gone hitherto unnoticed. This value of this approach will be enhanced by significantly increasing the time resolution of our saved data, in order to get into less explored temporal territory.

5. Problems

Six putative triples have been detected. The first occurred on our second night of use of the new instrument. It was soon discounted on the grounds that the device was not yet optimized for observing; neither high voltage nor DACs were set correctly. A problem apparent from some of our other triple coincidences is that for very bright stars, the DACs occasionally fail to reset properly. We don't understand why this occasionally happens, but have found that after a try or two, the DACs set to the appropriate level.

When intermittent clouds pass by, a DAC setting established at the beginning of the observation will not result in a consistent count rate. Should the clouds then clear, apparent brightening of the source may overwhelm the DACs. This leads to the occasional false positive, which will nevertheless be checked out as described above. Probable cause will be apparent from brightening of the source, and higher than optimal count rates.

6. Upgrades

Our Hamamatsu R7400U-01 photomultiplier tubes (PMTs) have performed well. Nevertheless, we have recently upgraded to Hamamatsu R7400U-20 tubes, which offer higher quantum efficiency (QE) , but with somewhat higher thermal background noise. Effective spectral range is extended approximately 150 nm into the near infrared. We are investigating ways to increase the readout rate, to more effectively search for low level signals on short timescales. (Note that the slow readout from our counters occurs well down the data stream from our very fast coincidence circuits, and so does not hinder our ability to detect and record nanosecond pulses.)

Our biggest constraint on observing time is availability of observers, so we are working incrementally toward complete automation of the telescope. The first major steps toward more efficient operation are presently underway. New and much more precise position encoders are installed. The telescope control system is now being replaced as part of a broader modernization program at the observatory. A new telescope control interface is being programmed, which will allow object coordinate entry from a list, and automatic slew. A new, far more efficient and adaptable guide camera will be installed soon, which will allow such features as center on brightest object, center on offset from brightest object, and easy storage of a low resolution snapshot of each field. The focus motor controller is being upgraded to provide for automatic focusing. These improvements will increase efficiency and ease of attended observing, and are steps toward our ultimate goal of complete automation. Once the above hardware is in place, we will work toward automatic pointing, centering and focusing, which will further enhance observing efficiency. An observer on site will still be required to monitor weather, ensure proper object identification, open and close the dome and properly stow the telescope. Subsequent automation of the latter functions will allow fully robotic, unattended operation, and maximum utilization of available telescope time.

Robotic observing will require additional preparation. It will be necessary to inspect each field in advance, and where the program object is not clearly the brightest object within the circle of probable error for pointing of the telescope, to require pattern match to a chart. Otherwise the brightest object will be automatically chosen, always taking a snapshot for later confirmation. Our longterm intentions are to work toward employing some form of area detectors, following the creative lead of Horowitz et al. (2001; see also Howard, this conference).

References

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