Upgrade to Keck's interface with US Strategic Command regarding use of lasers

In response to WMKO call for white papers

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As part of the Robo-AO laser adaptive optics system[1,2], and in coordination with US Strategic Command (USSC), we have developed new laser/satellite de-confliction procedures which use the existing USSC protocols to open the majority of the overhead sky for possible observation without requiring pre-planning. By requesting predictive avoidance authorization for individual fixed azimuth and elevation ranges, as opposed to individual sidereal targets, we can enable laser observations of the majority of overhead targets at any given time. Adopting similar procedures for the Keck laser adaptive optics systems will a) increase the efficiency of operations by reducing the workload on and planning by observers and observatory staff and b) enable the use of the laser adaptive optics system to respond to targets-of-opportunity, increasing Keck's ability to contribute to high-angular-resolution time-domain astronomy with higher sky coverage than possible without a laser.

Background

When coordinating with USSC on the use of lasers propagating into space (see ref. 3), the laser operator is required to send in a list of targets to be observed 1 to 3 days before the observations occur. USSC will then respond with the times that it is safe to propagate the laser at each of those targets. Until recently, the list of targets sent by the laser operator was limited to a total of 150 targets per list, and each list could contain only one target type.

Currently Keck sends in two lists to USSC for each night of laser observations: one list includes a fixed azimuth and elevation pointing to zenith for engineering and laser check-out, and another with right ascension and declination coordinates populated by the night's observers along with a few engineering targets. In any given night, observers are limited in their use of the laser adaptive optics system to just those targets they selected ahead of time.

In contrast, we have developed new procedures for interfacing with USSC as part of the Robo-AO project. Instead of sending in lists of fixed azimuth and elevation or right ascension and declination, we send in lists of fixed azimuth and elevation regions on the sky (called "Fixed Field of View", ref. 3, pp. 7), each of approximately 6 square degrees. Until recently, we had been sending in 5 lists of targets every night, which was sufficient to fully cover the entire sky above 40 degrees elevation. USSC has just approved the use of 400 targets per list, and we have demonstrated the successful use of this upgrade during a Robo-AO observing run in March, 2014 (and are now only sending in 2 lists at a time).

We send in the exact same list of targets every single time to further simplify operations, a process which we have fully automated as part of our operations: the Robo-AO control computer generates its own lists every day and sends them directly to USSC via email; and the system processes incoming emails from USSC and uses the appropriate safe times to propagate for each night. By having safe open times for the majority of the overhead sky, we have been able to respond to immediate

requests to observe objects with the laser. As an example, in the summer of 2013 a TripleSpec observer on the Palomar 200” called us in the middle of our observing run to confirm that a suspicious object they were observing was a binary. We interrupted our queue, swung to that target, checked that we had clearance to propagate the laser in that part of the sky and confirmed it was a < 0.5” binary, all in less than 5 minutes.

Proposal

We propose that Keck observatory adopt a strategy similar to how Robo-AO interfaces with USSC. We believe that this will reduce the workload on observers and the observatory staff, responding to Keck’s science goal of highly efficient operations. A large fraction of the Keck community are involved with numerous time-domain projects, e.g., the Nearby Supernova Factory, the Palomar (Zwicky) Transient Factory, the Catalina Real-Time Transient Survey , Pan-STARRS and ATLAS, and having the ability to immediately trigger a laser observation of key transients would give the Keck community an edge in this field. This responds directly to Keck’s science goal of high angular resolution astronomy and exploiting emerging opportunities, specifically in the time domain. We expect that forthcoming U.S. facilities, e.g. TMT and GMT, will likely adopt this strategy and lessons learned implementing on a large aperture would be extremely valuable.

We are willing to share our know-how and code and with Keck operations to minimize cost to make this upgrade happen. We do not expect this upgrade to require more than a few work-months of effort to implement.

References

1. C. Baranec, et al., "Rise of the machines: first year operations of the Robo-AO visible-light laser-adaptive-optics instrument," Proc. AMOS Technologies Conf. 2013. http://arxiv.org/abs/1309.4432

2. http://robo-ao.org

3. "Interface Control Document (ICD) between the Laser Clearinghouse (LCH) and Observatories," Rev A2, 18 November, 2009, USSTRATCOM JFCC SPACE, Vandenberg AFB, California.