W. M. KECK OBSERVATORY

Keck Adaptive Optics Note 269

Summary of Laser Propagation Restrictions and Procedures

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1. Introduction

This document summarizes the procedures which the observatory has agreed to follow regarding propagation of the Keck 2 dye laser. It is intended primarily to acquaint potential users of the Keck laser guide star adaptive optics (LGSAO) system with the restrictions which laser safety considerations and agreements will apply to LGSAO observations. This document has been revised in October 2005 to include references to the new documents we submitted to the FAA in 2005, and to reflect changes in our operational model during occurrences of thin clouds.

2. Authority

The observing assistant has ultimate authority over observatory and personnel safety decisions, and compliance with FAA, MKO and other agreements regarding laser propagation. They will make their decisions in consultation with the laser and LGSAO operators, support astronomer, and observer, following the guidelines listed in this document.

3. Aircraft Safety

The FAA restricts outdoor laser projection because of possible danger or distraction to aircraft crew. In order to satisfy FAA requirements, the observatory has agreed to the following protocols regarding aircraft safety. For more details, see KAONs 361 and 360.

1. At least 2 aircraft spotters must be on station during laser projection.
2. The laser must be shuttered if spotters detect an aircraft within 25º of the beam.
3. The laser must be shuttered if thick clouds are present within 25º of the beam, preventing approaching aircraft from being seen.
4. A boresight IR camera system with a 20º field of view provides an automated, redundant aircraft safety capability. It will shutter the laser when a bright IR source is detected near the beam.

The boresight camera may be disabled by the laser operator if false positive detections (such as of moonlight) seriously impact observing efficiency.

4. Mauna Kea Laser Guide Star Policy

The following restrictions on laser guide star operation were agreed upon by representatives of the observatories on Mauna Kea to minimize the impact of laser projection on non-laser projecting telescopes. They are detailed in KAON 153.

5. The power of a single beacon may not be greater than 50W.
6. Laser beacons may not be projected at elevation < 20º.
7. If a collision between the Rayleigh scattered light or the laser guide star and the field of view of another telescope is detected, the laser must be shuttered.
8. The laser must be shuttered if intervening clouds cause other telescopes to be impacted by scattered light.

A Laser Traffic Control System (LTCS) has been implemented to address restriction 7. It provides predictions of any future collisions with the fields of view of participating telescope on Mauna Kea, assuming sidereal tracking at their present position. The laser is automatically shuttered if a collision is detected with the field of view of an observatory deemed impacted (e.g., using optical instruments or guiders).

If the LTCS link with an observatory is down, the laser operator or observing assistant will immediately contact the observatory by phone, inform them that the LTCS link is down and enter manually their pointing coordinates in the LTCS. We will not shutter the laser during this event as this may cause the loss of 30-minute-long integration time.

We will request the said observatory to work with their support team on restoring the link again. It is the responsibility of each observatory to either provide a working link or provide coordinates for each target being observed if they are laser impacted. Keck support will try to provide as much help as possible to restore the link and help mitigate any risk of laser light impact on said observatory.

If the entire LTCS system is down due to a general network outage, then the laser may not be propagated until it is restored.

We have decided to interpret restriction 8 as follows: The spotters will shutter the laser if thicks clouds appear within 25degrees of the beam (per section 3, item 3). We have no evidence that laser back-scattered light on thin clouds are affecting other observatories and believe that the LTCS parameters in place for each observatory are conservative enough to prevent such laser light contamination. Our experience is that we have been able to propagate through thin cirrus (and have productive LGSAO science night). We recommend this issue to be re-visited by the MKO Laser Technical group.
In the meantime, the spotters will not shutter for thin clouds as long as clouds do not prevent them from spotting aircraft. When there are thin clouds, the spotters shall report to the Observing Assistant on the passing of thin clouds that could produce an increase in scattered light. The OA and the LGSAO operator will monitor the scattered light using the WFS intensity display, the Acquisition Camera and other available tools: if the amount of scattered light is such that the laser return has decreased by more than a factor 2 on the WFS (0.75 magnitude), the LGSAO operator and the Observing Assistant will close the shutter.
The observer may then either wait for the clouds to pass, choose an LGSAO target in a clear region of the sky, or if this is not possible, revert to their NGSAO or NIRSPEC backup program.

5. US Space Command approval

Though the possibility seems remote, the US Space Command is concerned that high-power ground-based lasers may cause damage to sensors onboard surveillance spacecraft in low-Earth orbit. We are therefore required to have each target approved prior to observation. Target lists are sent and approval received by fax, generally requiring 72-hr turnaround time. In the past year of LGSAO operations, only a handful of targets have been restricted. Nevertheless, the observatory has agreed to the following procedures:

9. No target may be observed which US Space Command has not approved.
10. The laser may not be pointed more than 2 arcminutes from an approved target position.

6. Other Restrictions

For a variety of reasons including aircraft and spotter safety and instrument performance, the following restrictions must be followed:

11. The laser may only be propagated between 12° evening twilight and 12° morning twilight.
12. The LGSAO operations team will use evening twilight and the first 30 minutes after 12° evening twilight for AO checkout, laser alignment, and characterization.
13. Finally, all the usual observatory weather restrictions apply, as summarized here: http://www.keck.hawaii.edu/obsupport/handbook/Summary_Table.html

7. Impact on LGS-AO Observing Efficiency

The restrictions listed here which have the greatest impact on observing efficiency are the non-LGSAO specific weather restrictions, interruptions due to thin clouds (any illuminated cloud, or thick clouds within 25º of the beam), and those due to LTCS collisions with other telescopes.

LTCS collisions typically occur several (1-5) times per night, with each interruption lasting 1-30 minutes. When an LTCS collision predicted to last longer than ~5 minutes occurs, it may be advisable to move to another target. If alternate targets are available, the total time lost to LTCS collisions is generally less than 20 minutes per night.

Interruptions due to clouds are more problematic. Thin cirrus-type clouds, in particular, could prohibit projection of the laser, while NGSAO and NIRSPEC observations would only be slightly impacted. Such conditions occur ~10% of all nights on Mauna Kea (Bely, 1987), and observers are therefore required to prepare either NGSAO or NIRSPEC backup programs.

8. References

1. Bely, P., "Weather and seeing on Mauna Kea," *PASP* 99, 560-570, 1987.
2. Le Mignant, D. & Stomski, P., "Use of aircraft spotters for K2 Laser safety," *KAON* 360, 2005.
3. Le Mignant, D., “Procedures for Laser Safety Observing”, KAON 361, 2005
4. Le Mignant, D. & Stomski, P., "FAA Notification of our proposal to conduct outdoor laser operations," *KAON* 363, 2005.
5. Wizinowich, P., D. Simons, H. Takami, C. Veiller, and R. Wainscoat, "Coordination and use of laser beacons for adaptive optics on Mauna Kea”, *KAON* 153, 1998.