University of California – Santa Barbara

Department of Chemistry and Biochemistry

Optical Characterization Facility

Safe operations manual addendum for laser instrumentation

Rev. 1.1

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Introduction

The purpose of this document is to provide supplemental information relevant for the safe operations of laser instrumentation in the Optical Characterization Facility (OCF). It identifies main research tasks and related hazards associated with lasers, provides information about facility-specific hazard controls, establishes training requirement for the OCF lasers users. This document augments safety regulations developed by UCSB EH&S department.

Summary of OCF operation

OCF is a user facility dedicated for advanced spectroscopic studies. These experiments include ultra-fast time-resolved spectroscopy, steady state emission measurements, non-linear optical probing. Techniques to be used include transient absorption and luminescence probing, two-photon emission excitation, and intensity-dependent transmission measurements. Research activities at OCF are focused on studies of artificially-structured molecular materials such as conducting polymers, semiconductor nanocrystals, novel organic compounds, *etc*. Several state-of-art laser systems are available at OCF: continuous wave (CW) solid state and gas lasers, femtosecond (fs) Ti:Sapphire lasers and regenerative-amplifiers, optical parametric amplifiers (OPAs). Also, OCF provides users with electronic equipment, such as detectors, power supplies, digital lock-in amplifier, oscilloscopes, infrared (IR) viewers, *etc*, required for operation of lasers, data acquisition and analysis. Experiments and data analysis are conducted by trained users and/or OCF personnel.

OCF is located in rooms 3210 and 3109A, Chemistry building, and room 4637A in PSBN OCF coordinator (Dr. Alexander Mikhailovsky) can be reached at extension 2327 or via email at polycarp@ucsb.edu.

Hazard identification and controls

A. Laser Beam-Related Hazards

Most of experimental setups available at OCF include the Class IV, IIIa and IIIb lasers (both CW and pulsed. Please see the Attachment 1 for the list of laser equipment). Hazards associated with Class IV lasers include

a. Diffuse reflection ocular hazard
b. Direct reflection ocular hazard
c. Skin damage hazard
d. Fire hazard

Vision damage caused by a reflected laser beam is the most frequent type of accidents caused by improper use of lasers. Class IV lasers can emit at any wavelength, often close to or beyond the edge of the human vision range. A weak spot on the screen could be a reflection of a multi-watt beam. High repetition rates and pulse energy often lead to significant eye damage on the time-scales shorter than protective reaction time of the eye-lead. Due to high output power, even diffuse reflection of the Class IV laser beam can cause a serious vision loss.

Ti:Sapphire lasers installed in OCF (Spectraphysics Tsunami, Astrella, and 3900S) can emit in the spectral range 660-1100 nm. TOPAS Prime OPA can produce dangerous laser beams in the range 235-2500 nm. Most of humans can not see radiation with wavelength longer than 830 nm at all, and eye sensitivity to near IR radiation with shorter wavelengths is very low. NEVER rely on visual perception of the laser beam intensity, use IR viewers to find the beam and powermeter to measure its power. Always check for reflected and scattered beams with IR viewers.

High intensity of the Class IV laser radiation can cause skin damage easily. Many OCF lasers can cause skin burns, pulsed lasers can also ablate the skin. The risk of burns and skin ablation is especially high if the beam is focused. The fire hazard is also associated with high intensity of the laser beam. Laser beam can set on fire light-absorbing materials, samples, even researcher's clothes. IR laser beams may represent extreme fire hazard since they can not be seen by a human eye. Use IR viewer to make sure that there is no unaccounted beams in the lab.

Never place objects into the waist of a focused pulsed laser (Spitfire, Tsunami, Astrella, TOPAS Prime) beam. Due to very high peak intensity of laser pulses, even inflammable objects can explode and cause a fire or an injury.

Level of the laser hazards increases during alignment of a laser system, since the user has unrestricted access to high intensity beams and could be exposed to uncontained reflections. OCF users are allowed to perform alignment procedures essential for their research work after appropriate training (such as tuning the emission wavelength). Other

alignment procedures can be performed only under direct supervision of the OCF personnel.

Laser Hazard Controls

Engineering controls.

1. The Nominal Hazard Zone (NHZ) is taken to be the entire room in which the lasers are operated.
2. All lasers have interlocked covers and enclosures. Interlocks should be checked on the regular basis by the OCF staff and maintained in the working condition.
3. Beams of the CW pump lasers (Revolution, Astrella, and Verdi G) are enclosed into beam tubes. This protection should never be removed by OCF users. Installation of additional beam enclosures by users is not mandatory but recommended.
4. Laser operators are protected from the reflected and/or scattered laser beams by screens and curtains. Portable metal screens should be used to block stray reflections from the optical components.

Administrative controls.

1. Warning lights are installed or placards are posted at the OCF entrances to inform visitors, users, and staff members about the lasers status. If a Class IV laser is on, only OCF personnel, authorized users, and escorted visitors are allowed to enter.
2. Users must receive appropriate safety training. Level of the training depends on level of involvement in the OCF operations.

    a. Occasional user

    Occasional users can use OCF lasers only under supervision of the OCF personnel. Required training:

    - UCSB laser safety manual
    - OCF CHP
    - OCF laser safety addendum (this document)

    b. Permanent user

    Permanent users can use OCF laser equipment without direct supervision of the OCF staff. Required training:

    - UCSB laser safety manual
    - OCF CHP
    - OCF laser safety addendum (this document)
    - Laser operation manual (for the laser(s) used)
    - UCSB laser safety training (online, via UCSB learning center)
    - Interview with the OCF coordinator

3. All activities involving use of lasers must be supervised by the OCF staff. Even permanent user must consult OCF coordinator before starting a new project or experiment, in order to evaluate hazards and develop appropriate controls. OCF staff members have a right to ban users from work, if the safety is compromised. All research activities and major changes in optical setups must be approved by the OCF staff.
4. Users must implement safe work practices. Users, P.I.s, and OCF staff members are equally responsible for the workplace safety.
    - Before doing the work, hazards analysis must be performed and appropriate controls developed.
    - During the scope of the work, users must check regularly for unaccounted hazards (e.g., beam reflections, unblocked beams) and eliminate them promptly.
    - After completion of the work, additional hazard analysis may be performed in order to provide a feedback for future experiments.
    - Users must inform OCF personnel and other users about real and possible problems promptly. Experience sharing is strongly encouraged.
5. Additional safety rules
    - All reflective objects (e.g., rings, badges, watches) must be taken off before performing any work involving lasers. OCF personnel is not responsible for theft or loss of these items.
    - Laser beam must be blocked by an appropriate beam dump when any optical component is replaced or added or the laser beam is not used.
    - Bending or leaning on the optical table is prohibited. Users shall avoid placing eyes at the beam level. Stepstools or ladders should be used to reach remote areas of the optical table.
    - If necessary, OCF personnel may impose two-persons rule on any operation.
    - If not being used for more than 2 hours, lasers must be interlocked by removing safety keys from locks on the power supplies.

Personal Protection Equipment (PPE)

Laser safety eyewear for all OCF lasers is available to users. Eyewear used must be compatible with laser emission wavelength (See Attachment 2 for the laser goggles compatibility chart). Users must be aware that laser safety glasses are for diffuse light viewing only. Direct exposure must be avoided by all means.

Laser safety glasses must be worn by users all the time, unless the beams are contained or blocked completely.

Laser Alignment Procedures

Laser alignment involves additional hazards, since probability of exposure to the laser radiation increases greatly. The following rules must be observed during the laser alignment:

- Two-persons rule must be observed, if the major alignment is performed by an OCF user.
- All other activities are prohibited in the same room, unless appropriate protection is provided.
- Only essential personnel is allowed in the work area. Warning signs should be placed near the OCF entrances.

Attachment 1.

List of the lasers available at OCF

1. Coherent Verdi G: 10 Watts (cw), 532 nm, Class IV
2. Spectra-physics Tsunami: 10 nJ, 650-1000 nm, 90 fsec (pulse width), 80 MHz (PRF), Class IV.
3. Coherent Astrella: ≤1.2 mJ, 800 nm, 90 fsec (pulse width), ≤5 kHz (PRF), Class IV.
4. Spectra-physics BeamLock 2060-8, ≤8 Watts (cw), 351,363, 457,476, 488, 496, 514 nm, Class IV.
5. Light Conversions Topas Prime OPA with UVVis harmonic unit, ≤300 uJ, 235 – 2500 nm, ≤130 fs (pulsewidth), ≤5 kHz (PRF), Class IV.
6. Coherent Obis diode lasers, ≤500 mW (CW), 375, 458, 488,660, 808 nm. Class IIIb.
7. Spectra-physics 3900S, 1 Watt (cw), 690-1000m, Class IV

Attachment 2

Laser safety goggles compatibility chart

Laser	Emission wavelength	Type of safety glasses
Verdi-G	532 nm	LSK-Argon/KTP
Astrella	800 nm	LPA-ALEX
Tsunami	700-1000 nm	LPA-ALEX
Model 3900	700-1000 nm	LPA-ALEX
Topas Prime	235-2500nm	Select goggles according to the wavelength used to ensure OD5+ blocking
Coherent Obis	375-808 nm	Select goggles according to the wavelength used to ensure OD5+ blocking
Beamlok	350-514 nm	LSK-Argon/KTP