Laser Incident Involving a Beam Splitter

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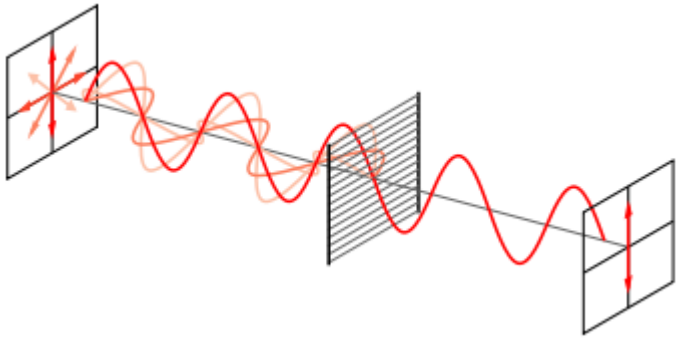
Dangerous Tools on the Optical Table

- The list of dangerous optics according to *Laser Lessons News Letters, Volume 2 Issue 2,* published by *Lawrence Livermore National Laboratory (LLNL-MI-639898)*, includes:
  - Polarizers
  - Beam splitters
  - Dichroic mirrors
  - Periscopes
  - Vertical optical tables

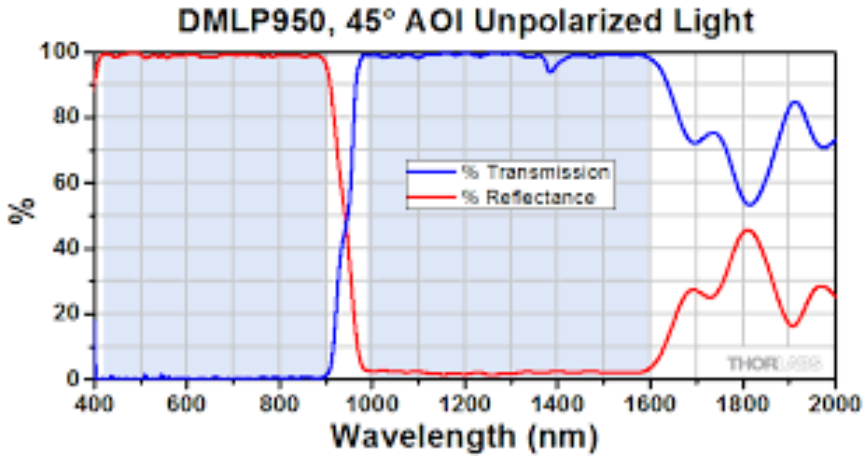
Polarizers

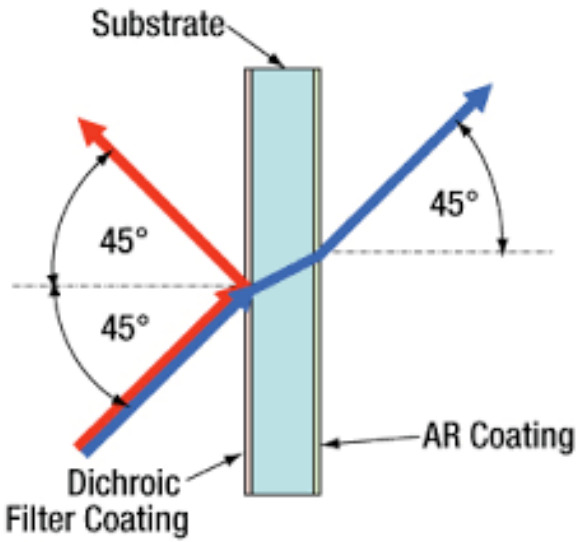
- A **polarizer** is an optical filter that lets light waves of a specific polarization pass and blocks (or discard) light waves of other polarizations
- Rotating polarizers are involved in more accidents than any other type of optic



Dichroic Mirrors

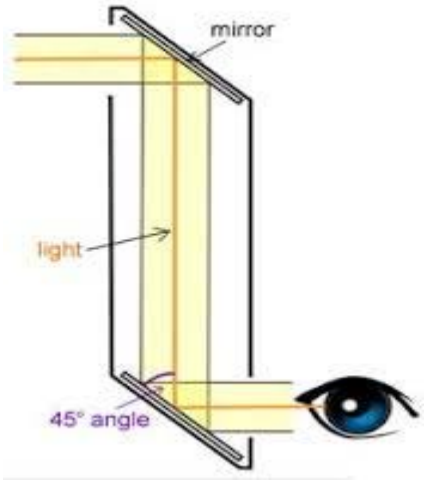
- A **dichroic mirror** has significantly different reflection or transmission properties at two different wavelengths
- The reflection is highly depended on angle of incidence
- For high power lasers even small percentage of leakage (1-3%) can cause harm





Periscopes

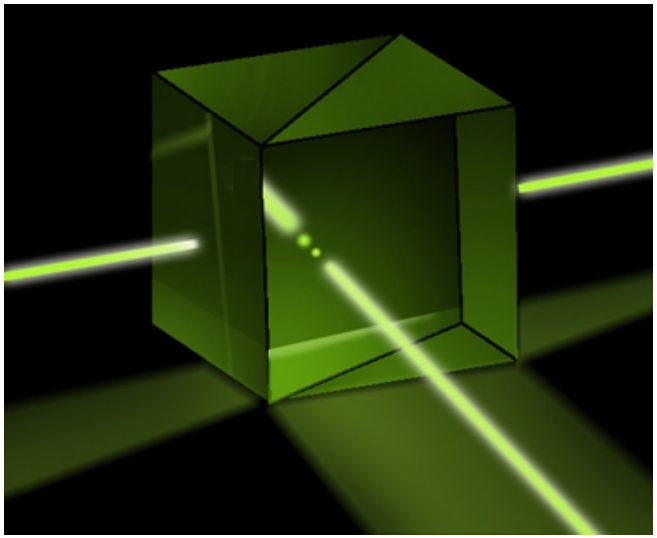
- A system of two mirrors used to change the beam height upward or downward
- This can be source of misaligned reflections
- Use beam blocks, barriers, tubes and warning labels

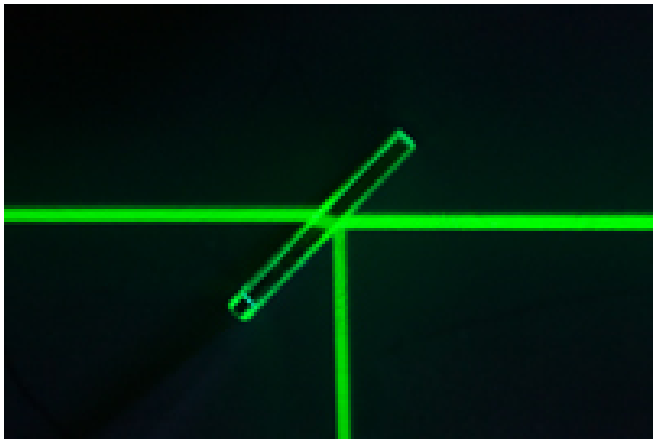


Vertical Optical Tables

- Installing optics on such a table goes against the first principles of laser safety: keep the beam outside of eye level standing or sitting
- Strict beam control required

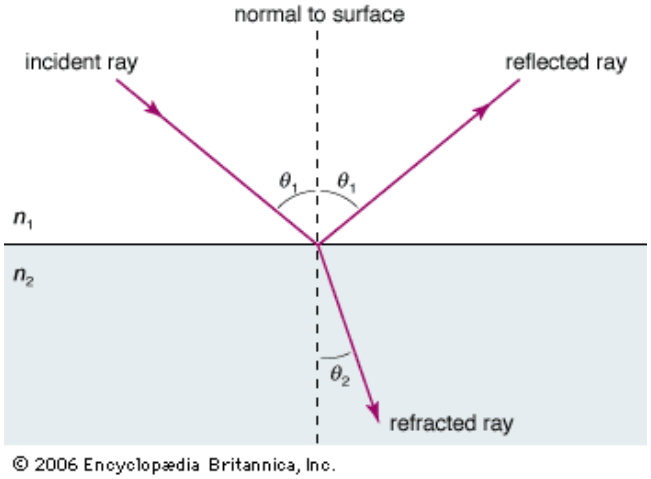
Beam Splitters

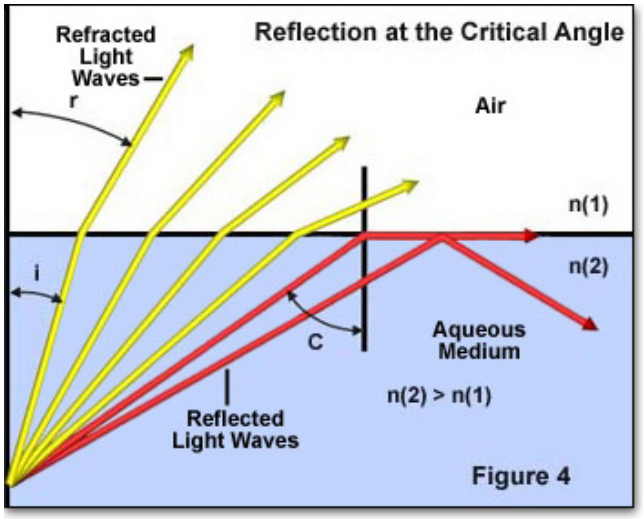




- The reflected beam is perpendicular on the main beam
- Used in combination with a polarizer to control the power of the main beam replacing classical filters
- The discard beam is the source of hazard

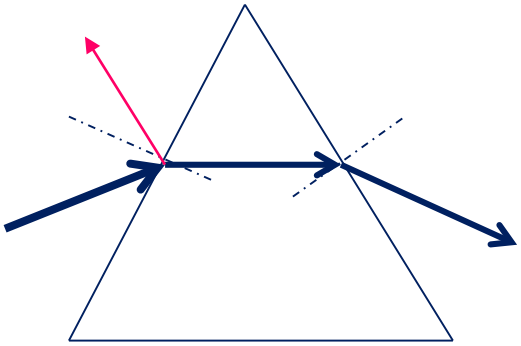
Reflection and Refraction

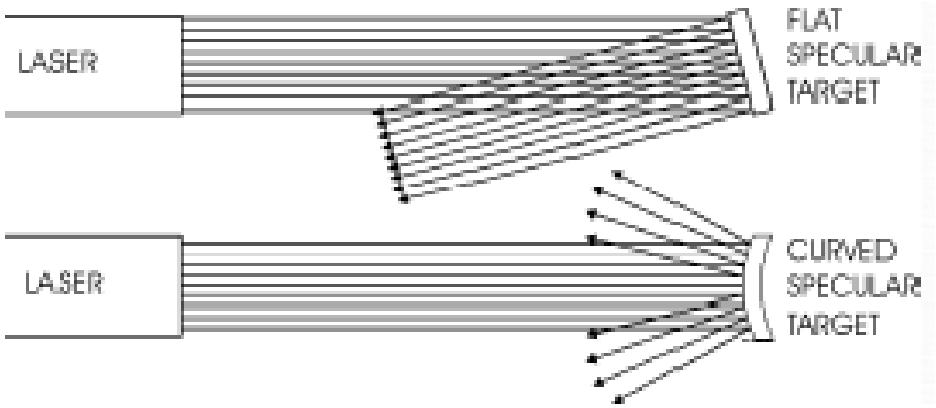


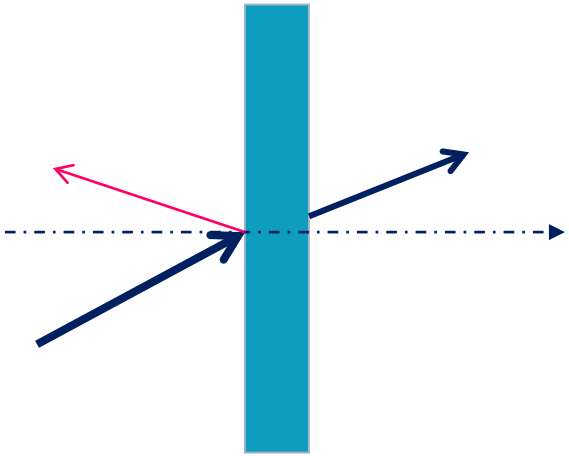


- Refraction is always accompanied by reflection
- How much light is reflected depends on the incident angle (from about 4% for normal incidents, to 100% at or more than the limit angle– fiber optic)

Stray Beams

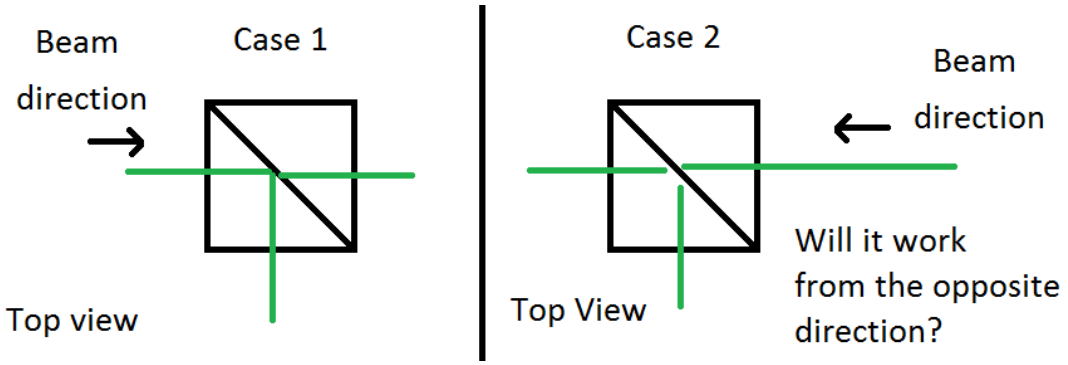






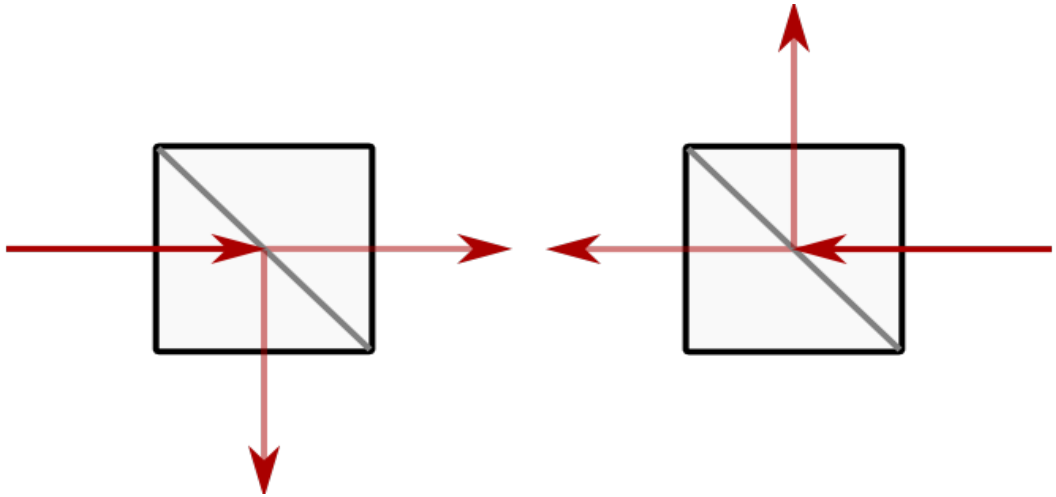
- The most dangerous stray beams are from flat surfaces

Correct Use of Beam Splitters



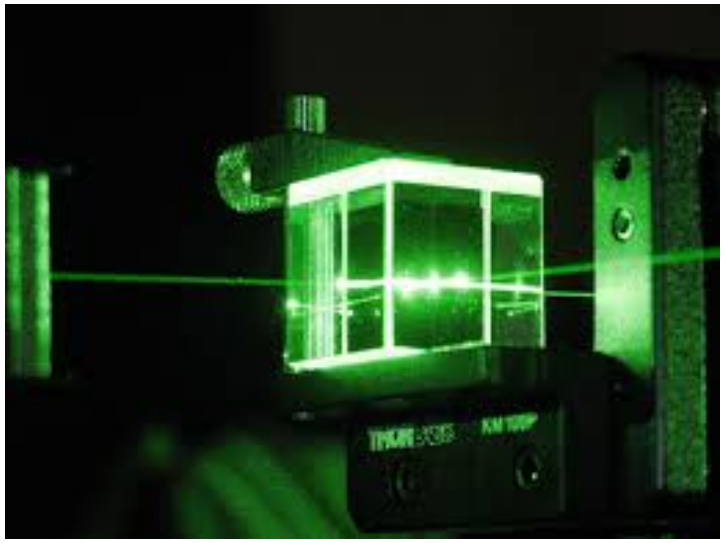
- Is this the case?
  NO

The beam splitter works like this:

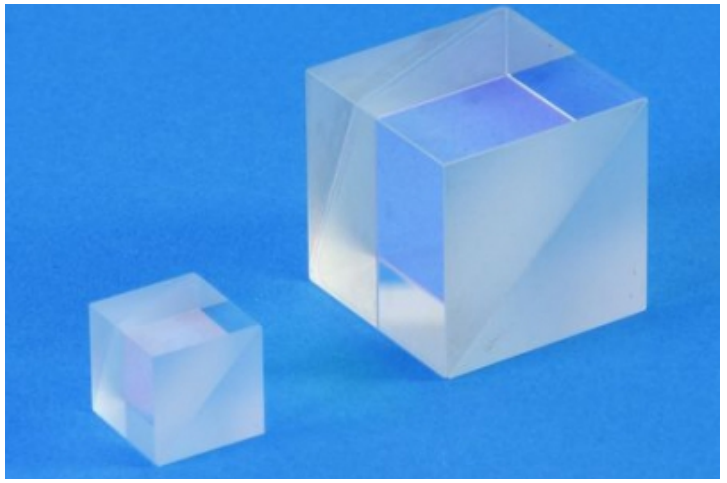


Correct Use of Beam Splitters

- Both transmitted and rejected beam are horizontal



- Transmitted beam is horizontal but rejected beam is vertical



The Incident

- To avoid the use of a beams stopper, the student mounted the beam splitter in such a way that the rejected beam went down
- When he mounted a lens after the splitter, the rejected beam was directed upwards
- He had a 800 nm vertical beam without knowing about it
- The beam entered between the laser eye goggles and the face, hit the prescription glasses and was reflected in his eye
- The good news: he reduced the power during the alignment, and after so many reflections the light entering in his eye was low power – no injury occurred

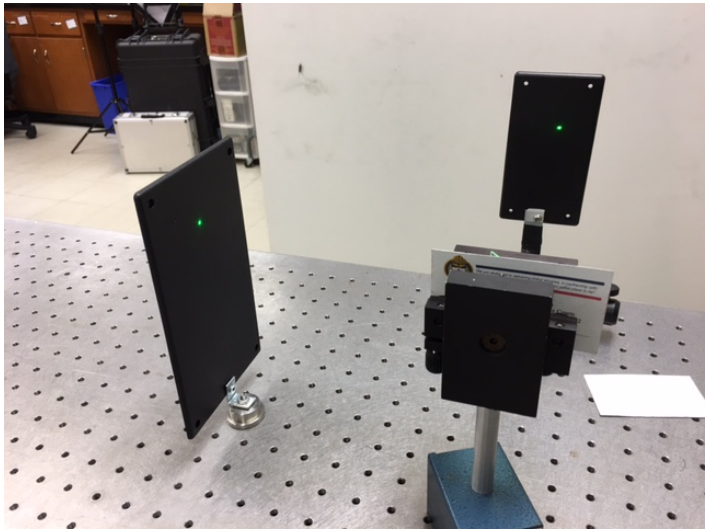
Lessons Learned

- Insufficient understanding of stray beams
- Incorrect understanding of the use of beam splitter

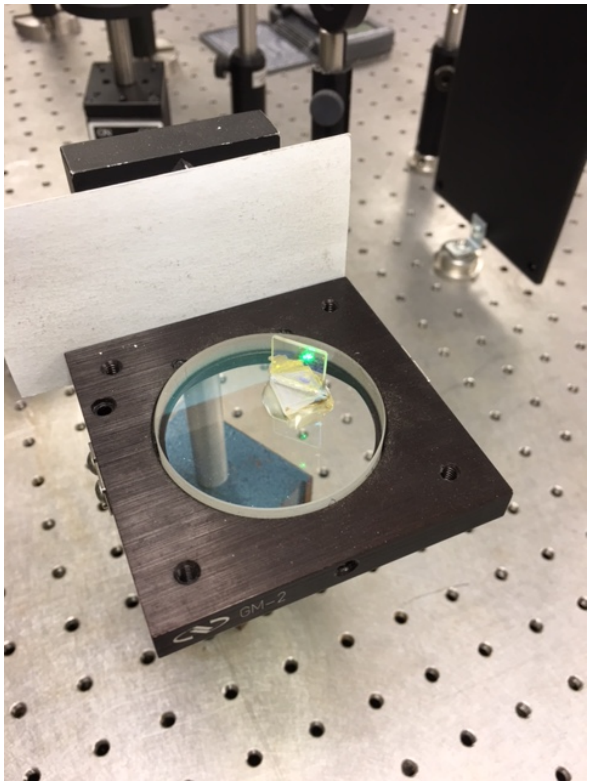
Actions taken

- Add the beam splitter to the “hands on” training
- The laser supervisor must approve the change of the procedures in the lab

Actions Taken – Training Improvement



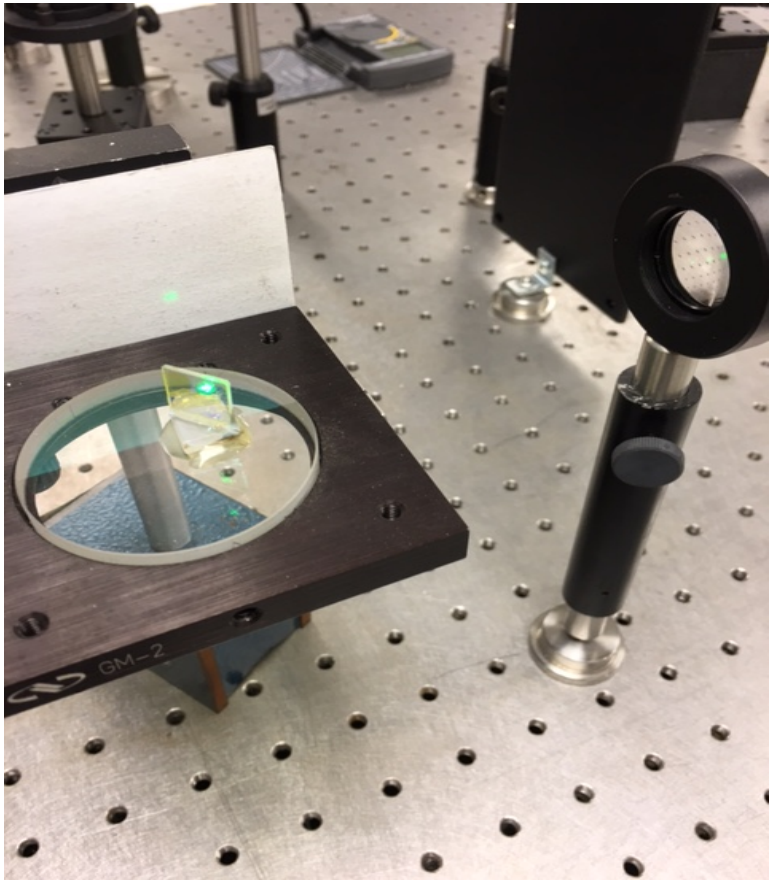
- Back view without lens



- Front view without lens

Actions Taken – Training Improvement

- The stray beam from the lens (visible on white) is reflected away from the user
- If the beam splitter is used incorrectly, the stray beam from the lens goes up



Front view with lens