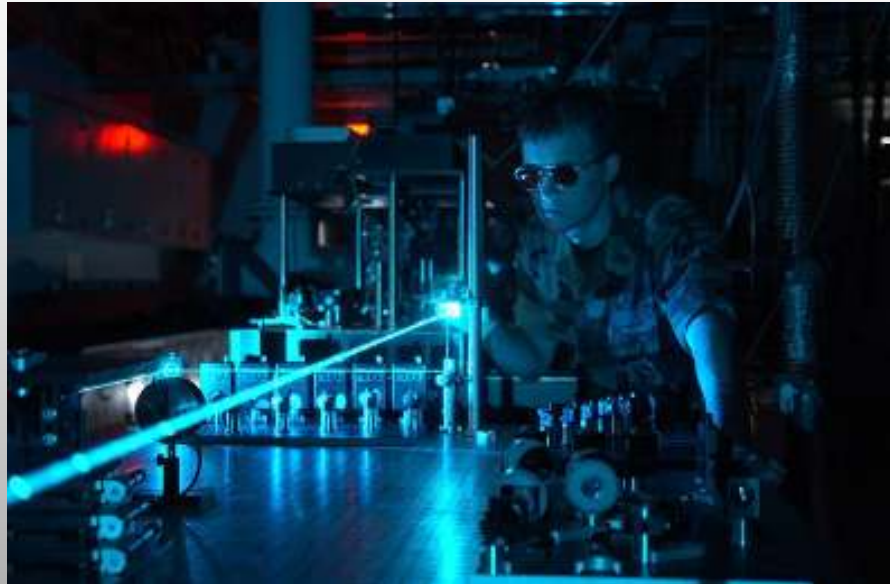


LASER



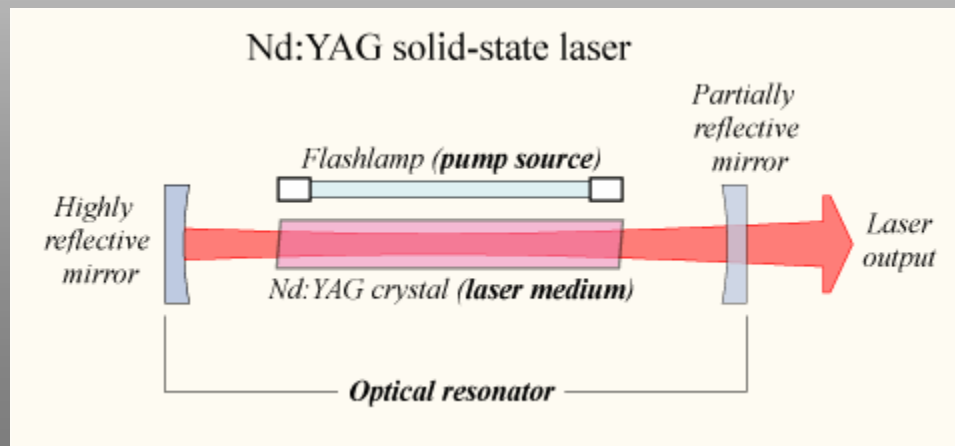
History and Applications

Pehr Hovey / pehrhovey.net

MAT594CP Spring 2009

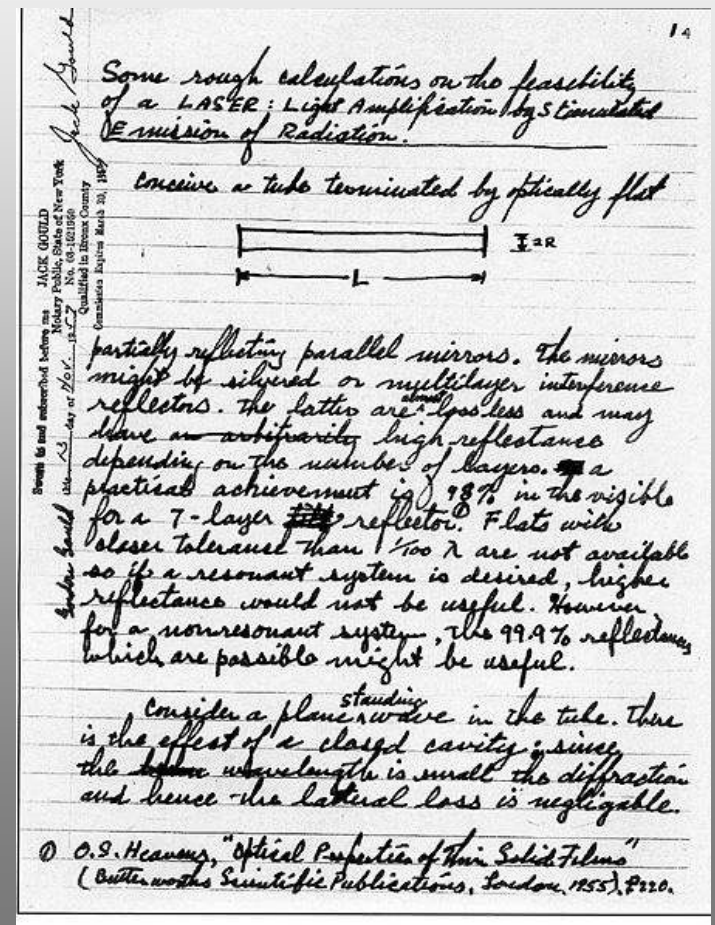
Laser Overview

- Laser generates *coherent* light through *Stimulated Emission of Radiation*
- Three main parts:
 - Optical pump
 - Gain medium
 - Optical Resonator (mirrors)



Laser History

- 1917 – Einstein theorizes Stimulated Emission
- 1950 – Alfred Kastler proposes Optical Pumping
- 1957 – Gordon Gould (Columbia Univ) coins term LASER
- 1960 -- First working laser at Hughes Laboratory (pulsed ruby)
- 1960 – First gas laser
- 1962 – First idea of semiconductor laser
- 1970 – Room Temperature continuous semiconductor laser



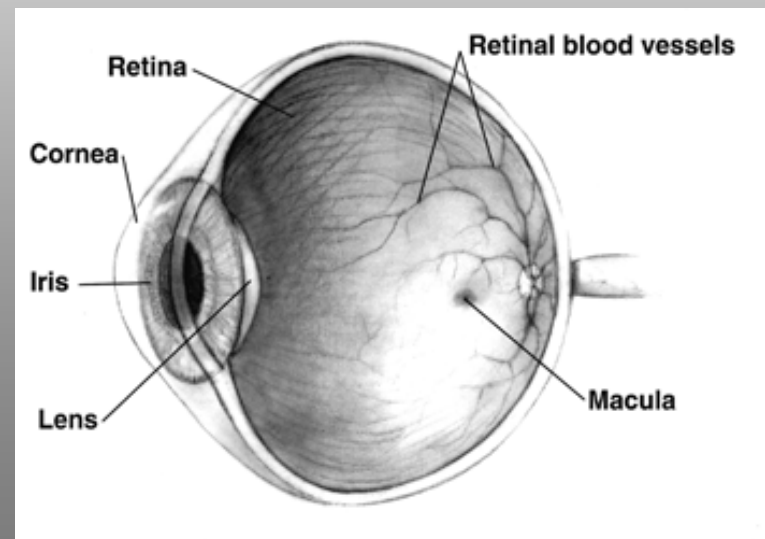
Laser Safety

- Highly focused energy can cause burns, start fires
- Industrial lasers also have concerns with high voltage, chemicals, pressure...



Laser Safety

- Thermal Damage: Lasers can burn the eyes
- Photochemical damage: photoreceptors over-excited by laser intensity
- Damage varies by wavelength:
 - Visible/Near-IR (400-1400nm) is focused by lens and burns retina, causing blindspots
 - Invisible radiation is absorbed by cornea, causes cataracts and blurring



Laser Safety

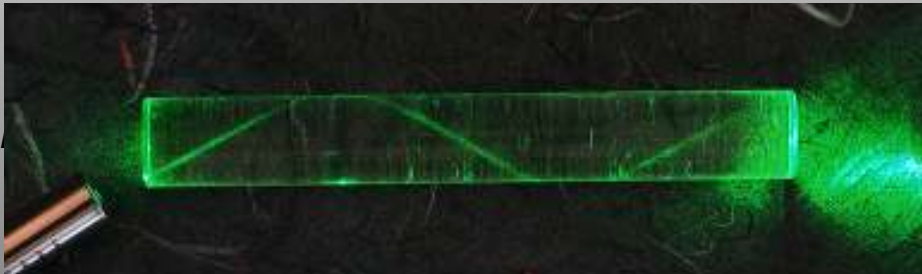
- ***Party laser 'blinds' Russian ravers (2008)***
 - *"Partygoers say heavy rains forced organizers to erect massive tents for the all-night dance party. The damage seems to have been caused when laser beams that were intended for outdoor use to illuminate the sky, were somehow turned or **reflected** onto the crowd."*
 - *"They all have retinal burns, scarring is visible on them. Loss of vision in individual cases is as high as 80%, and regaining it is already impossible"*
 - <http://www.newscientist.com/article/dn14310>

Laser Safety

- ***Lasers to dazzle drivers at Iraqi checkpoints (2006)***
 - *“US soldiers in Iraq are to use lasers to **dazzle** drivers who fail to slow down at military checkpoints.”*
 - *“Military officials hope use of the lasers will help prevent innocent Iraqis and foreigners being shot as they approach the checkpoints.”*
 - *“Beyond 70 m it complies with US safety standards, having a power output of less than 2.56 mw per cm². At a shorter range the laser's power output becomes **unsafe** and would be expected to cause **lasting eye damage**.”*
 - *“Lasers designed to cause permanent blindness were internationally banned under a UN agreement in 1995.”*
 - <http://www.newscientist.com/article/dn9201>

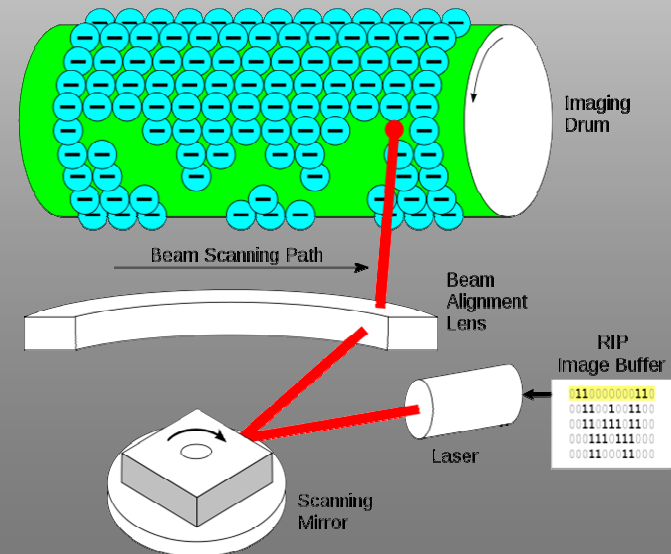
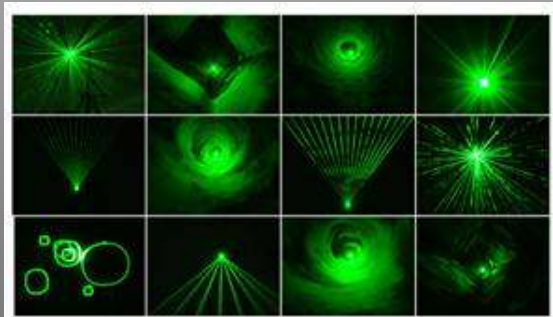
Lasers in Consumer Tech

- *Optical Storage Media*
 - *CD, DVD, Blu-ray, Holographic Disks*
 - *Millions sold, helped make LASERs affordable for other uses*
- *Fiber-optic Telecommunication*
 - *Use modulated light pulses to transmit data over long distances with bandwidth via glass fibers*
 - *LASER has better coupling efficiency and faster switching than LEDs*



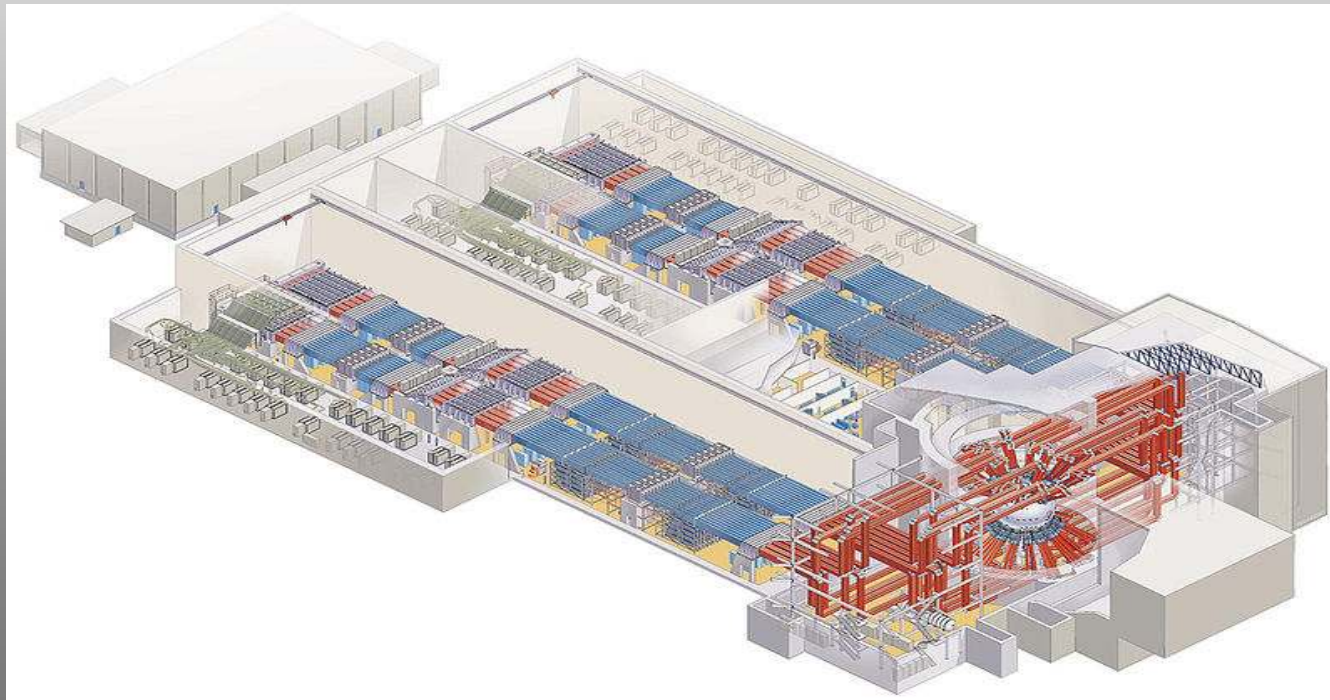
Lasers in Consumer Tech

- *Laser Printers*
 - *Printer Drum is negatively charged, dry toner particles are positively charged*
 - *LASER neutralizes the charge where the image is white so toner does not stick*
 - *Highly focused beam allows for high resolution imaging*
- *Laser Pointers*
- *Club / Entertainment Laser*



Lasers in Science

- National Ignition Facility (Lawrence Livermore Lab, CA)
 - Laser-based Inertial Confinement Fusion (ICF) device
 - 192 high-powered lasers heat and compress Hydrogen to induce Nuclear Fusion
 - Goal is to reach *ignition* where there is a net energy gain



Lasers in Science

- Lasers as Weapons: Strategic Defense Initiative
 - Space-based lasers to destroy satellites and missiles
 - Nicknamed 'Star Wars' program, commissioned by Reagan in 1980s
 - Lasers are in a class known as Directed Energy Weapons which also includes sonic and traditional (incoherent) light weapons



Lasers in Science

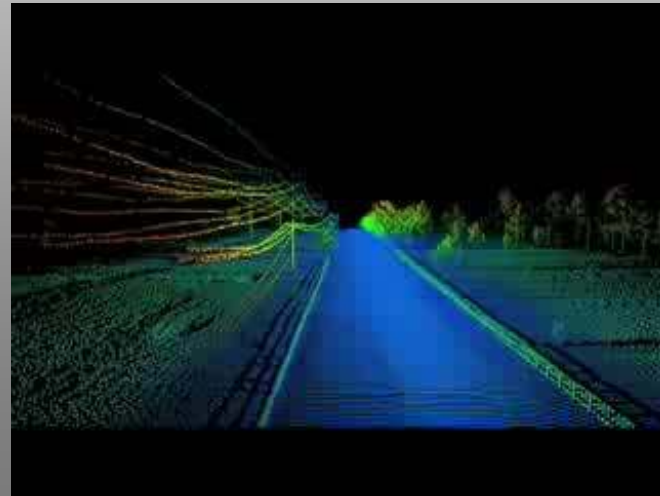
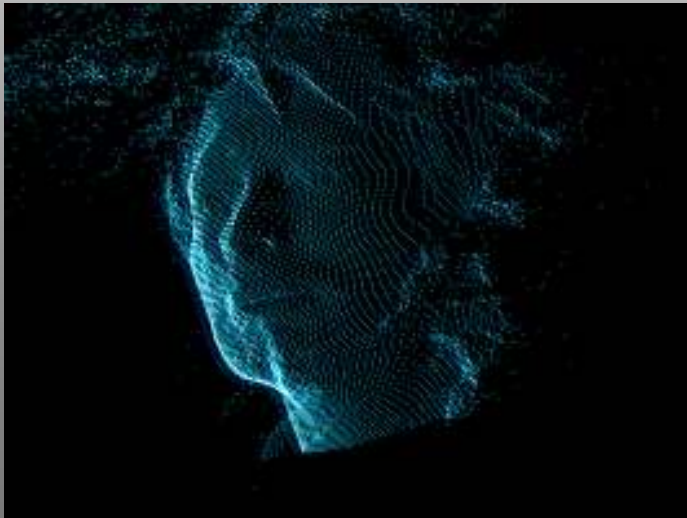
- Lasers as Weapons: Strategic Defense Initiative
 - Lasers can also be ground-based
 - Smaller scale lasers for anti-personnel purposes
 - http://en.wikipedia.org/wiki/Starfire_Optical_Range
 - http://en.wikipedia.org/wiki/Strategic_Defense_Initiative



- Laser Beam Welding (LBW)
 - High power and focused energy is good for quick & accurate welding
 - Used frequently in Automotive manufacturing due to high throughput
- Laser Cooling
 - Specially tuned laser frequencies can cause atoms to scatter photons and lose momentum which results in a net cooling effect
 - Lowest possible frequency is called Doppler Temperature and depends on the atom
 - Pioneered by Steven Chu, current U.S. Secretary of Energy

Lasers in Art

- 3D Laser Scanning
 - Laser beam used to accurately measure distances & depth across a field of view
 - Laser rangefinder measures time-of-flight of laser pulse to determine distance
 - Rotating mirrors allow measurement of every point in field-of-view
 - Typically measures 10,000 – 100,000 points per second
 - Used in architectural planning and preservation but also in art
 - Example: Radiohead House of Cards video
<http://www.youtube.com/watch?v=8nTFjVm9sTQ>
<http://code.google.com/creative/radiohead/viewer.html>



Lasers in Art

- Laser Painting

- Long exposure photography with laser light as the painting medium

- Used to accentuate a real-life scene or entire scene

<http://www.nova.com>

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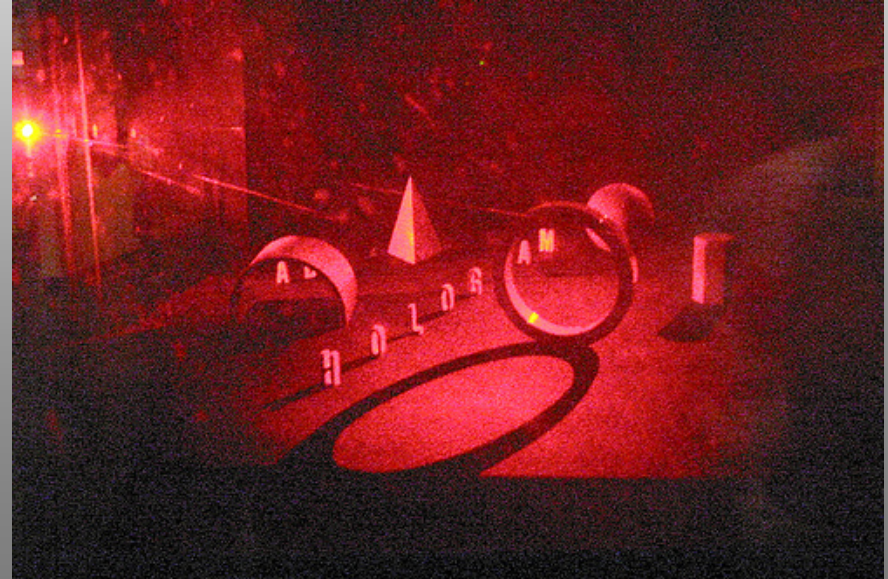
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NOVA
lasers

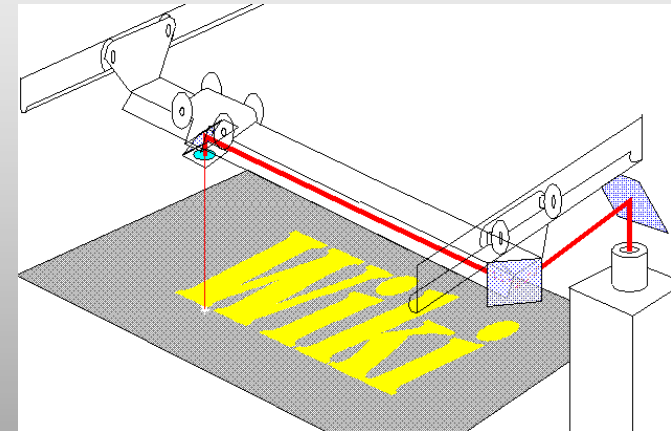
Lasers in Art

- Holography
 - Light scattered from a 3D object is record and later reconstructed
 - Allows a 2D surface to appear 3D
 - Discovered in 1947 by Dennis Gabor, Salvador Dali was an early pioneer of Holographic Art
 - MIT Museum has large collection of holographic art



Lasers in Art

- Laser Engraving
 - Highly focused energy allows for detailed patterns to be engraved on a solid surface without affecting the rest of the surface



Lasers in Art

- Laser as a designator for interaction
 - Cameras can easily see a bright laser pointer which lets a user interact with a system
 - My robot pointer example: http://www.youtube.com/watch?v=wvlJ_d9yXus
 - Large Scale example: **L.A.S.E.R. Tag**
 - Graffiti Research Lab, Rotterdam
 - Camera tracks laser dot and projects graffiti in response
 - Software available to download:
<http://muonics.net/blog/index.php?postid=26>



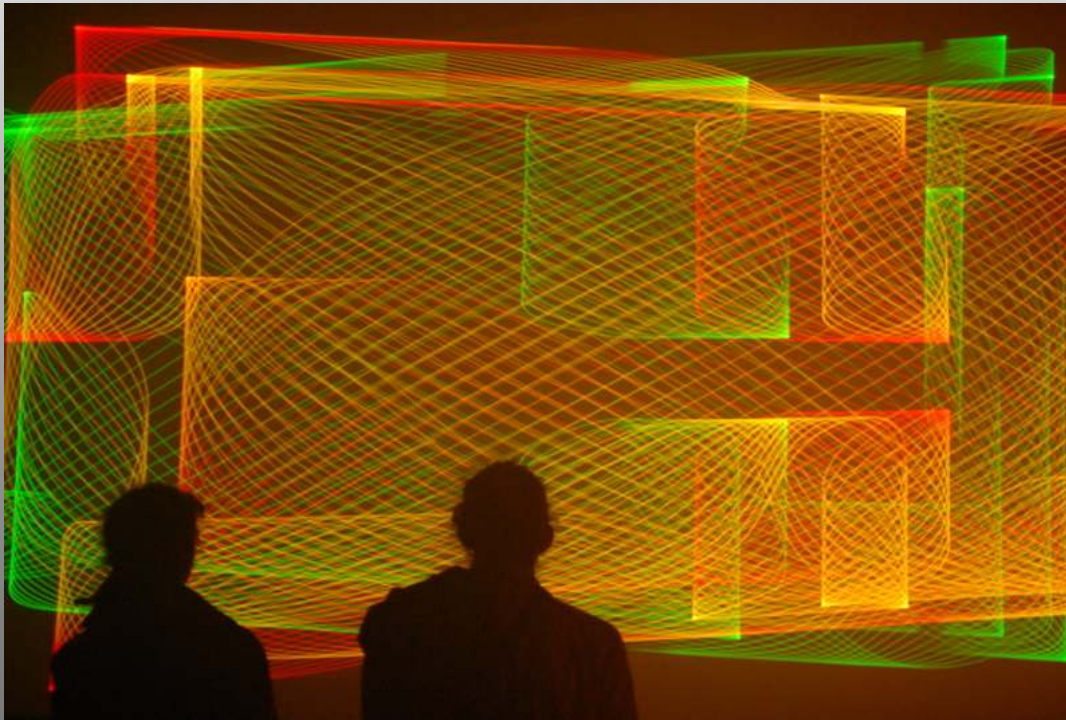
Lasers in Art

- Laser beams as art: Hiro Yamagata
 - large scale colorful laser installations
 - Guggenheim Bilbao Spain, 2001
<http://www.hiroyamagata.com/exhibition/>



Lasers in Art

- Laser beams as art: Edwin Van der Heide
 - Laser Sound Performance 2004-2007
 - Visualizing sound using lasers. Uses Lissajous figures which relate X and Y using pairs of sinusoidal waves
<http://www.evdh.net/lsp/index.html>



Lasers in Art

- Laser beams as art: Hope Street Project
 - Two Cathedrals in Liverpool, England are linked via green laser
 - A second laser beam is used to create a sound effect
 - <http://www.hopelaser.com>



Lasers in Art

- Laser beams as art: Flaming Lips
 - Gave hundreds of laser pointers to the audience at their concert
http://www.youtube.com/watch?v=LRIU_gO64_4



My Project:

- Laser Shadow: Interactive installation where passersby are shadowed by an outline of their movements
- Place a webcam facing a solid colored wall in a hallway such as Elings
- Use Computer vision software to perform edge-detection on the video
- Filter the video to isolate major forms (i.e., people)
- Time delay the video so it is behind the subjects
 - Latency would make it difficult to do a true outline so it should be delayed
 - Safety concerns also suggest this approach
- Draw the detected edges via laser

My Project:

- Similar project: Aperature
 - <http://www.fredericeyl.de/aperture/index.php?main=2&sub=8>



My Project:

