Can we make enemy soldiers blind using lasers?

by

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Background:
Lasers have long been used by our military forces:

- In distance measurements
- Target pointer in aircrafts for smart bombs
- Target pointer on rifles
- Beam rider for steering missiles
- Flash blinder for disturbing missiles and pilots
- Gated viewing through fog
- Green light submarine detection
The classification of lasers is almost the same everywhere in the world, but the rules concerning civilian use of lasers and rules for permission and registration of instruments vary from country to country.

Military use of lasers are in most countries not ruled by civilian laws.
What about laser weapons?

If you can cut in steel, then you can destroy an eye. How dangerous are actually different lasers?

Can we make soldiers blind?
Many people think that looking into a laser beam can make them blind.

Is that correct?

Yes, there are such lasers! I will describe some of them and show examples.
This laser was never produced. But it is possible to make it, if enough money is available. It was constructed theoretically under Richard M. Nixons administration in USA and about 20 units was thought to circulate in satellites around the earth. The intention was to burn Russian nuclear missiles when they came up through the atmosphere. This laser could possibly make you blind – it can cook you.

This laser, a laser diode, often used in a therapeutic laser instrument. This laser can not harm you. It can possibly help healing an injured eye!
This fibroma was removed with a 15 watt surgical CO$_2$ laser, 50 mm focal length.

Can that laser make you blind? **NO.** It might burn the cornea in or near the focal area, but not make someone blind!
An Alexandrite laser for hair removal.

Can this laser make you blind?

NO
These lasers can make you blind

But they are very expensive, very heavy
and takes a lot of kilowatts to run
This laser can make you blind

Price: 380,000 €
A Q-switched Nd:YAG-laser – can it make you blind if someone shoots right into your eyes? NO
Dart arrows ...

Price: 2.50 €

... can make an eye blind
Ear protection must be worn too!
A slingshot can make you blind. It can be used by anyone older than 5. It is very cheap. You don’t need a responsible doctor ….
Bullet proof vest must be worn.

No comments !!!

It would be much safer if it was a class 4 laser; they might cause an injury, but they can’t make you blind.
CAUTION: Pointing a laser into someone’s eyes can be hazardous to his health. However, it is somewhat less hazardous than pointing a gun at someone.
Other laser risks

High voltage

Warning! High voltage capacitors are ridiculously dangerous things. They can store enough energy to kill you instantly.
Examples of eye injuries from strong lasers
Figure 1. Retinal Injury in a Teenage Boy and Laser Pointers.

A photograph of the fundus of the left eye.

A photograph of the fundus of the right eye.
What is strange with this report is that this boy has injuries in the fovea of both eyes. It means that two different “shots” have been fired, first in one eye, then in the other. Such a shot is rather painful. To get a permanent injury, both high power and enough exposure time is needed.

To injure the fovea, you need to look directly into the beam. First with the laser pointed to one eye and then to the other.

It is difficult to understand that such a thing can happen by mistake. The measured output of the laser in this case was 150 mW and a single sweep over the eyes can not cause such injuries.
Lars is looking into two green laser pointers, 50 mW and 5 mW power.
Three shots from a Nd:YAG-laser, from three different angels into a rabbit eye, caused bleeding.

From K. L. Barat, photonic Spectra, March 2005
Injury from a military range finder; Nd:YAG-laser.

From K. L. Barat, photonic Spectra, March 2005
Very strong laser pulses, e.g. from Q-switched lasers, can cause "blooming" and even an "explosion" in the retina.

So, be aware of Q-switched lasers, they will not make you blind, but can cause a serious injury in the retina.
Eyes can stand much stronger light than most people believe.

Also, if we get an injury, healing processes starts and the eyes are no exception. Eye injury healing processes can also be stimulated by Laser Phototherapy.
Further, strong lasers are used in the following eye treatments:

- Laser trabeculoplasty for open angle glaucoma
- Laser iridotomy in pigment dispersion syndrome
- Laser photocoagulation for neovascular age-related macular degeneration
- Photodynamic Therapy of wet macular degeneration
- Laser assisted in situ keratomileusis (LASIK) for myopia correction
- Laser treatment of diabetic retinopathy
- Laser treatment of solar retinopathy
- Laser treatment of age related macular degeneration
- Lasering drusen
- Treatment of keratoconjunctivitis with LLLT
- Correction of myopia (PRK) and astigmatic keratotomy (AK)
- Laser in transpupillary thermotherapy (TTT)
- Laser photolysis of cataract
- Laser welding of the cornea
- Laser posterior capsulotomy
- Selective retinal pigment epithelium laser treatment

... and some other treatments
Also, it is not "laser" light that may be dangerous.

It is any light of certain power, and exposure time, in certain wavelength interval, with certain pulse energy (if pulsed), with certain geometric configuration (divergence, solid angle) etc that may cause such irradiation in the retina that the MPE (maximum permissible exposure) is exceeded much enough.

Examples of such light sources are IPL, strong flash lamps, certain xenon arc lamps.
Are there good protection possibilities?

Yes, most important is knowledge!
Laser safety glasses are very efficient but there is a risk:
If you use the wrong type, you may think that you are protected, but may be not.
Then, what makes some lasers dangerous?
There are certain risk factors, which?

Summary of risk factors

1. High power
2. Long exposure time
3. Parallel beam
4. Not visible wavelength
5. Small beam diameter
6. Extreme pulsing (e.g. Q-switching)
7. Using a binocular when looking into a laser.

1. Extended source / several sources decreases the risk.
Narrow beam - one of the risk factors

A wide beam is less hazardous to an eye than a narrow beam because only a fraction passes through the pupil, the rest comes outside.
Classification of lasers – laser classes

Parameters:
- Laser type
- Wavelength
- Output power
- Divergence
- Extended source
- Pulsing

The classification of lasers is one of the procedures that are included in the so-called CE-approval containing a lot of international standards.

A classified laser will belong to one of the groups 1 – 4.

1, 2, 3R, 3A, 3B

In Sweden, lasers in these groups are free to use. Doctor or dentist

4
An eye is working like a digital camera where the retina is a detector matrix with millions of pixels in the form of light sensitive cells. When these cells are hit by visible light, they are producing a nerve signal. From this signal, our brain is building up an image.

When looking against the sun, the image will be a picture of the sun with sun spots and all. In the case of an unpleasant intensity, our blink reflex is "switching off", first by blinking then by turning your head.
A parallel beam is depicted at the retina as a small point.
Beam divergence.

Laser

Size of pupil 7 mm $\phi$

Size of beam 10 cm $\phi$
Green laser pointer was used to attack the well known football player Lionel Messi.

The spot is encircled on the figure to the left. In the newspaper article it was said: "He could have been blind!"

Size of a pupil. About 0.1% of the laser light can pass through the pupil. If the laser power is 100 mW, about 0.1 mW can reach the retina.
Let us assume a Q-switched Nd:YAG-laser for distance measuring. Aperture diameter 7 mm, beam divergence 1 mrad and pulse energy 1 J. Just in front of the laser this can cause a serious retinal injury.

Energy density outside aperture is 2.6 J/cm² and at 100 meter distance (it has then a diameter of 10 cm) the energy that can pass through a pupil with a diameter of 7 mm is 0.005 J. This is not enough to cause an injury unless the target person is looking directly at the laser with binoculars in the moment of firing.
The pupil is limiting the laser power that is entering into the eye.

2 cm wide laser beam

The focused laser beam has a diameter in the order of a few micrometer
The lens is focusing the laser beam on the retina. The focus point has a diameter in the order of a few micro meters. A possible retinal burn is very small.
Different directions

If two strong lasers hit the eye from two different directions, there will be two retinal burns.

However, in order to make a person blind, a lot of burning with many different incident angles have to be performed.
Treatment with two HeNe-lasers
<table>
<thead>
<tr>
<th>Wavelength in nm</th>
<th>Risk Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Far IR and MidIR</td>
<td>Very low risk spectral region</td>
</tr>
<tr>
<td>2500 nm</td>
<td>Low risk spectral region</td>
</tr>
<tr>
<td>1400 nm</td>
<td>Most dangerous spectral region</td>
</tr>
<tr>
<td>Near IR</td>
<td></td>
</tr>
<tr>
<td>800 nm</td>
<td>Visible light</td>
</tr>
<tr>
<td>400 nm</td>
<td>Ultraviolet radiation</td>
</tr>
<tr>
<td>Near UV 300 nm</td>
<td>Low danger for laser but be careful with mercury lamps and arc welding</td>
</tr>
<tr>
<td>Mid and far UV</td>
<td>Ultraviolet radiation with shorter wavelength than 300 nm is stopped by the cornea. The excimer lasers emit in this region. Sunshine in snowy areas and welding can cause snowblindness.</td>
</tr>
</tbody>
</table>

Infrared radiation with wavelengths longer than 2500 nm is stopped by the cornea. Here we find the CO₂-laser and the Er:YAG-laser.

Infrared radiation with wavelengths between 1400 and 2500 nm is stopped by the lens. Here we find the Ho:YAG laser.

Visible and infrared radiation from 800 to 1400 nm is focused on the retina. Here we find most of the lasers, e.g., Nd:YAG, Ruby, GaAs, GaAlAs, HeNe, Indium, Argon laser.

Ultraviolet radiation with wavelengths between 300 and 400 nm is stopped by the lens. There are no lasers within the medical field in this region. The sun and solariums emit here.
**Therapeutic lasers (usually in laser class 3B)** ...

... are practically risk free. **Fear of lasers** cause more problems than the lasers themselves do.

Therapeutic lasers are usually in the power region 1 - 500 mW.

**Therapeutic lasers can cure** many eye diseases
Low-Level Laser Therapy Improves Vision in Patients with Age-Related Macular Degeneration

Boris T. Ivandic, M.D., and Tomislav Ivandic, M.D.

**Results:** LLLT significantly improved visual acuity ($p < 0.00001$ versus baseline) in 162/182 (95%) of eyes with cataracts and 142/146 (97%) of eyes without cataracts. The prevalence of metamorphopsia, scotoma, and dyschromatopsia was reduced. In patients with wet AMD, edema and bleeding improved. The improved vision was maintained for 3–36 months after treatm.
**Conclusion:**

Lasers are of very low risk compared to:

- Dart arrows.
- Air guns.
- Knives.
- Stones thrown.
- Slingshots.
- Practically all weapons.
- Broken branches on trees in the forest.
- Fireworks
- Acids
- etc
There are stories about soldiers that have been blind by lasers.

They are not true.

Nobody,

... yes, nobody has become blind from a laser. Any laser.
Thanks for listening