Photonlexicon

Using a concave lens to increase divergence - picking the right strength
Printable View

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tocket   02-14-2010, 14:38

Using a concave lens to increase divergence - picking the right strength

I've been looking into installing a lens in my projector to increase the divergence enough to make audience scanning safe. I've seen recommendations to use -3 diopter lenses in small rooms, but I wanted to be able to calculate appropriate strengths for different conditions.

Lens strength is often specified in diopters. It is simply the inverse of the focal length, that is:

$D = 1/f$

Where D is the strength in diopters (m^-1) and f the focal length in meters. A collimated beam that passes through a lens will get a half-angle divergence of:

$\theta = r0/|f| = r0*|D|$

Where r0 is the radius of the collimated beam. Note that it's the absolute value of the strength that is used. A concave lens will give the same divergence as a convex of the same power. The convex lens will however have its focal point in front of the lens, which is not desirable. It is also interesting to note that the divergence is directly proportional to the beam diameter, which means that the initial size of the beams is very important and that they must be matched.

The size (radius) of the beam at a distance z is given by:

$r = r0*z/|f| + r0 = r0*z*|D| + r0$

For example, using a -3 diopter lens to diverge a beam with a 3 mm diameter and measuring at 4 meters:

$r = 1.5 \text{ mm} * 4 \text{ m} * |-3| \text{ m}^{-1} + 1.5 \text{ mm} = 19.5 \text{ mm}$

Which means that the beam will be 39 mm wide at 4 m. Assuming a circular beam with a flat profile (not very realistic though) the following equation can be used to calculate the irradiance, which is really what matters from a safety perspective:

$E = \Phi/A = \Phi/(\pi*r^2) = \Phi/(\pi*r0^2*z^2*D^2)$

Where E is the irradiance (W/mm²) and Φ is the radiant flux (W). To convert to W/cm², multiply by 100. While the obtained values here should be taken with a grain of salt, because beam profiles are never flat, it is useful to see that doubling the strength of the lens (or distance) gives 4 times lower irradiance. The actual irradiance must be measured to assure safety.

Hope this will be useful to someone.

Now, while on the topic of lenses. Where the hell do I get one? I've visited all my local opticians and it turns out that they don't actually have these lenses. Well, except for one... but he wanted 120 € for a single uncut plastic lens :eek:

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mixedgas   02-14-2010, 15:12

Now, while on the topic of lenses. Where the hell do I get one? I've visited all my local opticians and it turns out that they don't actually have these lenses. Well, except for one... but he wanted 120 € for a

single uncut plastic lens :eek:[/QUOTE]

I guess in Europe you do not have kiosks selling replacement glasses without perscriptions for 5-6$ a pair at every chemists??? (note for Americans, Chemist = Pharmacy Europe, I'm told...)

If not, surplusshed.com

Steve

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mixedgas

Hope this will be useful to someone.

THANK YOU!
This thread should be a sticky.... Surpirisingly this math is left out of most optics texts..

Steve

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tocket

> Quote:
>
> Originally Posted by **mixedgas** »
>
> I guess in Europe you do not have kiosks selling replacement glasses without perscriptions for 5-6$ a pair at every chemists??? (note for Americans, Chemist = Pharmacy Europe, I'm told...)
>
> If not, surplusshed.com
>
> Steve

Not in Sweden. You can buy reading glasses (positive strength) in many places, but if you're nearsighted you have to go to the optician and pay $$$. There actually seems to be a law regulating this.

Anyway, thanks to a certain forum member I am now sorted with the lenses. :)

3ricj

lenses

THorlabs or edmonds. They have quite a selection, and much of it can be low cost. Get an AR coated lens to match your lasers, and you are good to go!

> Quote:
>
> Originally Posted by **tocket** »
>
> Now, while on the topic of lenses. Where the hell do I get one? I've visited all my local opticians and it turns out that they don't actually have these lenses. Well, except for one... but he wanted 120 € for a single uncut plastic lens :eek:

White-Light

> Quote:

*Originally Posted by **tocket*** »

For example, using a -3 diopter lens to diverge a beam with a 3 mm diameter and measuring at 4 meters:

*r = 1.5 mm * 4 m * |-3| m^-1 + 1.5 mm = 19.5 mm*

Which means that the beam will be 39 mm wide at 4 m. Assuming a circular beam with a flat profile (not very realistic though) the following equation can be used to calculate the irradiance, which is really what matters from a safety perspective:

:eek:

Is that a mistake in the last line or have I missed a step. Its seemed to jump from 19.5mm to 39mm.

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krazer   03-13-2010, 13:50

Radius vs diameter
Laser people use diameter, scientists use radius :rolleyes:

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mccarrot   03-26-2010, 07:53

I can get you a -2.9 plano concave lens which will fit in front of your aperture.

10 euro ex shipping?

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aijii   03-27-2010, 22:40

Those calculations don't take into account the divergence of the beam before it enters the lens. If i set the lens strength to 0, with a 7mm beam in I get a 7mm diverged beam at a distance.

However just say that, your original beam had a half angle divergence of 1mRad, and the lens added an additional 1mRad, would the resulting divergence be a simple addition of these two ?

White-Light   03-28-2010, 03:00

Quote:

*Originally Posted by **krazer*** »

Radius vs diameter
Laser people use diameter, scientists use radius :rolleyes:

OK thanks, never noticed the difference in the formula. What comes of being non scientific (well for the last 30 years anyway!)

White-Light   03-28-2010, 03:09

As a related aside, what is the 100x MPE safe exposure reading for an 8mm diameter pupil?

ILDA always publish it as 100x MPE or 100 MW/cm².

However, as this means nothing in the real world to many people (without calculating and as

this relates most relevantly to the *simple method*) I've always wondered why they don't publish the standard as dual bracketed figure of 100 MW/cm² (XXmw / 8mm diameter) given that the pupil diameter is always an assumed constant.

Would make it much easier and safer for end users to implement if the figure was also quoted as a figure they could simply go out and use with a power meter with an 8mm sensor area. Obviously if sensor size if slightly different to 8mm eg 7mm (I'm not sure what the standard aperture is, then the figure could eg be quoted in terms of 100 MW/cm² (XXmw / 7mm diameter laser power meter head). Point is to make it easy for the end user to implement with a standard sized power head.

It takes away the risk or complication of further erronous calculation introducing end user errors or the risk of the end user interpreting 100 MW/cm² as 100 MW/ sensor reading.

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mccarrot   03-28-2010, 07:52

100Mw/cm2 will even fry your brains :eek:

The MPE for your eye calculated with a blink response of 0,25 seconds = 2,5mW/cm2

A MPE for typical slow scanning beam (0,01s) = 10mW/cm2 this is what "they" call MPE

But for a fast scanning show where the pulse duration is "only" 18microseconds the MPE = 27mW/cm

Now with the new simplified method they are talking about 10MPE which is considered relatively safe then they refer to 10x the standard MPE = 100mW/cm2

All these MPE values are measured with a pupil diamter of 7mm

1 When there is some ambient lighting (there always is) and your pupil is 5mm instead of 7mm the exposure is reduced by 50% and the pulsetime is reduced by 30

2 In the real world you also have things called adverse reaction where the pupil get smaller, and the head is turned away.

Those last two parts are the main reason why no accidents happen with the many high MPE shows you see everywhere.

White-Light   03-28-2010, 14:23

Thanks for the reply. I was talking about the 10x mPE standard but typed 100x MPE by mistake (I keep getting that confused!).

It was that which I was referring to when I said it might be easier for ILDA to quote a dual figure of 100mw/cm2 and another figure based on the average sensor diameter so that all anyone needed to do to use the simple method was check their sensor diameter against the stated ILDA diameter as quoted and take a straight measurement (no calculation needed that way provided your sensor was the standard size).

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mccarrot   03-28-2010, 23:46

Take a small piece of metal, drill a 7mm hole in it and put it in front of your detector.

If you read **3,6mW you are at MPE**

36mW = 10MPE

Its that simple, but you need sensitive head, most thermal meters are not that accurate in the mW range.

White-Light

03-29-2010, 01:01

Thanks :)........

JStewart

03-29-2010, 02:56

3.6mW through a 7mm aperture is not the correct MPE figure to use. Any system that does not have an effective scan-fail and a means of ensuring the effective pulse duration and repetition rate for the chosen MPE are not exceeded, should be using the 25.4W/m^2 irradiance, as the maximum exposure. Which means just under 1mW through a 7mm aperture. On the common Lasercheck, the detector size is 8mm, so this means the reading should be no greater than 1.27mW.

One thing people in the UK and Europe should be a bit careful of is stating that they are using the ILDA 10x MPE or 100x MPE. For to do so, at the moment, in some member states, and across the whole of the EU as of the end of next month, is stating that you are committing a regulatory offence.

ALDA (sorry ILDA:)) appears not to have told its members that in the EU there is a new regulation coming into force on the 27th April that effectively makes it a criminal offence to exceed the MPE, which is quite a surprise given how many of its members are European, and are therefore directly effected by this new legislation. The ICNIRP guidance figures that we have all been using as guidance in the past, are set to become the legal limits.

Now whether we think the levels are correct or not, is neither here nor there unfortunately. They are what they are, and will, (if not already in some parts of the EU), become the mandatory limits.

So it's probably worth just being aware that putting it in writing that you are working to levels 10x the legal limit may not be such a good idea, in terms of insurance cover, or in the event a steward or member of bar staff etc wanted to claim that their eyesight had been effected by the laser effects.

James Stewart.

norty303

03-29-2010, 04:14

Quote:

> that effectively makes it a criminal offence to exceed the MPE

Ouch!
I'm surprised there hasn't been a bit more noise about this on the forum then.
Can you provide the details of the new regulation so we can read up?

However, I guess that any changes will only be as good as any enforcement, and opertors will continue to do their own thing regardless of guidelines/law

White-Light

03-29-2010, 05:45

Maybe ILDA need to revise the standard naming then so 10x MPE becomes the new MPE standard and what was MPE becomes the old standard.

Someone at ILDA clearly needs to contact the EU beaurocrats and liaise with them over this issue before the new standard becomes effetively outlawed by Eurocrats using an out dated standard.

JStewart   03-29-2010, 07:01

OK, I'll answer briefly on this thread, as I don't want to hijack what is an excellent topic about altering beam divergence. I suppose if this is something people want to speak about more, then it's only fair to start a new thread.

The new European legislation comes from the EU Directive 2006/25/EC. And as the numbering scheme suggests, this has been simmering on the back burner since 2006. The full text can be downloaded from:

Physical Agents (Artificial Optical Radiation) Directive 2006/25/EC

http://eur-lex.europa.eu/lexuriserv/...n0038 0059.pdf

As with most of these types of document, it is a good cure for insomnia. ☺

The goal of the legislation is to provide a minimum level of safety to workers where harmful light sources may be used, in a way that is uniform across the EU. It is therefore up to each member state to implement its own set of rules that meet the requirements of the 'Directive'. In the UK we are set to have this implemented with the new 'Control of Artificial Optical Radiation at Work Regulations 2010' which where published for consultation back in November 2009. Other countries will have their own equivalent regulations. And they may already be in force. France and Romania are two countries I know that have already implemented AORD.

You'll see that the directive not only covers lasers, but also non-coherent light sources. Initially there were concerns how this would impact the theatre and performance industries which use a wide range of high brightness light sources. But the research so far is indicating that the limits are not going to pose any significant problem. And as bright as some of these other sources may 'appear', none come close to having the same power densities of even a modest laser beam.

Unfortunately ILDA does not 'set' the standard on MPE limits. An ILDA 'recommendation' is not an international safety standard. It never was. It was just a recommendation. ILDA has no regulatory authority to issue safety standards, for they are only a trade association. The MPE data is produced by an international scientific organisation called ICNIRP. It is the EU parliament that has decided upon these values as the legally binding limits.

Unfortunately ILDA have been aware of this legislation for a while. I mentioned it to their safety chairman and director following the Russian incident, but received a rather dismissive reply. (hence my quip in my earlier post referring to them as the 'American' rather then 'International' Laser Display Association)

Patrick Murphy was also here in the UK in September last year, talking about ILDA's recommendation at a safety meeting where the EU directive was also spoken about in great detail. At the time I did point the potential problem with ILDA recommending to its membership in Europe the x10 MPE issue, and what it could mean it terms of liability. However, I'm sure they have their own plans on how they are going to advise members on staying within the law.

I'm actually not against the x10 MPE proposal itself, if it is used with reliable equipment and well thought out shows (e.g. no slow moving finger beams from multi-Watt lasers at close quarters). But my point was that people need to be a bit careful about how they approach this if they are not to be seen as irradiating people in excess of the new workplace exposure limits.

Sorry it turned out to not be so brief a response.

James.

mccarrot   03-29-2010, 07:58

Could you PLEASE post a new topic about the new Legislation in europe.

Most of us did not know about this but its mendantory information.

Thank you.

Doc   03-29-2010, 09:24

Quote:

    1 Attachment(s)

*Originally Posted by **mccarrot*** »

Could you PLEASE post a new topic about the new Legislation in europe.

Most of us did not know about this but its mendantory information.

Thank you.

Here's the full document.

Note that the chairman is a Mr H. Winkler, I always wondered what Fonzy was up to these days *retardo

norty303   03-29-2010, 09:31

Thanks very much for the very full and informative response James.
I agree, a thread in its own right would be best for visibility and maximum participation.
Perhaps it is up to the ILDA 'membership' to make it known that they would like some sort of steer if nothing is forthcoming.

White-Light   03-29-2010, 10:22

I've only glanced at it because I can't be bothered to read all of the bumph but as I read it (the 1st few lines anyway :)), its a workplace directive to protect "workers" not a public display directive so presumably the duty only applies to protecting employees from the radiation, not the audience at large.

I can see ways of overcoming this: 1. Keep all employees outside of the scanning zone (not necessarily practical eg in the case of security staff), or 2. Issue employees with safety equipment so as to protect against the hazard when they enter the scanned zone eg. laser goggles and if necessary clothing that protects the skin.

PS sorry for the thread hijack but expanding beams for safety is kind of related. I do agree some seperation would be nice but its best done by a mod as then posts can be moved.

Doc   03-29-2010, 10:28

Quote:

*Originally Posted by **White-Light*** »

Issue employees with safety equipment so as to protect against the hazard when they enter the scanned zone eg. laser goggles and if necessary clothing that protects the skin.

Can you imagine the fear that would strike into your audience?

Employees "suiting up" with PPE to venture in to the audience scanning zone!

White-Light

Quote:

> Originally Posted by **Doc** »
>
> *Can you imagine the fear that would strike into your audience?*
>
> *Employees "suiting up" with PPE to venture in to the audience scanning zone!*

Its better than not having a show. Don't employees already have to wear ear plugs in nightclubs (or at least be issued with them?).

I also see customers regularly wearing sun glasses in trance audiences. It wouldn't take a huge leap of faith to see a company producing wrap around stylish sunglasses for employees with laser protective lenses in.

norty303

Now started a dedicated thread starting with James post over here
http://www.photonlexicon.com/forums/...767#post140767

aijii

Maths

I'm trying to convert the equation above to a form that allows one to calculate the distance for a given irradiance...

its been almost 10 years since I did maths at school... my head hurts.

anybody care to help ?

Doc

I will make this into a spreadsheet when I have time, right now I am having a 5 miunte break from soldering up my interlock boards *retardo

mccarrot

I just checked, the concave lenses I have are -2,7 This increases the divrigence enough to be at 10MPE for my 500mW at 8 meters distance.

So for small venues its perfect.

I also demonstrated the lenses at the last snowLEM. You would think fat beams would destroy the whole laser effect, but it stays pretty nice to watch.

I think greenalien also got some of these lenses

aijii

Quote:

1 Attachment(s)

> *Originally Posted by **Doc** »*
>
> *I will make this into a spreadsheet when I have time, right now I am having a 5 miunte break from soldering up my interlock boards *retardo*

You mean like this ? ;)

Trying to solve the E = Radiant Flux/Area equation to provide the distance for a given irradiance.. as you'll see in the spreadsheet.. but there is no formula yet..

White-Light

03-30-2010, 15:59

Quote:

> *Originally Posted by **mccarrot** »*
>
> *I just checked, the concave lenses I have are -2,7 This increases the divrigence enough to be at 10MPE for my 500mW at 8 meters distance.*
>
> *So for small venues its perfect.*
>
> *I also demonstrated the lenses at the last snowLEM. You would think fat beams would destroy the whole laser effect, but it stays pretty nice to watch.*
>
> *I think greenalien also got some of these lenses*

Have you tried higher power lenses at smaller distances?

Myself and Jem had a brief play a while ago with lenses up to -12 diopters on the 500mw I had and the beams looked Ok but I'd have to concede the distance was probably only 2 metres as we were in a small office at the time.

I was just wondering at what lens power point and distance the beams start to become so fat that the show breaks down.

A local event to me currently uses a 1W laser (I'm told could be making 1.4-1.5 watts) with no power reduction and the nearest person maybe 20 feet from the beams. Although no one has been hurt and although no camera damage has occurred, I'd like to try increasing safety by offering some advice.

As the venue is very small maybe only 60 feet end to end (dance floor area alone) I was kind of wondering what the highest power of lens you could get away with in that kind of area without destroying the effect.

BTW I in no way condone the use of a 1-1.5 Watt laser in this size venue or so near to the crowd. However, I have no connection with the organisation nor any influence over the organisers although I do know them at aquiantance level.

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mccarrot

03-31-2010, 09:51

Quote:

> *Originally Posted by **White-Light** »*
>
> *A local event to me currently uses a 1W laser (I'm told could be making 1.4-1.5 watts) with no power reduction and the nearest person maybe 20 feet from the beams. Although no one has been hurt and although no camera damage has occurred, I'd like to try increasing safety by offering some advice.*

You wont get "hurt" or "blind" that fast, but you can almost sure people have had "changes" to the eye. but most people would not even recognize those changes, as a normal person would not know the difference between a floater, and eye damage caused by lasers.

But I'm not sure if its wise to put this kind of information on a public forum, because maybe people will think a floater is caused by a laser.

I will Put the -2.7 lens in front of my 700mW Brick and measure the divrigence before and after.
But I think a bigger value of -3 is unusable unless the location is really small.

mccarrot   03-31-2010, 10:28

Here we go,

3 Attachment(s)

Laser used, Viasho 650mW putting out 500mW after the apperture (dirty galvo mirrors)

Beam size at apperture: 2mm

Beam size at 5 meters: 5mm

Beam size at 5 meters with -2,7 concanve aprox 30mm

mw/cm2 at 5 meters without concave: 1700mw/cm2!! (this is 170xMPE)

mw/cm2 at 5 meters with -2,7 concave 170mW/cm (17xMPE)

(measured wih a coherent fieldmax TOII, ultra sensitive PM3 head and a 7mm aperture)

So you can see the power is reduces by a factor 10 with a -2.7 lens.

Can someone calculate the divergence? i'm too lazy to find the formula :o

Doc   03-31-2010, 11:43

5.599 mrad .

mccarrot   03-31-2010, 13:33

Thanks,

I also found a calculator:
http://www.pseudonomen.com/lasers/ca...alculator.html

So without the lens the laser got 1mRad divergence, and with the lens 5mRad divergence and decreasing the exposure by a factor 10.

So a -2,7 concave is a good lens to have with your laser gear.

White-Light   03-31-2010, 15:26

Very interesting and many thanks for doing the tests, much appreciated.

Although its probably not a linear response, a rough guesstimation based on a linear response and your figures would tend to suggest that the laser if 1.5w is probably at 510x MPE!!! (3x170x result).

I guess the only question that remains now is what effect stronger lenses have on both MPE and the visible beam quality at the furthest point at the back of the room. Being such a small venue I'm sure they could get away with a much more powerful lens but I wonder at what point the visible quality of the beam breaks down to a fuzzy rather than sharp beam.

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mccarrot   04-01-2010, 10:04

More info:

My 500mW viasho with 500mW after the aperture window did 6MPE (60mW/cm) (yes I have a working scanfail) after 30meters distance.

The laser got a aprox divergence of about 1,5mW and after 30 meters the beams already started to look fat.

So a -2,7 lens at this distance will look ugly