Re: Stargazer arrested for using green laser

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From: canopus56 (*canopus56_at_yahoo.com*)
Date: 01/07/05

Date: 7 Jan 2005 14:26:35 −0800

Larry Stedman wrote:
<snip> Something about distance and beam diffusion, etc.
> It'd be interesting to hear from those who posted that what they make of
> all this.

My primary interest in the green laser threads was to better understand how to compute the size of hazard zones and the likely vision effects within those zones when using consumer Class IIIA lasers at star parties. The following computations may be a useful quanitification on the effects zones for consumer Class IIIA lasers with respect to aircraft dicussed in this and other threads.

In summary, with respect to a star party, the flash blindness zone for a Class IIIA laser probably is around 270 feet; the glare annoyance effect zone (applicable to your aircraft question) probably ends at around 1200 ft. Additionally, other star party attendees will reflexively blink if their eyes are struck by a consumer Class IIIA laser up to 50ft away. (For the aircraft scenario, I seem to recall that FAA visual flight regulations require aircraft to maintain an altitude of at least 1000 ft above of the ground at all times, except during landing and take−off.)

This estimate is based on my informal amateur calculations for a Class IIIA laser (5mWatts< and 1 milliradian dispersal) and is consistent with FAA published effects for the biological effects of consumer lasers.

A FAA biological laser effect study lists two key emission levels of concern by consumer laser users who want to avoid annoying community members:

1) Flash−blindness and after images can occur to luminosity levels of 1 x 10−4 Watts^cm.

2) Annoyance glare occurs to 5 x 10−6 Watts^cm.

The following table is the source for these effects and emissions levels. (The MPE Level column in the following table is relevant to the following discussion. The Nominal Hazard Zone in this reference applies to non−consumer Class IIIB and IV lasers.)

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Table 1 − Excerpt from Rockwell "Safety Recommendations of Laser Pointers"

Rockwell, Jr., James R., and Ertle, William J., Rockwell Laser Industries, Moss, C. Eugene, National Institutes of Occupational Safety & Health. Undated. Safety Recommendations of Laser Pointers. << http://www.rli.com/resources/pointer.asp undated, accessed 1/5/2005 >>

The NHZ associated with open−beam Class IIIB and Class IV laser installations can be useful in assessing area hazards and implementing controls. The summary in Table 1 shows the magnitude of the NHZ's for a visible frequency laser pointer emitting 5mW:

Table 1

Nominal Hazard Zones for Visible Diode Pointers
Power: 5 mW − Divergence: 1 mr − beam size: 2 mm
Based on: FAA 74002D Outdoor Laser/High Intensity Light Demonstrations

Bioeffect MPE Level * Nominal Hazard Zone
Condition (W/cm2) (feet)

BLINK REFLEX 2.6 x 10−3 51

FLASH−BLINDNESS
/AFTERIMAGE 100 x 10−6 262

GLARE 5 x 10−6 1,171

"NO EFFECT" 50 x 10−9 11,707

[MPE = Maximum premissible exposure]

The different visual effect "MPE" criteria used in the NHZ computations in Table 1 were are based upon the U.S. Standard for the Federal Aviation Administration: FAA 74002D Outdoor Laser/High Intensity Light Demonstrations which provide a numerical basis for the various bioeffect criteria [6].

(6) FAA 74002D Outdoor Laser/High Intensity Light Demonstrations: From Chapter 34: Outdoor Laser/ High Intensity Light Demonstrations, Federal Aviation Administration

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Class IIIA consumer lasers emit less than 5 milliWatts and have a dispersion of 1 milliradian. The following table is my informal computation showing the diameter of the beam and the energy density at various distances. These numbers overstate the hazard and annoyance zones, since the initial beam diameter assumed to be 0 mm. (1 or 2 mm initial beam size would be a more reasonable assumption.)

The key columns in the following table at the distance to the target (Dt ft) and the brightness of the emission at that distance (W^cm). Compare the W^cm column with the FAA biological effect limits.

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Table 2 − Informal computation of laser brightness at distance

Brightness computation for Class IIIA lasers
5mW< initial power and 1 milliradian dispersion

Dt ft	Dt m	Bdiain	Bdiacm	BAreain	BAreacm	W^cm	Per	dlt_mag
50	15	0.6	2	0.3	1.8	2.75E−03	55.08%	8.1
100	30	1.2	3	1.1	7.3	6.89E−04	13.77%	9.7
175	53	2.1	5	3.5	22.2	2.25E−04	4.496%	10.9
200	61	2.4	6	4.5	29.0	1.72E−04	3.443%	11.2
275	84	3.3	8	8.6	54.9	9.10E−05	1.821%	11.8
300	91	3.6	9	10.2	65.4	7.65E−05	1.530%	12.0
500	152	6	15	28.3	181.6	2.75E−05	0.551%	13.1
825	251	9.9	25	77.0	494.3	1.01E−05	0.202%	14.2
1000	304	12	30	113.1	726.2	6.89E−06	0.138%	14.7
1100	334	13.2	33	136.8	878.7	5.69E−06	0.114%	14.9
1500	456	18	46	254.5	1634.0	3.06E−06	0.061%	15.5
2000	608	24	61	452.4	2904.9	1.72E−06	0.034%	16.2
3000	912	36	91	1017.9	6535.9	7.65E−07	0.015%	17.0
4000	1216	48	122	1809.6	11619.5	4.30E−07	0.009%	17.7
5000	1520	60	152	2827.4	18155.4	2.75E−07	0.006%	18.1
6000	1824	72	182	4071.5	26143.8	1.91E−07	0.004%	18.5
7000	2129	84	213	5541.8	35584.6	1.41E−07	0.003%	18.9
8000	2433	96	243	7238.2	46477.8	1.08E−07	0.002%	19.2
9000	2737	108	274	9160.9	58823.5	8.50E−08	0.002%	19.4
10000	3041	120	304	11309.7	72621.6	6.89E−08	0.001%	19.7
11000	3345	132	334	13684.8	87872.1	5.69E−08	0.001%	19.9

Dt ft = Distance feet
Dt m = Distance meters
Bdiain = Beam diameter inches at distance
Bidacm = Beam diameter centimeters at distance
BAreain = Beam area inches at distance
BAreacm = Beam area centimeters at distance
mW^cm = milliWatts per square centimeter
Per = change in milliWatts per square centimeter from distance zero (5mW) to distance
dl_mag = same as Percent, expressed in changes in magnitude
delta_mag (m1 − m2) =

2.5 * log_10 * (mW^cm / 5mW at zero distance)

(Note delta_mag is not the apparent magnitude, since
magnitude at distance zero is not known)

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With respect to an inadvertent aircraft strike from using a consumer laser at a star party, at 1500 ft, a consumer Class IIIA laser has already dropped to well−below the emission level needed to cause an FAA measured flash blindness/after image effect (1 x 10−4 W^cm) and is below the FAA glare effect level (5 x 10−6 W^cm).

As others have noted in the various green laser threads in this usenet group, the 5mWatt emission of a Class IIIA laser is an upper limit. Many consumer Class IIIA lasers used by amateur astronmers operate at much less than 5mWatts. If your consumer laser pointer or other astronomical laser product (like a laser collimator) has a tag on it that says "CAUTION", it operates at less than 2.5 mWatts. If your consumer laser pointer has a tag on it that says "DANGER", is operates between 2.5 mWatts and 5 mWatts.

For comparision purposes, the following is a recomputation of Table 2 for a Class IIIA consumer laser emitting 2.5 mWatts:

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Table 3 − Informal computation of laser brightness at distance

Brightness computation for a Class IIIA laser emitting 2.5m Watts initial power and 1 milliradian dispersion

Dt ft	Dt m	Bdiain	Bdiacm	BAreain	BAreacm	W^cm Per	dlt_mag
50	15	0.6	2	0.3	1.8	1.38E−03	55.08% 8.1
100	30	1.2	3	1.1	7.3	3.44E−04	13.77% 9.7
175	53	2.1	5	3.5	22.2	1.12E−04	4.496% 10.9
200	61	2.4	6	4.5	29.0	8.61E−05	3.443% 11.2
275	84	3.3	8	8.6	54.9	4.55E−05	1.821% 11.8
300	91	3.6	9	10.2	65.4	3.83E−05	1.530% 12.0
500	152	6	15	28.3	181.6	1.38E−05	0.551% 13.1
825	251	9.9	25	77.0	494.3	5.06E−06	0.202% 14.2
1000	304	12	30	113.1	726.2	3.44E−06	0.138% 14.7
1100	334	13.2	33	136.8	878.7	2.85E−06	0.114% 14.9
1500	456	18	46	254.5	1634.0	1.53E−06	0.061% 15.5
2000	608	24	61	452.4	2904.9	8.61E−07	0.034% 16.2
3000	912	36	91	1017.9	6535.9	3.83E−07	0.015% 17.0
4000	1216	48	122	1809.6	11619.5	2.15E−07	0.009% 17.7
5000	1520	60	152	2827.4	18155.4	1.38E−07	0.006% 18.1
6000	1824	72	182	4071.5	26143.8	9.56E−08	0.004% 18.5
7000	2129	84	213	5541.8	35584.6	7.03E−08	0.003% 18.9
8000	2433	96	243	7238.2	46477.8	5.38E−08	0.002% 19.2
9000	2737	108	274	9160.9	58823.5	4.25E−08	0.002% 19.4

10000 3041 120 304 11309.7 72621.6 3.44E−08 0.001% 19.7
11000 3345 132 334 13684.8 87872.1 2.85E−08 0.001% 19.9

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For the 2.5mWatt laser, the flash−blindness zone (1 x 10−4 W^cm)
ends around 200ft; the glare effect zone (5 x 10−6 W^cm) around 825ft.

I hope the above provides some illumination (minor pun intended −:)
) on this discussion, and promotes safe consumer Class IIIA laser use
at star parties.

− Canopus56

P.S. − I have no special physics training or background.