Green Laser Pointers: SMART Use

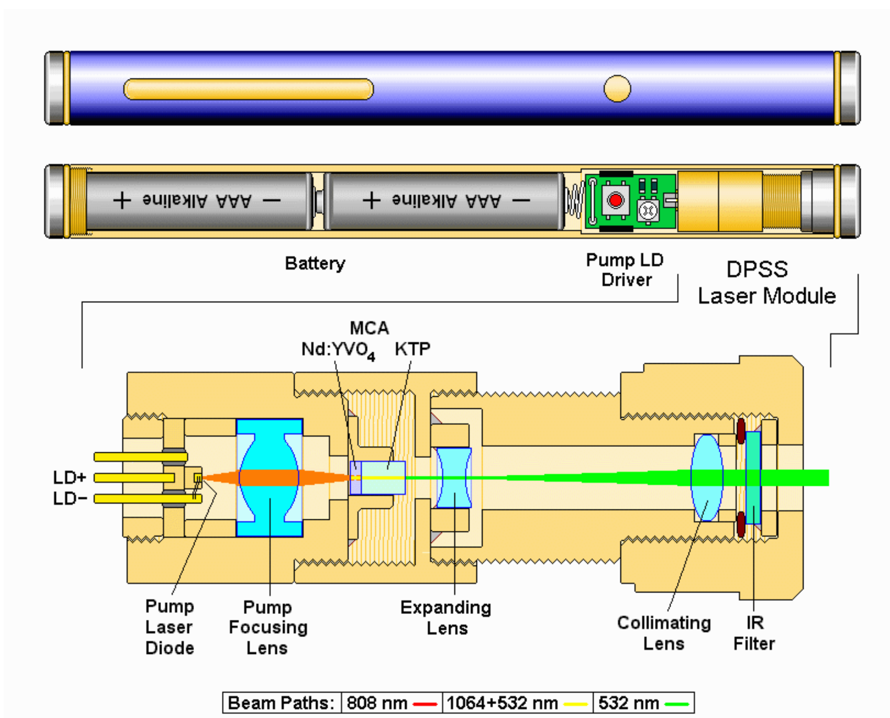
RASC GLP Committee

2010 marks 50 years since the "invention" of the laser. The laser (***L***ight ***A***mplification by ***S***timulated ***E***mission of ***R***adiation), in common with rocket-propelled space travel, electronic computing, and nuclear fusion, is seen as a classic technology of the modern age. One of the fathers of the laser, Nobel Prize winner Charles H. Townes, memorably characterized its invention as a "solution looking for a problem"(1). Applications in daily life and research have multiplied, along with improvements in the technology, towards a greater choice of wavelengths, dramatically increased power, and ever decreasing costs. Astronomers are among the beneficiaries of these developments, but maturity of technology is not always matched by maturity of use, and we may yet find our access to lasers for education and public outreach (EPO) severely curtailed by the immature actions of others.

Lasers owe their effectiveness to the coherence, amplification, and narrow divergence of the beam of monochromatic (single wavelength) light they emit. In simple terms, *coherence* occurs when waves are in a constant phase relationship (wave peaks and troughs are in step), *amplification* develops through the process described below, and *narrow divergence* results when the increase in beam diameter over distance is limited.

How do lasers work?

Energy is fed through a gain medium (e.g., gas, or crystal) by an energy pump raising electrons to a higher energy state; when the electrons in the higher energy state outnumber those in the ground state, population inversion occurs, leading to higher levels of stimulated emission (*i.e.*, an electron perturbed by a photon drops to a lower energy level releasing another photon), and more coherent light passes through the system than is absorbed. The optical amplification is increased when the coherent beam acquires further energy through reflection back and forth within a cavity resonator; when the gain medium is saturated, laser light passes through a lens and filter assembly, and finally out the front bezel.



Typical Green DPSS Laser Pointer Using MCA

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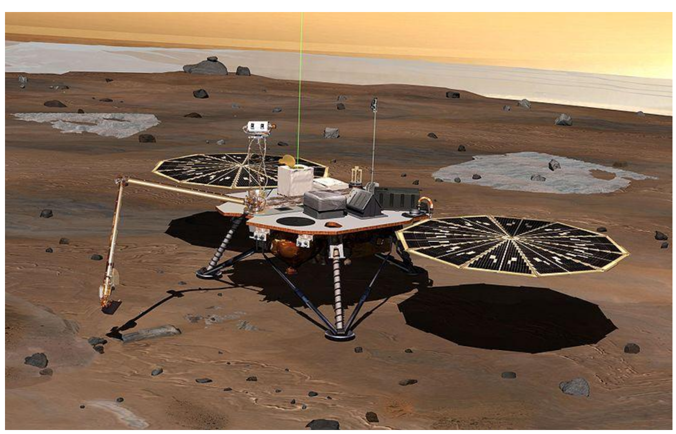
Lasers have found multiple uses in astronomy and space science. The most notable of such uses is the projection of laser guide stars in adaptive optics systems, a technology which can greatly reduce the effects of atmospheric distortion, and result in unprecedented gains in resolution.

Observatories of the Starfire Optical Range ©USAF

Lasers are also found in space, as in the LIDAR onboard the Mars Phoenix Lander.



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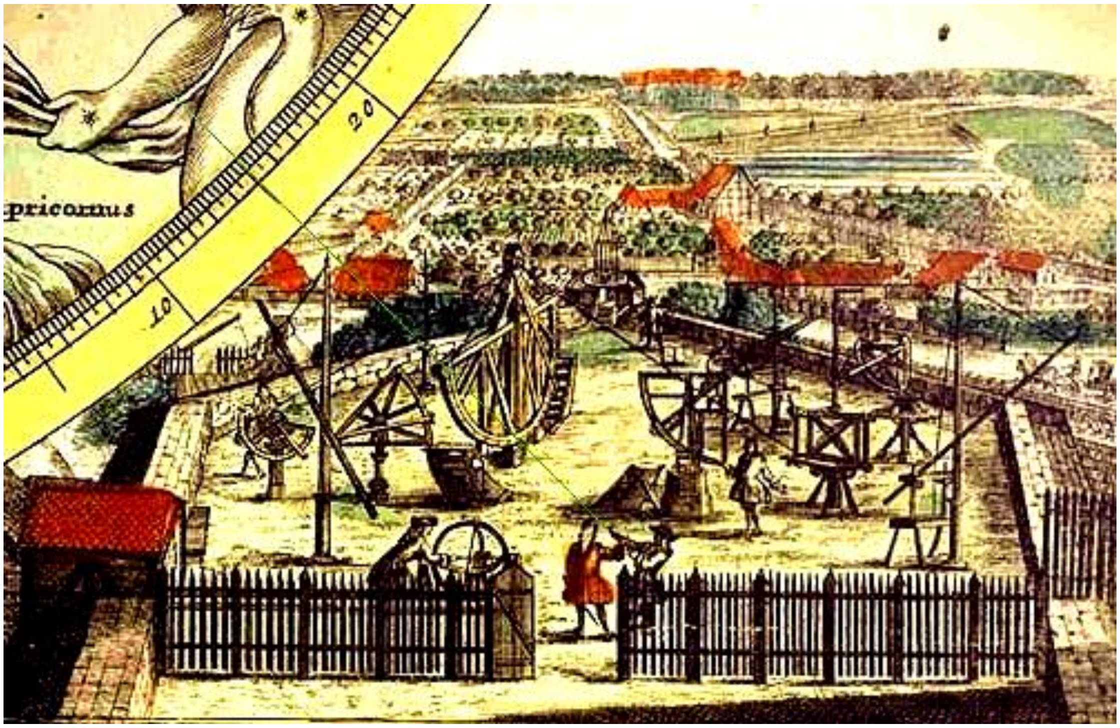

Georg Eimmart's Nürnberg Observatory as depicted in the Doppelmayr-Homann Atlas Cœlestis 1742, 18. An enlightenment star party. GLPs are not mentioned in the Encyclopédie, or the Trans. Roy. Soc., or by Messier; could this image show pernicious RASCal tampering?

The most common astronomical use for lasers is in EPO. Green Laser Pointers (GLPs), emitting light at λ=532 nm, have proved remarkably effective for pointing out celestial phenomena. This is because the peak sensitivities for photopic and scotopic vision are near this wavelength (at 555 nm and 507 nm, respectively). When directed skyward a GLP beam is visible because of Rayleigh Scattering (elastic reflection of light by air molecules), and scattering from larger air-borne particulate matter. This accounts for our perception of GLP light as **bright**.

If GLPs are increasingly available to astronomers for EPO, they are also available to socially-inept individuals absorbed in Star-Wars fantasies. This, unfortunately, is a problem for astronomers. Chief among the misuses of GLPs is the malicious flashing of aircraft. The problem predates the easy obtainability of GLPs; in 2001 more than 150 incidents of aircraft flashed with red laser pointers were reported over a 3-year period in one region of the US alone (2). The disorientating effect of GLP light in the cockpit of an aircraft is much greater than for red laser light. The ***danger*** is real.

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The GLP, useful in responsible and informed hands, can be dangerous in the hands of the irresponsible. **There is no creditable science case to be made denying this.** How bright is the light from a common 5 mW GLP?

beam from a 5 mW GLP
Intensity=$3.8x10^{6}$ cd (candelas)
Luminance=$5x10^{12}$ cd/m^2

To put the latter number into perspective,
at the surface of the Sun
Luminance=$1.9x10^{9}$ cd/m^2

so a common GLP has 2,600 x the luminance (surface brightness) of the Sun

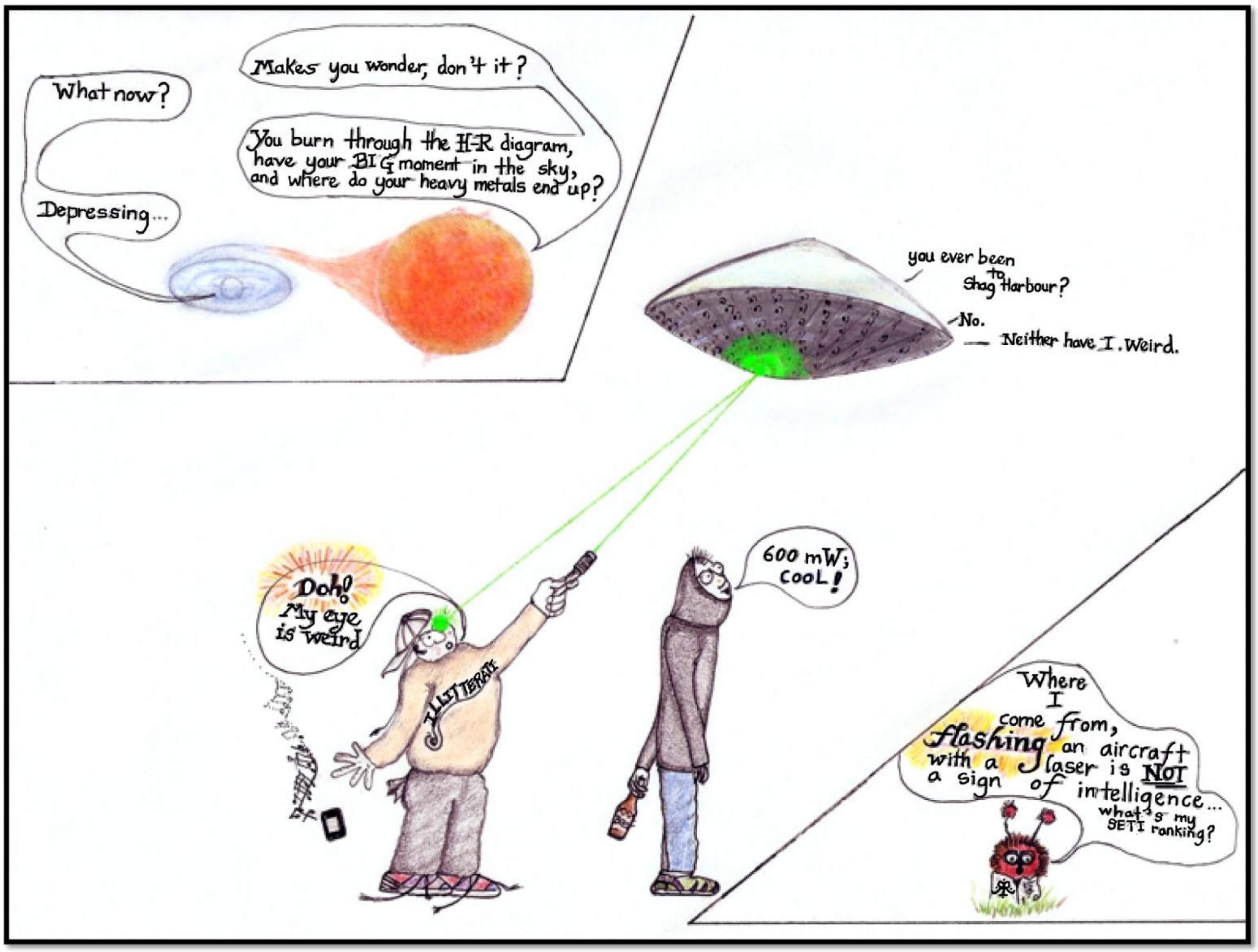
The power required to light an incandescent bulb so that it would appear as bright as a 5 mW GLP when aimed at someone is 3 megawatts, enough to power a sizeable **town**.

At a distance of 3.5 km, a 5 mW GLP will provide the same illuminance (surface illumination) as does the full Moon.

From a distance of 320 km (for example, from the ISS) a GLP will appear as bright as the planet Jupiter (neglecting atmospheric absorption).

Thus, at “everyday” distances (several kilometres or less) a 5 mW GLP is going to be damn bright, and a major hazard to anyone whose attention is needed elsewhere, like a pilot or the driver of a car, ***especially*** at night (3).

For those who are wondering, there ***IS*** good medical evidence for laser induced damage to vision, both short-term and long-term, although more studies are needed (4).



There is a perception that GLP flashing of aircraft is on the rise here in Canada, as well as abroad.

Public perceptions around GLPs ought to be of concern to astronomers.

Some press reports of flashing incidents in recent years have attempted to make a connection between amateur astronomers and the misuse of GLPs. Some reported opinions of law-enforcement agents, pilots, and managers of Canadian air space are similar. A local branch of a government agency has even implemented an onerous registration and approval procedure for amateur astronomical GLP use as *the* solution to the problem, yet to date not a single amateur astronomer has been charged for the flashing of aircraft.

If even a vague perception that we are to blame for GLP abuse gains wide currency, given the stakes involved—the downing of a passenger aircraft *vs*. GLPs for EPO—then GLPs may no longer be available to us. That is not the worst scenario, however.

The concerns of law enforcement officials, pilots' associations, medical practitioners and the general public about the misuse of GLPs are legitimate.

There is no creditable science case to be made denying this, either.

If the case for responsible GLP use in EPO is to win acceptance from the public at large, then we must start by acknowledging those concerns, and show that we advocate safe and responsible GLP use. Before turning to that, what is the worst case scenario?

If an amateur astronomer is charged with flashing a plane which crashes, then all the effort of IYA will be lost, EPO will become very difficult, fund raising impossible, and if the defendant is a RASC member, we could lose our charitable status, which would be the end of the Society. Think it can't happen? Think Again!

Think SMART when you use a GLP:

***S*afe**=place safety foremost

***M*ature**=keep GLPs in responsible hands

***A*stute**=use GLPs skilfully and economically

***R*ational**=match your GLP use to your scientific approach

***T*actical**=think ahead—plan your GLP use

Ensure that GLPs are operated only by designated, responsible adults, preferably RASC members who are familiar with the potential hazards of laser light.

We recommend the following guidelines for safe and rational GLP use:

1 ***take special care not to shine GLPs in the direction of any person, vehicle, aircraft, or wildlife*;**

2 ***avoid using a GLP near an airport or airport runway approach*****;**

3 use the minimum power to do the job: if a 5 mW laser is bright enough, why use a stronger one? (5);

4 be aware that distraction and distress can be experienced by anyone illuminated by green laser light, even if the level is well below that which would cause physiological damage;

5 Use good sense in storing GLPs. Don't leave lasers accessible to children. Consider removing the batteries when you are done using a GLP.

By following these guidelines (which are simply common sense), RASC members will reduce the chance of an unfortunate incident involving GLPs, and will demonstrate due diligence while leading public astronomical activities.

Remember, the future use of GLPs in Canada is in YOUR hands. YOUR actions count!

References

(1) Townes, C.H. (2003). The First Laser. In Laura Garwin, L. & Lincoln, T. (Eds.), *A Century of Nature: Twenty-One Discoveries that Changed Science and the World*. Chicago: University of Chicago Press (107–112)

(2) Nakagawara, V.B. & Montgomery, R.W. (2001). *Laser Pointers: Their Potential Affects on Vision and Aviation Safety*. Washington, D.C.: USDT FAA

(3) Rosenfeld, R.A. & Bishop, R. *et al*. (2010). RASC GLP Committee webpage. http://www.rasc.ca/education/other/glpuse.shtml

(4) Rosenfeld, R.A. *et al.* (2009). The RASC and Green Laser Pointers (GLPs): discussion document. Toronto: RASC http://www.rasc.ca/private/reports/rasc_glp_discussion_document_nc094.pdf

(5) Bará et al. (2010). Green Laser Pointers for Astronomy: How Much Power is Enough? In *Optometry and Vision Science*, 87, 2 (140-144)

The authors wish to thank the following for help received: Dave Chapman, Ralph Chou, Paul Gray & Hugues Lacombe. Any remaining errors are solely the authors' responsibility.

Big Scary Laser

Do not look Into beam
with remaining eye

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