In recognition of the danger, under the Canadian *Aeronautics Act* anyone convicted of intentionally aiming a GLP at an aircraft is subject to maximum penalties of a 5-year prison term and a $100,000 fine. In the United States, shining a laser at an aircraft is a federal crime. Hundreds of such inane actions occur annually in North America, and several people have been caught and given prison terms.

A GLP is a safe and useful tool for education and public outreach in astronomy when used by a knowledgeable, mature person. Here are nine guidelines for GLP use:

1. ***Never*** **point a GLP at any person, vehicle, aircraft, or wildlife.**

2. **Do not use a GLP within 10 km of an airport. The chance of an unintended flashing of an aircraft is significant near an airport.**

3. **As a teaching aid under a dark sky, a GLP that emits a light beam of power 5 milliwatts (5 mW) is adequate. Powers of 10 to 30 mW are better under brighter urban skies, and for instructing a large group. GLPs of more than 30 mW should be avoided because of the greater risk of irreversible damage to vision. In the United States 5 mW is the legal limit imposed by the Food and Drug Administration (FDA). In the United Kingdom, 1 mW is the legal limit.**

4. **When using a GLP as a teaching aid under a dark sky, before pointing at a star or planet, be certain that it *is* a star or planet and not the light of an aircraft.**

5. **As soon as you have pointed out an object, turn the GLP off; the purpose is astronomy, not a distracting laser-light-show.**

6. **To avoid accidental eye exposure, while a GLP is operating, hold it overhead and pointed skyward.**

7. **Do not let a child handle a GLP, or anyone who is not aware of the hazards.**

8. **Store a GLP in a secure place, away from children and anyone else who might misuse the device. To be extra safe, remove the batteries.**

9. **Anyone attending a star party, or a site frequented by astrophotographers or those engaged in other types of astronomical data collection, should ask about GLP usage at the site, and govern the use or non-use of GLPs accordingly.**

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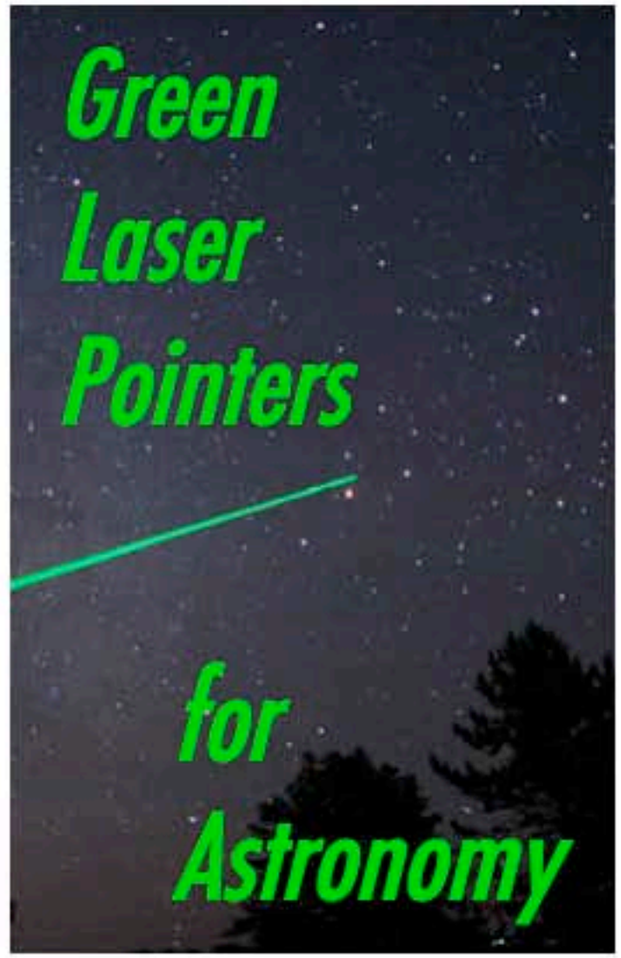
Text by Dr. Roy Bishop
2011



The Royal Astronomical Society of Canada (RASC) is Canada's leading organization dedicated to astronomical education and public outreach. The mission of the RASC is to promote knowledge of our place in the universe, through publications, talks for the public, observations of the heavens, research, and facilitating monthly and annual meetings amongst its many members across Canada. This brochure has been prepared by the Society as a guide to the safe use of laser pointers under the night sky.

Advances in technology have benefited many aspects of astronomy, including public outreach. **Green Laser Pointers** (GLPs) are effective teaching aids for introducing people to the night sky. Also, amateur astronomers sometimes use GLPs as aiming devices on telescopes. At night the light beam of a GLP aimed into the sky is visible because the air scatters some of the light back toward observers on the ground.

Red laser pointers are not suitable for that purpose because red light is scattered less effectively than green light, bright-adapted vision is not very sensitive to red light, and dark-adapted vision is blind to dim red light. The peak sensitivity of the eye is in the green part of the spectrum, so the beam of a GLP is readily visible and may be used to direct attention to a star or a planet in the night sky.

How far can a laser beam reach? As is evident in the photo, a GLP beam aimed into the night sky ends at a definite point that appears to be not very far away. However, that appearance is an illusion resulting from the diffraction-induced, angular spread of the beam. To a GLP operator, or anyone else located near the vertex of the diverging beam, the *perceived* angular width of the beam does not become narrower with distance as it would if the beam were parallel. Consequently the far end of the nearly end-on beam appears to be relatively nearby, making the green shaft of light resemble a "Star Wars Lightsaber", whereas the beam actually extends to the *vanishing point* of perspective, effectively at infinity.

Under a dark, clear sky, a GLP beam becomes invisible where there is nothing to scatter light back toward the observer. That occurs where the beam leaves Earth's atmosphere. Atmospheric extinction is less than 0.5 magnitude, so the majority of the photons in the beam of a GLP aimed into a clear sky leave Earth and continue down the corridors of interstellar space. The beam's reach is essentially infinite, although to a person in the beam looking back at the GLP, the angular spread of the beam makes the GLP appear less blindingly bright the further away it is. For example, a 5 mW (5 milliwatt, or 5 thousandths of a watt) GLP aimed at the International Space Station passing 400 km overhead will look about as bright as the planet Jupiter to astronauts on the ISS.

A 5 mW GLP beam aimed at a point near the star Antares. Light scattered back toward the camera made the beam visible. (R. Bishop photo)

GLPs can be dangerous. In the hands of individuals who do not understand the hazard or are socially inept, GLPs can be *very* dangerous. The danger is due to the extremely high luminance (surface brightness) of the laser diode in a GLP. That brightness, in turn, is a result of the very small angular divergence of the GLP beam. A beam having a power of only a tenth of a watt (100 mW) can cause permanent damage to vision by destroying portions of the retina if it is directed toward the eyes of anyone near the GLP. At distances within a few kilometres, the extreme brightness of even a 5 mW GLP can cause serious distraction, momentary blindness, and afterimages. The consequences could be catastrophic if the beam is directed toward anyone whose attention is urgently needed elsewhere, such as the driver of a car or the pilot of an aircraft, especially at night.