Create your own laser show

BY DAVID M. BERG

The movements and colors of a laser show are fascinating. Shapes dance in a dark room, in colors too intense to be real. The trick is to make that magic accessible using objects from everyday life. Students can then see that the real magic is in the physical principles, not in a black box of fancy technology.

I developed some simple equipment that demonstrates most effects used in commercial laser shows. Excluding the laser, the equipment costs less than $10. With some lively music, it is sufficiently versatile to put on a captivating show.

I use a 1 mw red HeNe laser. It provides adequate intensity to project patterns approximately 2 m in diameter in normal classroom darkness. A diode laser pointer also works, although the larger beam diameter reduces the perceived intensity of the images (see Fig. 1).

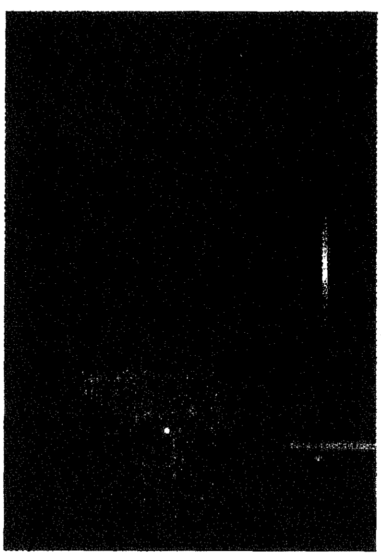

Figure 1. Laser patterns—the laser is pointed at the camera and screen 2 m behind the projector.

The key component is a single mirror "laser projector." It consists of a 1-in. square of bathroom mirror, suspended by four rubber bands (see Fig. 2). The rubber bands are attached to the mirror by pieces of wire coat hanger epoxied to its back. The other ends of the rubber bands are held by wire clips. These clips are slipped over the outside edge of a frame cut from a ¼-in thick foam core poster board. The foam core frame is wide both for structural strength and to make it easier to hold. I use a three-fingered test tube clamp and ring stand to support it.

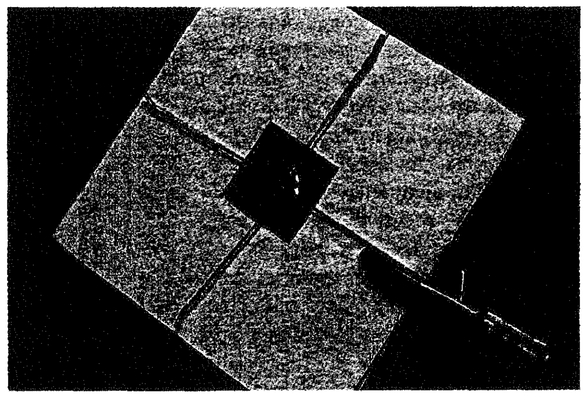

Figure 2. Projector mirror (1-in. square) suspended by rubber bands on a foam core frame.

To project patterns, I place the laser on a small riser (its cardboard carrying box) and point the laser toward the audience (see Fig. 3). I locate the projector so the beam hits the center of the mirror. By tilting the projector, I can produce patterns either on the wall behind me or on the ceiling.

Many different patterns can be produced depending on how the mirror is excited. Tapping the mirror itself produces large, rapidly decaying loops. I find the most interesting patterns by striking the foam core frame with one hand, while damping it with the other. It is possible, though not easy, to produce perfect circles by striking the frame near its corner. Sometimes I spend an hour by myself playing with patterns to go with a new piece of music.

Another intriguing effect is to replicate the line pattern in a square grid. One pattern becomes eight or more identical patterns moving in exact synchrony. To create this effect requires a high-efficiency, square-ruled, holographic diffraction grating made of unbreakable plastic. By tremendous good luck, exactly such a grating is available as a toy called Jupiterscope™ (Edmund Scientific, $3.75). I hold the Jupiterscope near the laser projector so that it intercepts only the outgoing beam. With one hand, I tap the projector and with the other, hold and rotate the Jupiterscope. This effect works best in a very dark room, so the higher and fainter orders are visible.

The last effect in the show is produced by moving a piece of textured "shower glass" through the beam. This produces a diffuse, sparkly pattern with many dark and light interference fringes. Students have likened it to goldfish or fireflies. Tapping the projector makes the sharp fringes disappear.

This demonstration is adaptable

to many room environments. I use a "boom box" to provide music for the show. A projector screen is the most efficient surface to show the patterns, but a white wall or ceiling also works well. In some ways, a ceiling is better because it does not remind the students of work.

Understanding and wonder

The outline of my presentation is the same for all age groups. I start by drawing "flashlight pictures" on the wall. As I move the flashlight faster, the spot looks more like a line; however it never looks completely like a line because I can't move the flashlight fast enough. What we need is a way to move the light beam without moving the flashlight. Reflection from a mirror provides this means. By making the mirror small enough and mounting it with strong enough rubber bands, we can make the mirror go "boing." The mirror only has to be tilted a little to move the light spot a lot. The laser, in this case, serves only as a better flashlight. Because it provides a brighter spot, it produces an image more striking to the eye. Coherence is not important for these effects.

My goal is to maintain the balance between understanding and wonder. After the opening discussion, I present a 3-5 minute "laser show," with music, incorporating all the effects I mentioned above. I purposely do not explain all the effects in advance. After the show, the students ask questions about what interests them. This leads to good, interactive discussions. I especially like questions that begin, "What if you . . . ?"

Concept	Preschool	Grade School	High School	College
Persistence	Your eye sees a line.	It's really only a spot, but your eye remembers where the light has been.	Persistence is the property that makes television and movies work.	What refresh rate is required for your eye to perceive a stable figure?
Reflection	The spot moves when the mirror moves.	The angle of the mirror changes, so the spot moves.	How far does the mirror tilt to move the spot?	How would the pattern be different with a first surface mirror?
Resonant Frequency	It goes "Boing" so it is moving really fast.	A smaller mirror moves faster.	The resonant frequency is determined by tension of the rubber bands and the moment of the mirror.	Which modes are most important in making the figures?
Harmonic Motion	The spot goes round and round.	As the mirror goes back and forth on the rubber bands, the spot repeats the same pattern again and again.	The patterns are similar to Lissajous figures.	The mirror-rubber band system is a two-dimensional quasi-harmonic oscillator.
Diffraction	There are a whole bunch of spots.	The grating makes many copies of the spot; each moves in the same pattern.	Instead of spectra, laser light passing through a grating remains as spots.	The projector pattern is convolved with the grating diffraction pattern.
Interference Fringes	Those feathery things happen when the laser goes through the shower glass.	The feathery things are the only effect that depends on the special properties of the laser.	The light and dark lines show constructive and destructive interference of the light waves.	The spatial coherence is "busted" if we tap the projector; the interference effects disappear.

Table 1. Key learning concepts and related age groups.

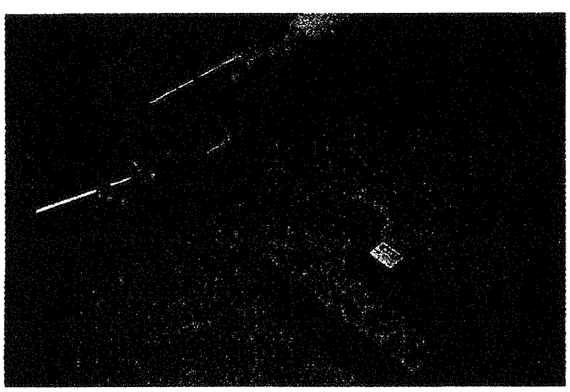

Figure 3. Laser show equipment: laser, projector, shower glass, and Jupiterscope™.

Good for all ages

A good optics demonstration should "work" for students of all ages. I have presented this demonstration to preschool through college groups. The actions are the same for all groups; only the words change. Table 1 outlines some key concepts that come out of the show. I have had a lot of fun with this demonstration. It is a good combination of physics and magic.

Acknowledgments

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