Terminology Standardization Committee

ILDA Laser Glossary

*Terms and definitions for the laser display industry*

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Introduction

The ILDA Laser Glossary is for two audiences. The first is ILDA members' clients, who may be new to laser display technology. The list describes common terms used in sales literature, show preparation, and contractual agreements.

The second audience is ILDA members themselves. The Glossary standardizes concepts which formerly had different names (“cell” and “frame”) and sets terms for new products (“PCAOM”).

ILDA's Official Terms

The Glossary contains the official terms which will be used in ILDA publications. As members create or update their publications, they should incorporate these terms. Examples include:

* Sales literature
* Contracts
* User manuals
* Equipment labeling
* ILDA articles and papers
* Press releases

As Ivan Dryer, two-time ILDA President and first recipient of the ILDA Career Achievement Award, notes, “The Glossary is a primary guide to laser display professionals who should know and use these definitions in accurately representing their products.”

Benefits of Standardization

Terminology standards make it easier for different companies to talk to each other, making more efficient working relationships.

People outside the industry who work with ILDA members also benefit from standards. They can better discuss their requirements with different ILDA companies when everyone is speaking the same language.

How to Use the Glossary

* To find a specific word, check the index at the back of the Glossary.
* To find words related to a field or part of laser display, check the section names on the first page.
* Words printed in italics are cross-references to other Glossary definitions. The cross-references may not be in the same section, so check the index if necessary to find a specific word.
* A few terms are listed in more than one section for convenience.

Revisions

We welcome comments, suggestions and additions to help improve the Glossary. Please call, fax or write to the Terminology Standardization Committee in care of ILDA:

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Lasers and Optical Devices

The first requirement of a laser show is, of course, a laser. This section defines various types of lasers, as well as the optical devices used with them.

Air-cooled laser

A laser using fans to force air over the laser tube and the power supply. Air-cooled lasers have the benefit of needing no water supply, although the fan noise can sometimes be a disadvantage. Usually only small and medium power lasers are air-cooled.

Very small lasers, typically helium-neon, need no fans. Although technically they are “air cooled” via convection, the term is usually applied only to fan-forced cooling.

Argon laser

A laser filled with argon gas. It gives off green and blue light. The strongest *lines* are at 514 nm (green) and 488 nm (blue).

Argons range from small 15 milliwatt 110 volt air-cooled models to large 50 watt 440 volt water-cooled systems. Argon lasers are the most common type of light show lasers since they provide usable brightness at a reasonable cost.

Chiller

A refrigration unit sometimes used with *water-cooled lasers*. It includes a compressor and thus can perform more cooling than a *heat exchanger*.

See also: *Recirculator.*

Dichroic filter, Dichroic mirror

A piece of glass with an optical thin-film coating that transmits certain colors (wavelengths), and reflects the remaining colors.

Dichroic filters are used to combine or eliminate specific colors as needed in a laser projector. Dichroic mirrors are used to maximize the amount of light reflected from a laser of a particular wavelength.

Dichroics should be handled with care to prevent damage to the coating.

See also: *Color box*.

Diffraction grating

A material, usually flexible plastic, containing microscopic lines (gratings) that break up light passing through it. They are used with lasers to create special beam or graphic effects.

Shining a laser image through diffraction gratings produce multiple copies of the original image. The most common grating produces a grid image. Other types of diffraction gratings produce a linear, circular, or abstract patterns.

Most gratings are used in the laser projector, but some pop music light shows distribute inexpensive cardboard glasses with grid diffraction gratings to the audience.

Diode laser

A semiconductor similar to an LED (light-emitting diode) but which produces coherent light. Diode lasers are small and efficient, which has led to their use in compact disc players and pen-type laser pointers.  
Currently, diode lasers are too dim or expensive for most light show uses. This is likely to change over the next few years.

See also: *Solid-state laser*.

Exciter

See *Power supply*.

Fiber optic cable

Flexible glass or plastic strands made into a cable, used to carry light from one place to another. There are two main types.

Transmission fibers carry the beam with as little loss as possible. They are used to transmit the laser's light to remotely located projection devices.

Display fibers have no cable jacket, so some light scatters out the side of the strands. The strands themselves become a special effect, such as a laser-lit “whip” or a glowing “rope” wrapped around objects.

Front-surface mirror

A piece of glass with an exposed broadband reflective optical coating.

In a conventional back-surface mirror, the reflective coating is protected with a heavy paint-like substance; reflections are seen through the glass. In a front-surface mirror, light does not have to travel through the glass to reach the coating.

Mirrors used in laser work are almost always front-surface, as they can reflect up to 99.8% of the incident light and they have no secondary reflections. Front-surface mirrors require greater care in handling to prevent damage to the coating.

See also: *Mirror.*

Head

1) A laser tube enclosed in a case: the laser head (as opposed to the laser *power supply*).

2) A set of X-Y scanners which can produce laser graphics. A projector may have a number of heads. For example, a four-head projector can produce four different sets of graphics simultaneously.

Heat exchanger

A cooling unit sometimes used with *water-cooled lasers*. Hot water from the laser is cooled by water-to-water or water-to-air heat transfer. There is no active refrigeration, as in a *chiller*.

See also: *Recirculator.*

Helium-neon laser

A laser filled with a helium/neon gas mixture. Most produce red-orange light having a wavelength of 633 nanometers.

“HeNe”s are low powered, in the 0.5 to 50 milliwatt range. Most run on 110 volts, come with built-in power supplies, and need no special cooling.

Some HeNes are made to produce orange (612 nm), yellow (594 nm) and green (543 nm) light. These have less power than a red HeNe of the same tube size and input power.

Helium-neon lasers are the most common type of gas laser. Because of their relatively low power, in laser display they are used only for small-scale light shows and studio monitors.

Krypton laser

A laser filled primarily with krypton gas. It produces red light, with yellow, green and blue also available with specially tailored optics. It has a very strong red *line* at 647 nm.

Kryptons are similar to argons (the same tube design can be used for both). However, kryptons give off less light power than an equivalent argon. Krypton lasers are primarily used when a powerful red light is needed.

Laser

A device which produces a coherent beam of light. The beam remains parallel for long distances and contains one or more extremely pure colors.

Light show lasers are usually gas-filled tubes using high voltage current to cause the gas to glow. Mirrors at each end of the tube help amplify a process called “stimulated emission”. Most of the stimulated emission light travels between the two mirrors; about 1% comes out of one of the mirrors to create the beam we see.

The gas used determines the color (or colors) of the beam. Gas lasers remain the overwhelming choice for display applications. The four main types used are a *helium-neon* mixture, *argon*, *krypton,* and an argon-krypton *“mixed gas”* mixture.

“Laser” was derived from “Light Amplification by Stimulated Emission of Radiation”.

See also: *Head, Helium-neon, Argon, Krypton, Mixed gas, Power supply, Diode laser, Solid-state laser.*

Mirror

1) Large mirrors are used to reflect the beam coming from a projector, forming a *beam sculpture* or matrix in the air. Usually the mirrors are surrounded by black metal, so light which might miss the mirror is harmlessly dissipated.

2) Small mirrors mounted on *actuators* can be activated to reflect the beam out over the audience or onto large mirrors to form a beam sculpture or matrix.

3) Small mirrors on precision mounts are used within projectors as steering mirrors to reflect the beam from place to place inside a projector.

4) Tiny mirrors are used on the shafts of laser *scanners*, which move the beam at high speeds to form graphics.

All of the mirrors above are usually *front-surface mirrors*.

Mixed gas laser

Many gas lasers contain mixtures of various gases, such as helium and neon. In the laser show industry, however, “mixed gas” usually refers to an argon-krypton mixture used to get a *white-light beam* containing red, green and blue lines.

Yellow lines are additionally available for applications such as four-head projectors with one head each for red, yellow, green and blue.

See also: *White-light laser*.

Power supply

A device converting readily available power, usually standard alternating current, into voltages necessary to energize laser tubes. It may also include other functions such as monitoring the laser's light output or current draw. A power supply is usually closely matched to a particular type of laser tube.

Power supplies for high-power lasers (0.5 watt and above) often require 208 or 440 volts three-phase, and are cooled with flowing water. The supply is one of the two main parts of a laser; the other is the laser *head*.

A power supply is also known as an exciter.

Recirculator

A pump used to recycle water, found in either a *chiller* or *heat exchanger*. The term “recirculator” is sometimes erroneously used to mean either of the more specific devices.

Solid-state laser

A laser where the lasing medium is a solid material such as a ruby rod. These can be optically pumped by a flashlamp or diodes.

Currently, solid-state lasers are too expensive for most light show uses. This may change over the next few years. The most promising solid-state laser uses a material called Nd:YAG, producing up to 50 watts of green light at 532 nm.

Water-cooled laser

A laser using water to cool the laser tube. Often the laser power supply's electronics are also water-cooled.

A gas laser (the type used in most laser display applications) is relatively inefficient. For example, an argon-filled laser producing 10 watts of light requires around 10,000 watts of electricity. In such a laser, water is used to carry off the 9,990 watts of excess energy as heat.

Flow rates of two gallons (9 liters) per minute are typical. In many areas, the water can simply flow through the laser and down a drain. In water conservation areas, a *chiller* or *heat exchanger* is used to recycle the cooling water.

Water supply considerations are always important to laser show producers. Even a brief interruption can cause problems. At best, flow sensors shut down the laser when the supply is inadequate. At worst, an expensive tube can overheat and be irreparably damaged.

White-light beam

Broadly, a laser beam which contains a number of different *wavelengths* (colors) so the beam appears white. If the beam is passed through a prism or diffraction grating, it is separated into individual laser beams, each of a single specific wavelength.

More specifically, a white-light beam ideally contains an equal mixture of red, green and blue light. It can be from a single *white-light laser* or from two or three lasers whose beams have been combined into a single beam. White-light beams are primarily used in *RGB laser projectors*.

See the definition of *white-light laser* for more information on what constitutes an “equal mixture” of light.

White-light laser

Many lasers can produce a number of *wavelengths* (colors) simultaneously. A white-light laser is designed to give a good balance of red, green and blue wavelengths.

Usually the laser is intended for an *RGB laser projector*. (Some models also deliberately add yellow light for specialized 4-color projectors.) Most white-light lasers use an argon/krypton gas mixture.

It is somewhat difficult to produce an equal balance of desired colors, and to keep this balance consistent during the lifetime of the laser tube. At present, there are no standards defining the exact wavelengths and color proportions for a laser to be called “white-light”.

In addition, the sought-after color balance can be defined either as equal amounts on a photometer, or as visually equal amounts. Since the eye is much more sensitive to green, a visually equal or “photopically balanced” laser has roughly five times more power in red and blue than in green. Most white-light lasers today are not photopically balanced.

See also: *Mixed gas laser*

Laser Projection Equipment

A laser projector uses a laser's beam and produces projected graphics, beams, lumia or other visual effects.

This section covers general terms used with laser projectors and their parts. The next section, “Projector subsystems”, discusses more specifically how the various sections of a projector relate to each other.

AOM (acousto-optic modulator)

A device used for dimming and blanking a laser beam. It can also be used for color control.

In an AOM, a laser beam is shone through an acousto-optic crystal. By applying an electric signal to the crystal, the beam's intensity (brightness) can be modulated.

For blanking and intensity control, a single AOM is used.

For color control, three AOMs can be used on separate red, green and blue beams. Using additional optics, the beams are recombined to form a single beam whose color depends on the AOMs' settings.

(For easier color control, more specialized *PCAOMs* are used. These require only one crystal to modulate a *white-light beam*, and they need no recombination optics.)

The primary advantage of an AOM is its speed. It can be modulated fast enough to control the intensity or color of single points within a complex scanned image. However, it is more complex to interface with slower-reacting scanners, since timing adjustments must be made.

See also: *Blanking, Scanner blanking, PCAOM*.

Actuator

A device that allows for the positioning of optical elements in a laser beam or for low-speed beam steering.

Some examples: Mirrors on an actuator arm direct beams to different devices in a projector or out over an audience. Dichroic filters on actuators are used in *color boxes*. A beam block on an actuator is used to create a *shutter*.

Actuators are typically a low-speed, heavy-duty version of an open loop scanner which allows for variable positions. Two-position solenoid-type devices can also be used.

Barrel distortion

A distortion caused by projecting onto a convex surface. For example, a grid projected on the outside of a dome has outwardly curved edges, where the centers curve out and the corners pull in. Single-axis barrel distortion occurs when projecting on the outside of a cylinder.

The distortion can be alleviated using optical elements, electronic devices or software to counter-distort the image.

The opposite of barrel distortion is called *pincushioning*.

Beam block

See *Mask*.

Beam splitter

A device which transmits part of a laser beam and reflects the other part. Usually, a beam splitter is a piece of glass with optical coatings; the type of coating determines the ratio between transmittance and reflectance.

Using beam splitters, a laser's beam is divided and sent to two or more devices simultaneously.

Blanking

The technique of turning the laser beam on and off with precise control (as opposed to *chopping*). For scanned graphics, blanking allows images to have disconnected sections where the beam is hidden. Blanking can be digital (on/off) or analog (continuous intensity control). The same techniques used for blanking control can be used to control intensity of red, green and blue beams, for color mixing. See also: *Acousto-optic modulator, Scanner blanking.*

Usage note: Brightness terms

Intensity, blanking, chopping, and shutter all refer to control of a laser beam's brightness.

* *Intensity* implies continuously variable (analog) control of brightness, although on/off (digital) control could also be included.
* *Blanking* implies on/off more than continuously variable, although both could be included.
* *Chopping* implies fast on/off brightness control at a regular rate. *Shutter* (verb) implies gross on/off control of the beam, too slow to be used for individual points.

**Note:** *Z axis* is sometimes incorrectly used for intensity information. This term should not be used for brightness, only for depth.

**Suggestions:**

* Use “intensity” for any variable control brightness, use “blanking” for any on/off control. If in doubt, use “intensity”.
* When referring to points which have their intensity controlled, use “blank points” or “blanked points”. This is not precisely correct if they have continuously variable intensity. However, it accords with common industry usage.
* Due to confusion with the noun “shutter”, do not use the verb “shutter” unless used to refer to the action taken by a physical shutter.

Color box

An informal term for a projector subsystem using three dichroic filters which pass cyan, magenta or yellow light. Actuators move the filters into a white-light beam. This provides a subtractive color blend, giving eight possible colors (red, green, blue, yellow, magenta, cyan, white and “black”)

For example, cyan (which passes green and blue) plus magenta (which passes red and blue) results in a blue beam (the only color passed by both).

A color box system usually colors the entire image, since actuators are relatively slow. This contrasts with scanner or PCAOM techniques which can color different sections of an image.

Chopping

The technique of turning the laser beam on and off at a regular rate (as opposed to *blanking*). High-speed chopping gives a “dotted line” effect. If used with densely scanned images, chopping creates areas of light and dark which shift as the chopping rate changes.

See also: *Color modulation*.

Closed-loop scanners

See *Scanner amplifier.*

Galvo, galvanometer

A limited excursion motor whose torque is directly proportional to the current. When current is applied, the galvo's shaft rotates through part of a circle. When current is removed, the shaft returns to the rest position. Examples include the ammeter in an automobile or the needle-style VU meter in audio equipment.

Galvo-based *scanners*, such as General Scanning model G-120 or Cambridge Technology model 6800, are often used in laser displays. Strictly speaking, the galvo is the motor device only, while a scanner includes the galvo, mirror mount, and mirror.

There are three types of galvos: moving iron (GS G-120), moving magnet (CT 6800), and moving coil (not used in laser light shows).

Head

* A laser tube enclosed in a case: the laser head (as opposed to the laser *power supply*).
* A set of X-Y scanners which can produce laser graphics. A projector may have a number of heads. For example, a four-head projector can produce four different sets of graphics simultaneously.

Keystoning

The distortion caused when a projector shines onto a screen from off-center. For example, a projector aimed up at a screen produces a wide image at top and a narrow image at bottom. (This shape is like that of the “keystone” at the top of an arch.)

Solutions to keystoning include repositioning the projector, or using optical elements, electronic devices or software to counter-distort the image.

Mask

A device used to obstruct the laser beam so it is blocked from undesired areas. The mask is usually placed at the final output aperture of the laser projector.

Masks are used for aesthetic reasons, to keep light from going off a screen, and as a safety feature, to ensure lasers cannot reach the audience in case of equipment malfunction.

This is also called a beam block.

Mirror

* Large mirrors are used to reflect the beam coming from a projector, forming a *beam sculpture* or matrix in the air. Usually the mirrors are surrounded by black metal, so light which might miss the mirror is harmlessly dissipated.
* Small mirrors mounted on *actuator*s can be activated to reflect the beam out over the audience or onto large mirrors to form a beam sculpture or matrix.
* Small mirrors on precision mounts are used within projectors as steering mirrors to reflect the beam from place to place inside a projector.
* Tiny mirrors are used on the shafts of laser *scanners*, which move the beam at high speeds to form graphics.

All of the mirrors above are usually *front-surface mirrors*.

Mirror mount

A tiny machined metal piece used to mount laser scanner mirrors to the galvanometer scanner shafts. Usually the mirror is glued to the mount; the mount has a set screw to hold it to the shaft.

The mount can be eliminated by gluing the mirror directly to the shaft. This reduces the weight moved by the scanner, increasing speed. But it makes it more difficult to replace scanner mirrors if one should break.

See also *Mirror.*

Open-loop scanners

See *Scanner amplifier.*

PCAOM (polychromatic acousto-optic modulator)

A device used to mix the colors in a *white-light laser beam*, to produce a final desired color. A PCAOM is a complex type of *acousto-optic modulator*. It can control the intensity of not one, but a number of *wavelengths* (colors) simultaneously using a single crystal.

Special driver electronics are employed to do this. The more channels in the driver, the more individual laser colors that can be conrolled.

A PCAOM is simple to incorporate in a projector, compared with other methods of color selection, such as using three separate AOMs to control red, green and blue components. A significant PCAOM advantage is that the output beam remains color converged; this eliminates additional optics needed to recombine separate colors into one beam. A PCAOM provides both blanking and color control in a single device.

An advantage it shares with AOMs is speed. It is fast enough to control the intensity or color of single points within a scanned image.

Usage note: PCAOM and AOTF

Some people may incorrectly use the term “AOTF” (acousto-optic tunable filter) to refer to PCAOMs. Both devices change the color of an input light source. However, an AOTF controls only one wavelength at a time; that wavelength is tunable. A PCAOM controls many wavelengths simultaneously; those wavelengths are fixed by the driver. Only PCAOMs are suitable for color control of multi-wavelength white-light laser beams.

Some manufacturers may use “PCM”. However, to avoid confusion with “pulse code modulation” (a common method of storing digital data in an analog format), ILDA recommends the more descriptive and accurate acronym “PCAOM.”

Pincushioning

A distortion caused by projecting onto a concave surface. For example, a grid projected on the inside of a dome has inwardly curved edges, where the corners stick out and the centers curve inward. Single-axis pincushion distortion occurs when projecting on the inside of a cylinder.

The distortion can be alleviated using optical elements, electronic devices or software to counter-distort the image.

The opposite of pincushioning is *barrel distortion*.

RGB laser projector

A laser projector whose color system can independently control the amount of red, green and blue light. These three components are combined to produce the final beam. This technique provides a wide range of colors.

RGB projectors can use different methods, including *scanner color*, *AOMs* and *PCAOMs*.

The term should not be used for *color boxes* or other methods which provide only eight basic colors. An RGB projector implies a wide range of colors due to being able to vary how much red, green and blue is used. The term also implies high-speed color control, so different parts of a scanned image can have different colors.

Scanner

Any device which moves a beam back and forth. This can include polygonal faceted scanners, acousto-optic deflectors, and *galvanometers* with mirrors.

In laser display, “scanner” usually refers to a galvanometer which rotates a shaft back and forth through part of a circle, rather than spinning continuously. A small mirror (approximately 5 x 8 mm) is attached to the shaft.

Two scanners are needed to draw laser graphics. The scanners are arranged so the beam reflects first off one mirror, then off the other. The first mirror moves the beam horizontally, the second moves it vertically. This arrangement means the scanners can position the beam anywhere within a square area.

The galvo shaft moves in response to an electrical current. By repeatedly following the same path at high speeds, the illusion of a single, fixed image is created.

Because of the mirror's mass, a scanner is limited in how fast it can move while still remaining accurate. Complex *scanner amplifier* circuits are used to get maximum performance. However, the limit is very roughly about 1000 scan points before *flicker* begins.

See also: *Vector graphics.*

Scanner amplifier

An electronic device which conditions a signal from a computer or other source, and makes it compatible with *scanners*.

Closed-loop scanner amplifiers are used with position-detecting scanners; the amplifier controls the scanner based on position feedback signals. Open-loop scanner amplifiers are used with non-position detecting scanners.

The more expensive closed-loop scanner systems are usually required for complex representational graphics such as logos.

Scanner blanking, scanner color

A method of blanking or coloring laser beams, using scanners. A scanner is set up using a mirror or small beam-blocking arm on its shaft. As the shaft rotates, the beam is reflected or blocked so it does not reach the scanners.

Often, a complex beam path is used to make an “optical lever”, as simple blocking methods may not be fast enough or may cause unwanted beam movement.

A blanking scanner on a single beam provides intensity control for that color. To get colored images, three scanners can be used on red, green and blue beams. The beams are recombined to form a single beam whose color depends on the scanner settings.

The primary advantage of scanner blanking and color is that it is easier to interface with beam-positioning scanners — all devices react at the same rate. However, AOMs and PCAOMs can turn on and off faster than scanners. This provides a wider range of effects (such as smaller “dotted lines”) and it does not require as many control points where the scan must pause to wait for the scanner to fully blank.

See also: *Acousto-optic modulator, Blanking, Scanner.*

Shear

A distortion where one axis is at an angle while the other is correctly straight. The resulting image is slanted. For example, horizontal shear causes normal text to look like italic type.

True shear is a result of not mounting the X and Y scanners exactly perpendicular to each other. (Apparent shear, caused by being at an angle to a projection surface, is really due to *keystoning*.)

Solutions to shear include repositioning the scanners or using optical elements or electronic devices to counter-distort the image.

Shutter

An actuator used to block the laser's beam. Usually positioned between the laser and the laser projector.

When activated, the shutter opens, letting the beam pass. This arrangement ensures that the beam will be safely blocked if power to the shutter should fail.

See also: *Blanking*

Throw

The distance between the laser projector and the projection surface. Too short a throw means that the scanners may not be able to cover the entire screen. Too long a throw means that the beam may diverge too far, or that special effect graphics such as lumia may be too dim.

Generally, laser projectors give longer effective throws than conventional slide, motion picture or television projectors. Also, the beam remains “in focus” anywhere throughout its travel, unlike images from conventional lensed projectors.

X-Y mount

A machined piece of metal which holds the scanners in the correct position relative to each other, so the beam can scan first off the horizontal (X) scanner, then off the vertical (Y) scanner. The mount also serves as a heat sink to carry away heat generated by the scanners' operation.

Projector subsystems

The following terms are suggested for the subsystems within a projector. These definitions are primarily for use within the context of the entire projector, to help distinguish one system from another.

These terms have been carefully defined. This is because fine distinctions can become extremely important when specifying the equipment to be provided at a laser show, or when drawing up contracts for installations.

Optics plate

A metal plate drilled and tapped with holes, often in a grid configuration. The optics plate is usually the base on which the projector is built.

Galvo, galvanometer

Refers to the basic galvanometer itself, without an attached mirror mount or mirror.

Scanner

A galvo with an attached mirror. There are often three parts, the galvo, a *mirror moun*t, and a mirror. See *scanner* for more information on general usage.

Scanner amplifier

Usually refers to the scan amp board only. Does not include a power supply or chassis unless this is specifically stated (in sales literature, etc.).

Scanner head

A pair of scanners in an *X-Y mount* with mirrors. Does not include the scanner amps, although those may be mounted close to the scanner head. Usually does not include any blanking system.

Projector head

Scanner head, plus any special optical effects such as beam switchers and *lumia*, in a finished chassis. Usually used when the laser beam is fed via *fiber optic cable* to a number of projector heads arranged on a stage or set. Does not include the *scanner amps*, although those may be mounted inside the projector head.

Does not necessarily include a blanking device or system.

Blanking system

The blanking system cannot be assumed to be in either the scanner head nor in the projector head. The blanking system is usually set apart from the scanner head (scanners plus mount). It may also be separated from a fiber-fed projector head, since the beam is often blanked before being launched into the fiber.

Therefore, the blanking system should be discussed as a separate subsystem; for example, when specifying number and location of heads.

Laser projector

Laser, scanner head, blanking system, special optical effects, and scanner amps, all in a single chassis. The inclusion of the laser, blanking and scanner-related electronics makes a laser projector more comprehensive than a projector head.

Laser system

A laser projector plus a signal source such as a tape playback unit, computer, or operator console.

Beam table

Optics plate plus special optical effects, usually beam positioning actuators, but also can include *lumia* and other effects. Does not include the laser.

Beam projector

Beam table plus laser. Usually implies no graphics scanning capability.

Usage note: Projector terms

The more specialized a particular system, the more specific your terms should be. For example, if a separate head is only used for beams, it should be called a “beam projector head” to distinguish it from a “graphics [only] projector head.”

Laser Shows and Special Effects

There are two main uses of display lasers: laser shows and special effects. In a show, the laser is the primary attraction. As a special effect, the laser supports a primary attraction.

The following terms are widely used in describing shows and effects.

Abstract

Laser-projected images which are usually non-representational (as opposed to *graphics*). This implies using synthesizers or other techniques which do not afford point-by-point position control of the beam, and usually implies using *scanners* to create the abstract image. Usually excludes *lumia*, *diffraction gratings*, or similar non-scanner techniques.

Beam effects

Using the laser's beam as a sculptural element in space (as opposed to shining it on a screen to create graphics). The beam can be static or kinetic.

If static, it is usually reflected off a series of widely spaced mirrors to create a “beam sculpture” or “beam matrix”.

If kinetic, it can be shot directly into space (over an audience), or can be directed to different groups of mirrors to create moving beam sculptures. A common technique is to scan the beam through theatrical smoke; if a line is scanned you see a plane of laser light, if a circle is scanned you see a cone.

These effects require high power lasers and often require smoke, dim lighting and other environmental controls.

See also: *Cone, Fan.*

Beam sequence

A beam effect where beams are directed to different mirrors in quick sequence. This gives a *Star Wars*-type impression of shooting beams bouncing around the performance arena.

Color modulation, color mod

Rapidly varying the color of the laser beam. In beam effects, color mod can be used on the entire beam matrix or can be sequenced in individual beams. In graphics effects, color appears to “chase” through an image.

A classic light show effect is to project a dense spiral pattern, then use color mod to create shifting zones of colors pulsating through the image.

See also: *Chopping*.

Cone

A beam effect where the beam is rapidly scanned to enclose space. For example, by scanning a circle, the effect looks like a cone of light emanating from the projector location. Other shapes can be scanned; for example, a square produces a pyramid “cone”.

Theatrical fog or smoke is often used to make the scanned light more visible.

See also: *Beam effects*.

Fan

A beam effect where the beam is rapidly scanned from side-to-side, usually through theatrical smoke. If the scanning is smooth, the audience sees a plane of light. If the beam scans discrete positions, the audience sees a ribbed fan of light. The fan can be rotated and translated to produce a moving fan effect.

Theatrical fog or smoke is often used to make the scanned light more visible.

See also: *Beam effects*.

Graphics

Laser-projected designs, usually representational (as opposed to *abstract*) such as logos or drawings. Graphics implies point-by-point control of the beam position, which in turn implies computer control of laser scanners. A computer can generate non-representational designs, but these are normally classed as graphics rather than abstracts.

Hologram

A light-sensitive film which captures and plays back light wave interference patterns. One of the most striking results is the true three-dimensional nature of the recreated holographic image.

Image holograms are not usually used in laser display technology. They are mentioned here because of a frequent misconception that laser shows can present “floating” 3D holographic projections.

Although a holographic image can appear to be floating in front of the film plate, the viewer must always be looking at or through the hologram. Viewing angles are usually limited to one or two people at a time, and image size is usually one cubic meter or less. At present, there are no free-floating “Princess Leia” Star Wars-type holograms.

**Note:** The term is hologram (“a laser recording of interference patterns”), not holograph (“a document wholly handwritten by the person under whose name it appears”).

Laserist

The person who performs a live laser show, especially in a planetarium environment. Can also be used for the person who designs and choreographs a pre-recorded show.

Laser light show

A presentation where laser light is the primary attraction (as opposed to *laser special effects*). The four main elements of a laser light show are: a*bstracts, graphics, lumia* and *beam effects*. These may be present in various combinations.

A laser show is usually set to music, often with other effects such as theatrical lighting and pyrotechnics. Musical shows are usually divided into a number of song-length *modules*.

Laser special effects

Any use of lasers where the laser is not the primary attraction (as opposed to *laser light show*). For example, a rock band may use complex laser lighting effects comparable to standalone laser light shows. However, because the band itself is the primary attraction, the lasers are considered supporting special effects.

Laserium®

A registered trademark of Laser Images Inc., referring to their laser light shows. Sometimes used incorrectly as a synonym for any planetarium-based laser light show.

Lumia

A gauze-like laser effect produced by shining a laser beam through distorting material such as rippled glass. Lumia are often composed of fine parallel lines of light and dark, and they show the characteristic *speckle* of coherent light. There are many different lumia effects, depending on the type of distorting material.

Module

A song-length segment of a *laser light show*. A module is the smallest unit of music-plus-lasers which can artistically stand on its own.

A typical planetarium-type laser show is usually made up entirely of different modules.

Three-dimensional (3D) laser effects

In laser effects, can refer to beam effects or multiple scrim techniques. (In laser graphics, “3D” usually refers to either a 3D graphics database or to stereoscopic projection systems.)

Laser *beam effects* are inherently 3D, filling space with static or kinetic beams. However, these cannot create space-filling objects. Science-fiction films have popularized the misconception that lasers can project large freestanding 3D images. At present, there is no technique which can do this without the image being enclosed in a small volume.

One interesting simulation is to project laser graphics through partially translucent screens; a series of these screens can give a floating mid-air effect. This is not true 3D as all images are identical, and merely increase in size with increased projection distance.

See also: *Three-dimensional laser graphics,* *Hologram*.

Computer Graphics for Laser Shows

In traditional computer graphics there is an unfortunate lack of agreement over basic terms and concepts. To help avoid this in the laser computer graphics field, ILDA suggests the following terms.

Anchor points

Additional points placed to help slow the laser beam. Anchor points are usually added at corners and tight curves, to help the scanners accurately follow the desired path.

See also: *Velocity point*.

Animation

A sequence of frames where each frame is slightly different, giving the illusion of motion. “Animation” refers to the complete group including *key frames* and *tweens*.

These can be *precomputed*, such as traditional hand-drawn animations. Or they can be computed in *realtime*; for example, the single frame of a logo may grow in size and rotate to produce the animation.

See also: *Key frames, Tweens*.

Artware

Frames and animations used in creating laser modules and shows. Artware can be created by the end user, but the term usually implies “clip art” sold or traded by a third party. This term is preferred over “clip art”.

See also: *Showware*

Blanked points

Those points in a computer-controlled graphic that are turned off by the blanking device so they cannot be seen.

Cel or cell

See *Frame*.

Coordinates

The placement of a point in Cartesian space; used in laser graphics software. A point at (5,10) is located five units to the right of, and ten units above the origin (0,0).

See also: *Point*.

Depth Cueing

An effect in 3D graphics where lines appearing further from the viewer are dimmed. This helps enhance the 3D illusion for wireframe images such as those used with lasers.

Erase

A special effect used in computer-controlled laser graphics. A design disappears point-by-point, as if being erased. The opposite effect is called *write out*.

Frame

A sequence of points forming a single, fixed drawing or design. It is analogous to a motion picture frame. The alternative terms “cel” or “cell” are sometimes seen.

Usage note: Graphic parts

There is a clear progression in laser computer graphics of the various parts which make up the final graphic. For example, a frame is made up of points; an animation is made up of frames.

The following terms are recommended as the progression of computer graphics parts:

* Point
* Frame
* Animation
* Scene or module
* Show

As explained in the definition of module, the terms “scene” and “module” express a similar idea: a group of related frames and animations. They differ in that a scene is more of an artistic concept, while a module is more of a technical concept.

Key frames

Frames containing the start and end points of action in an animated scene. Intermediate positions are shown in the *tween* (“in-between”) frames. In computer animation, key frames are hand drawn and the computer calculates tweens. In hand animation, the key frames are drawn by the primary animator, while tweens may be drawn by an assistant.

Module

* In a traditional laser show, a module is a song-length segment. It is the smallest unit of music-plus-lasers which can artistically stand on its own. A traditional laser show is usually made up entirely of different modules.
* In laser computer graphics, a module is a complete set of frames, animations and scenes which can be played back by a user or operator. A laser show can be a single module, but is often a series of modules which have been arranged in sequence.

The terms “scene” and “module” express a similar idea: a group of related frames and animations. They differ in that a scene is more of an artistic concept, while a module is more of a technical concept.

Point

The smallest object which can be manipulated by laser graphics software. Usually includes X (horizontal) and Y (vertical) coordinates, and visibility (on or off) and/or color. Can also include Z (depth), size, shape and other attributes.

Computer controlled graphics work by rapidly moving the laser beam from one point to another. The software shows a sequence of points to form a “connect the dots” drawing.

See also: *Color, Coordinates, Point number, X axis, Y axis, Z axis*.

Point number

The sequence number of a particular point. For example, “point number 1” refers to the first set of coordinates in a point output list.

See also: *Point*.

Usage note: Points, point numbers

Use “point” to refer to points in general, use “point number” to refer to a particular point. For example, do not say “point 1” but “point number 1” or “point #1”.

Use “location” to refer to a point's placement in general, use “coordinates” to refer to a point's particular placement. For example, “The last point you draw is located in the center, at coordinates 0,0.”

Avoid confusing these important concepts. Here are two examples of poor usage: “Point 3 is at point 0,0”; “The laser moves to this point.” Clear usage is: “Point #3 is at coordinates 0,0”; “The laser moves to this location.”

Precomputed animation

In a computer graphics system, a frame sequence which has been hand-drawn, or calculated in a longer time than it takes to play back the animation.

As a consequence, every frame is stored in the computer memory, hard drive or similar device. Playback is done by recalling each frame in turn.

This is the opposite of *realtime animation.*

Raster graphics

Images created by constantly scanning from side to side and up and down —examples include television and computer printers.

Most laser projectors do not use raster graphics. This is because a raster graphic spreads the beam's power over the entire screen, making the beam visible only at certain times (as with television). The relatively few laser raster projectors available use high-powered lasers to overcome this problem.

An advantage of laser raster projectors is that most can be used to project video, making them powerful television projectors.

Non-video laser raster projectors are used to project moving words, giving a look similar to that of a “Times Square” moving lights signboard.

Raster graphics are contrasted with *vector graphics.*

Realtime animation

In a computer graphics system, a frame sequence which is developed from a source frame in “real time”. The manipulations or calculations are completed in less time than it takes to draw the source frame.

As a consequence, the source frame plus the manipulation instructions are stored in the computer memory, hard drive, or similar device. Playback is done during the presentation, by recalling the source frame and applying the manipulations.

This is the opposite of *precomputed animation*.

Retrace

A laser-drawn graphic consists of a series of connect-the-dot points. When all points have been drawn, the laser must return to the first point, to “re-trace” the graphic. The line from last point to first point is the retrace line.

Usually, retrace lines are undesired. They can be eliminated by drawing the graphic so the first and last points overlap, or by using a blanking device to block the laser beam during the retrace.

Scene

A sequence of frames and animations which are lyrically, thematically or temporally related to each other.

A lyrically related scene could illustrate the verse or chorus of a song. A thematically related scene could illustrate concepts such as love or events such as boy-meets-girl. A temporally related scene is what we think of as a movie scene: depicting events taking place at a single location during a short time period.

Showware

All or some of the parts used to create a module or show, such as scripts, computer graphics command programs, or taped audio and control signals. Showware can be created by the end user, but the term usually implies sale or trade by a third party.

See also: *Artware*

Three-dimensional (3D) laser graphics

In computer laser graphics, usually refers to either a 3D graphics database or a stereoscopic projection system. Can also be applied to 3D volumetric techniques.

* **3D database.** Referring to a system of storing height, width and depth information of an object. A 3D computer graphics system can then display a 2D projection of the 3D object drawn from any angle. The resulting projection seems to have depth due to the perspective drawing cues, especially if it rotates or moves.
* **3D stereoscopic.** Referring to a method of presenting a viewer with two simultaneous images, a slightly different one for each eye. The brain interprets the parallax cues from the views as if it were looking at a 3D object or scene. (Other non-stereoscopic cues, such as perspective drawing or rotation of a 3D database object, may be simultaneously employed to enhance the effect.) Special glasses are usually used to ensure that each eye is presented a unique view.
* **3D volumetric.** Referring to methods which present a 3D image within a volume. This is true 3D in that no glasses are required and the image truly occupies a volume in space. A common technique uses a rotating screen synchronized to the laser output. Usually the 3D volume is small, so volumetric laser displays are currently used only in research and technical applications.

See also: *Three-dimensional laser effects*.

Usage note: “3D”

When discussing 3D laser graphics, it is suggested that the specific terms “3D database”, “3D stereoscopic” or “3D volumetric” be used, at least on first reference.

Tweens

Individual frames which are part of an animation. The term comes from “in-between”. The complete set of tweens plus key frames is an animation.

See also: *Animation, Key frame*.

Vector graphics

Images created by moving from point to point — examples include handwriting and computer plotters. Most laser graphics are vector graphics.

To produce a laser graphic, a computer is first used to draw a series of connect-the-dot *points*. These are translated to electrical signals and are sent to the *scanners*. At the projection screen, the moving beam travels from point to point at high speeds, smoothing out the dots. This creates the illusion of a fixed, non-moving image.

One limitation is the number of dots which can be drawn before the fast-moving image begins to *flicker*. With lasers, the practical limit is roughly 1000 points.

Vector graphics are contrasted with *raster graphics.*

Velocity points

Additional points placed to keep the laser beam scan velocity constant during long excursions.

While anchor and velocity points express similar concepts, there are important differences. Anchor points are usually repeated visible points placed to “nail down” the laser beam at sharp turns. Velocity points are usually widely spaced blanked points used to prevent large, uncontrolled jumps as the scanner draws.

See also: *Anchor points*.

Write-out

A special effect used in computer laser graphics. The laser appears to “write out” a design such as a signature. The opposite effect is called *erase*.

X axis

Refers to horizontal (left-and-right) movement of the laser beam. In the ILDA Image Data Transfer format, negative values are to the left, positive values are to the right.

See also: *Coordinate*.

Y axis

Refers to vertical (up-and-down) movement of the laser beam. In the ILDA Image Data Transfer format, negative values are down, positive values are up.

See also: *Coordinate*.

Z axis

Refers to movement in front of or behind the viewing plane. (Used primarily with laser graphics software which uses a three-dimensional database.) In the ILDA Image Data Transfer format, negative values are to the rear (away from the viewer), positive values are to the front.

See also: *Coordinate*.

Usage note: “Z axis”

“Z axis” is sometimes incorrectly used to refer to intensity control, such as blanking. This term must be used only to refer to spatial information.

There are systems where the Z axis spatial information is used to control intensity, such as in *depth cuing*. Even in this case, “Z axis” refers properly to spatial (depth) information; its use for intensity is secondary.

Scientific and Technical Terms

Lasers can be described in both objective and subjective terms. Objectively, we measure wavelengths, wattage, and brightness. Subjectively, we perceive color, intensity and luminance.

The following scientific and technical terms are often used to describe lasers and laser light.

Brightness

An objective measure of how powerful light is over a specific area. (Specificially, watts per unit area per unit solid angle.)

Two lasers can be equal in power; the one with the smaller *divergence* has higher brightness, since the light is concentrated into a smaller area.

Coherence

A laser produces coherent light; conventional light sources produce incoherent light. Coherent light waves all travel the same direction (spatial coherence) at the same frequency and in phase (temporal coherence).

This gives rise to the very narrow beam and intense, pure light that characterizes laser. Coherence also produces shimmering laser *speckle* and the web-like effects of *lumia*.

Color

A subjective perception of light *wavelengths*.

One of the attractions of lasers is the intense, pure colors they produce. This is because they emit specific, narrow wavelengths of light, which we see as saturated colors. Scientifically, color is the perceived wavelength of light.

Different lasers produce different wavelengths or *lines*, depending on the type of lasing media. Most light-show lasers use gas as the lasing media. Only a few, well-defined lines are emitted by gas lasers with sufficient power to be useful in light shows. These colors cannot be filtered or otherwise modified to produce intermediate colors.

This means that only a relatively small number of naturally occurring laser lines are available. To get a wider range of colors, different lines are mixed together using various techniques. Most commonly, red, green and blue lines are individually controlled and combined into a single beam which theoretically can be any desired color.

See the *Laser projection equipment* section of this Glossary for more information on various color mixing techniques.

See also: *Line, Wavelength*.

Divergence

An objective measure of the amount that a laser beam spreads as it leaves the laser head.

High divergence produces larger spot sizes, which is undesired. Divergence can be a problem when the *throw* is long. Arrangements of lenses are usually used to minimize divergence in these cases.

Flicker

A perceptual effect in laser-drawn graphics when the laser cannot complete its path before the eye's persistence of vision sees the image fade. The effect, usually undesired, is that the image is flickering or pulsating.

Solutions include fully darkening the environment, changing the laser's power, speeding up the scanning rate, or reducing the complexity of the graphic traced by the laser.

A related effect occurs when viewing videotaped laser graphics. The laser's scan rate often does not match the TV camera's frame rate. The video image appears to flicker. Videotaped laser graphics generally exhibit much more apparent flicker than the original live laser graphics.

Line

Short for “spectral line”, referring to a particular *wavelength* of light in the visible spectrum.

See also: *Wavelength*.

Luminance

A subjective measure of how *brightness* is perceived by the eye. It depends not only on brightness but on wavelength.

Two lasers can be equal in brightness but a green beam has higher luminance than red, since the eye is more sensitive to green light.

Milliwatt

One thousand milliwatts equal one watt. Small lasers' beam powers are measured in milliwatts.

For example, a 50 mW laser is one-twentieth of a watt; a 500 mW laser is one-half watt..

See also: *Watt.*

Speckle

An effect caused by the *coherence* of laser light. Laser speckle looks like a dense pattern of dark and light areas, which shimmers as you move your head from side to side.

The more spread out the laser light on a surface, the more visible the speckle. For example, it is easier to see speckle when viewing *lumia* than when viewing graphics.

Only laser light exhibits this eerie, beautiful iridescence.

Watt

An objective measure of power; in lasers, usually refers to the optical output power, or strength, of a laser beam. Large light show lasers are generally in the 1 to 20 watt range.

Watts are also used in a more conventional sense, to measure electrical power used by a laser. For example, a 10 W (optical) argon laser consumes around 10,000 W of electrical power.

Wavelength

The distance from the crest of one wave to the next. In lasers, wavelength is important because it determines the perceived color of the light.

Visible light has wavelengths extending from about 700 nanometers (red) through orange (~600 nm), yellow (~580 nm), green (~550 nm), blue (~450 nm) and violet (~400 nm).

Most gas lasers used in laser display emit many wavelengths, or spectral *lines*, simultaneously. The lines have different strengths. Usually, only a few lines have significant brightness.

For example, an argon laser may produce seven or more lines. The principal lines have wavelengths of 514.5 nm (green) and 488.0 nm (blue); they account for about two-thirds of the laser's total light output.

The terms “wavelength”, “line” and “color” are often heard when discussing laser light colors. Although there are important technical differences between these concepts, in common usage they are often used interchangeably.

Safety

The primary hazard of light show lasers is eye damage. Higher power lasers also have some burn and fire hazards. However, no light show laser can do science-fiction type damage or disintegration.

Both equipment and show site must be made safe so beams cannot go into the audience. Usually, governmental regulatory agencies must be notified in writing before lasers can be used. Thus far, the regulations have worked well. There have been no reported injuries in the United States from light show lasers since U.S. federal regulations took effect in 1976.

All ILDA members active in U.S. laser displays are required to have a current CDRH variance.

BMRD

The Bureau of Medical and Radiation Devices, a division of Health and Welfare Canada, is the federal government agency which has jurisdiction over laser displays in Canada.

Some provinces also have their own regulations and regulatory agencies. A complete list is available from the BMRD.

CDRH

The Center for Devices and Radiological Health of the Food and Drug Administration, Department of Health and Human Services, is the principal federal regulatory agency covering U.S. laser displays.

Some states also have their own regulations and regulatory agencies. A complete list is available from the CDRH.

Mask

A device used to obstruct the laser beam so it is blocked from undesired areas. The mask is usually placed at the final output aperture of the laser projector.

Masks are used for aesthetic reasons, to keep light from going off a screen, and as a safety feature, to ensure lasers cannot reach the audience in case of equipment malfunction.

This is also called a beam block.

Radiation

The CDRH currently requires higher power U.S. lasers to bear labels reading “Warning: Laser radiation”. The word “radiation” refers merely to the laser's light. This is *not* high-energy ionizing “atomic” radiation, which is the more conventional use of the word.

The CDRH is considering changing the wording to the more appropriate “Warning: Laser light.”

Shutter

A device used to block the laser's beam. Usually positioned between the laser and the laser projector, so when engaged, no beam reaches the projector or other effects devices.

See also: *Blanking*

Variance

Any U.S. laser display viewed by the public must follow CDRH regulations. The regulations cover both laser equipment and the performance site. Permission to vary from the regulations is given on a case-by-case basis, in a document called a “variance”.

Only very small lasers (5 milliwatts or less) can be used in displays without a variance. Because of the higher power necessary in laser shows, a variance is almost always required.

All ILDA members doing laser shows in the United States are required to hold a current CDRH variance. ILDA members outside the U.S. are required to follow the regulations of the location in which they provide laser displays.

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