599 Series Dye Laser

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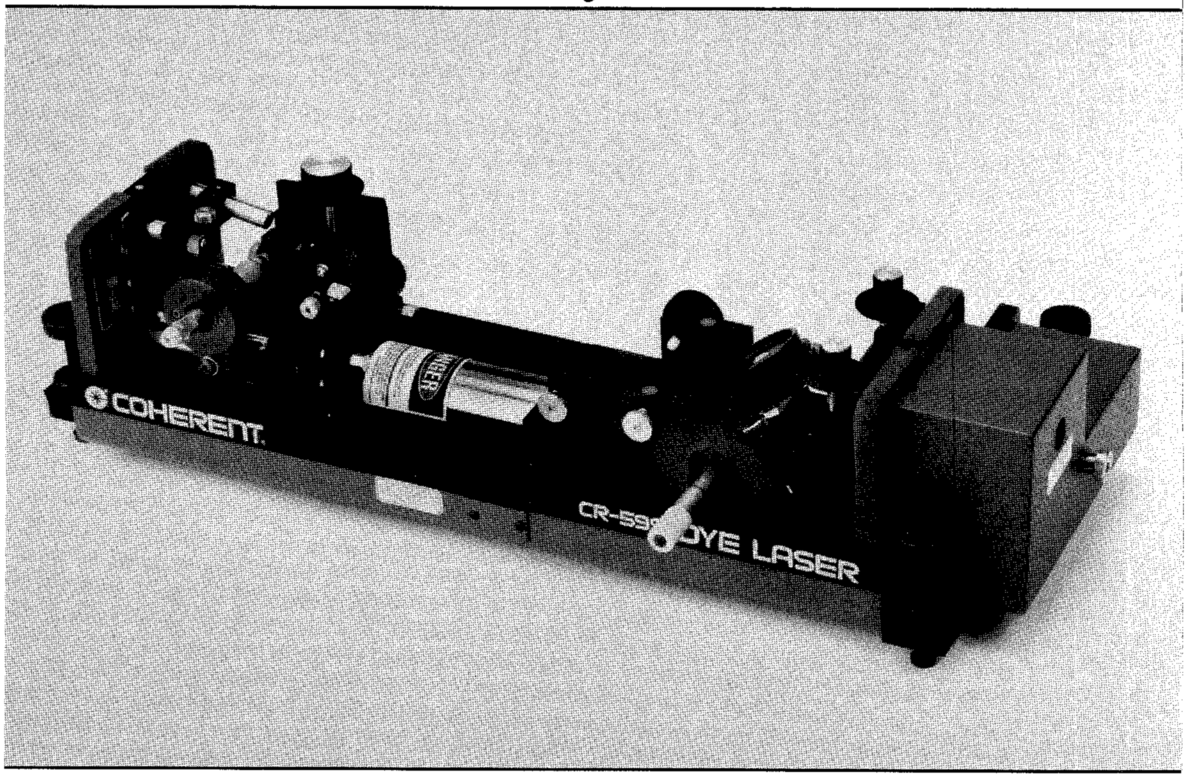
599 Standing Wave Dye Laser



- **Ultra-stable Invar resonator**
- **Variable cavity geometry**
- **Birefringent filter tuning**
- **40 GHz linewidth**

For broadband applications, the CR-599-01 Standing Wave Dye Laser provides an outstanding combination of reliability, ease of operation, and proven high performance.

Cavity Configuration

The CR-599-01 Standing Wave Dye Laser utilizes a three-mirror cavity design with all optical elements mounted directly to a 5 cm diameter Invar bar. The large mass and low thermal expansion of this element, linked with thermal length compensation in the mirror mounts, provide amplitude and frequency stability unequalled by quartz resonator designs. The use of an off-axis fold mirror in the resonator can result in an astigmatism in the cavity. The CR-599 is designed with a small fold angle, so no appreciable astigmatism results. A further astigmatism reduction is provided by optical compensation against the Brewster-angle jet stream. This means that the CR-599 has a stable cavity beam with a Gaussian intensity distribution, with a nearly circular beam profile for a TEM_{00} transverse mode. All mirrors are orthogonally mounted and directly driven,

Coherent utilizes high quality multilayer dielectric coatings on all high reflectors. This design provides a wide band-width (typically 70 to 100 nm) which aids in reducing the number of mirrors required to cover the full spectrum. The output couplers are individually designed to obtain maximum output power from each dye.

The pump beam from the ion laser is focussed into the dye stream with a dual-coated concave mirror. A single mirror is used for all argon wavelengths, visible or UV, thus simplifying alignment during a dye change and reducing mirror cost.

The folding mirror is mounted on an adjustable slide. This feature (available only from Coherent) allows the user to optimize the cavity configuration for each dye by changing the fold mirror radius. Variable cavity geometry results in maximum output power and tuning range by optimizing the beam waist diameter and power density in the jet stream. For example, the 3W pump laser threshold associated with the infrared dye HITC may be reduced to 750 mW simply by changing the standard 7.5 cm fold mirror to a 2.5 cm fold mirror. This unique design provides higher conversion efficiencies for low gain dyes such as the coumarins and produces higher output power before saturating with strong dyes such as the rhodamines.

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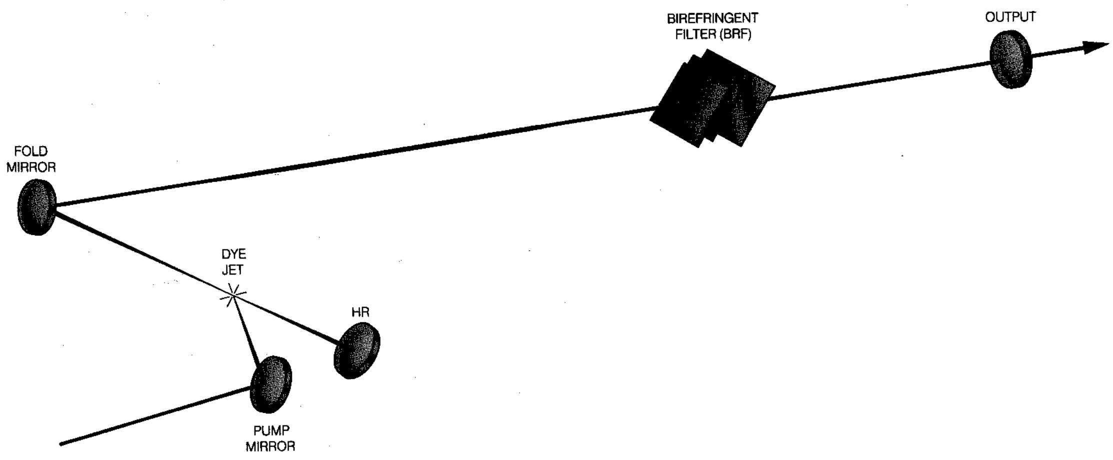
CR-599-01 OPTICAL DIAGRAM



Birefringent Filter Tuning
Birefringent filter tuning was invented by Coherent specifically for use in CW dye lasers. The extremely low insertion loss, broad tuning range, precise, repeatable tuning characteristics and insensitivity to cavity alignment make the birefringent filter the optimum wavelength selecting element for dye lasers.

The filter utlilizes polarization effects (birefringence) in crystalline quartz plates to tune the output of the dye laser. To ensure optimum performance, the plates are cut only after alignment by x-ray diffraction, and then are polished to a laser quality finish. This procedure assures 0.01 nm resolution and 0.1 nm repeatability with typical tuning linearity of 2%.

The birefringent filter has no reflective coatings and thus has very low insertion loss and broad tuning range. It will tune smoothly over the dye gain curve with a linewidth of less than 40 GHz. In contrast, a multilayer, dielectric coated tuning wedge has higher insertion loss. The wedge also requires an additional etalon to reduce the linewidth below 150 GHz.

The birefringent filter is available with one, two, or three plates. The output linewidth using a three-plate filter is typically 20-40 GHz, and using a two-plate filter is 60-100 GHz. The single-plate filter gives a linewidth of 500 GHz.

Dye Flow System
A precision stainless steel nozzle is used to inject an optically flat stream of dye across the laser's optical axis. This nozzle is hard mounted at Brewster's angle in a micropositioning stage which allows independent adjustment of vertical, horizontal, and angular position.

Unlike jet nozzles mounted in ball joints, this design simplifies jet alilgnment by decoupling lateral and rotational adjustments. The hard mounting eliminates nozzle creep, an inherent problem with plastic fittings.

The Model 591 dye circulation module contains the dye pump, filter, and reservoir and has complete instrumentation for precise control of the dye flow. The isolated design provides smooth, even dye flow with so little transmitted vibration that there is no need for costly surge tanks and accumulators. A water cooled heat exchanger maintains constant dye viscosity for uniform jet thickness.

CR 599 – OEM
Dye lasers are an extremely powerful tool and are being used for new applications beyond the scientific research market. Applications have arisen in medicine, entertainment and crime detection which require the special features of a dye laser. The CR 599-OEM is a dye laser designed specifically for the original equipment manufacturer. It is based on the proven CR-599 resonator design, and incorporates many of its performance features. The output power and mode specifications are similar to the CR-599-01. This laser is designed for low cost broadband tunable laser output and has no provisions for the placement of an intracavity etalon assembly.

If your application requires the special features of a dye laser, contact Coherent Laser Products Division. Coherent has the experience and expertise to tailor a system to your specific needs.

CR-599-01 OPTICS SELECTION GUIDE

DYE	HR OPTICAL COATING RANGE (nm)	FOLD MIRROR	R (mm)	HIGH REFLECTOR	R (mm)	OUTPUT MIRROR	T (%)	PUMP MIRROR	R (mm)
Stilbene 1	395-435	0158-788-02	75	0158-787-02	50	155-272-00	2-4	406-721-01	75
Stilbene 3	410-480	0158-788-03	75	0158-787-03	50	500-836-06	2-5	406-7721-01	75
Coumarin 102(1)	435-520	0158-788-04	75	0158-787-04	50	500-836-07	3-5	406-721-03	75
Coumarin 6	480-570	0158-788-05	75	0158-787-05	50	157-636-00	2-7	406-721-01	75
Rhodamine 110	510-605	0158-788-06	75	0158-787-06	50	500-836-03	2-5	406-721-01	75
Rhodamine 6G	572-665	0158-788-07	75	0158-787-07	50	500-836-03	2-5	406-721-01	75
DCM	620-740	0158-788-08	75	0158-787-08	50	500-836-01	3-5	406-721-01	75
Pyridine 2	680-810	0158-788-09	75	0158-787-09	50	157-634-00	1.5-3	406-721-01	75
LD700(2)	680-810	0158-788-09	75	0158-787-09	50	155-271-00	3-5	406-721-02	75
Styryl 9M	800-950	0158-788-11	75	0158-787-11	50	157-635-00	1-7	406-721-01	15

(1) Optics listed are for krypton pump
(2) To be announced

SPECIFICATIONS

Mode:	TEMoo
Polarization:	Vertical
Beam Diameter:(1)	0.6 mm
Beam Divergence:(1)	1.5 mrad
Jitter (Effective Linewidth):	40 GHz(2) (3 plate) 100 GHz(2) (2 plate)
Power Stability:(3)	3%/day
Noise:(3)	1% rms 10 Hz–100 kHz

(1) Nominal: depends on wavelength and cavity alignment.
(2) Full width at half maximum (FWHM) linewidth.
(3) The dye laser output replicates the output of the pump laser. These numbers refer to the inherent properties of the dye laser.

Specifications subject to change without notice.

OUTPUT POWER SPECIFICATIONS

DYE	λPEAK(nm) (APPROX)	PUMPED BY	OUTPUT(1)
Stilbene 1	415	2.5W UV	130mW
Stilbene 3	438	2.5W UV	360mW
Courmarin 102	490	2.5W violet (2)	480mW
Courmarin 6(3)	536	3.0W 488nm	240mW
Rhodamine 100	545	5.0W B-G	540mW
Rhodamine 6G	593	5.0W B-G	880mW
DCM	660	5.0W B-G	540mW
Pyridine 2	720	5.0W B-G	600mW
LD700	750	4.6W red(2)	1200mW
Styryl 9M	830	5.0W B-G	450mW

Specification Footnotes

(1) All output powers are at the peak of the dye, using recommended optics and with specified pump powers from an argon ion laser except where noted.
(2) Pump laser is a krypton ion laser.
(3) Dye is tested with 9 methylanthracene (9MA) as an additive.

3.0 CONTROLS AND OPERATION

3.1 OPTICAL ALIGNMENT OF DYE LASER

In Section 2.2.3 the alignment procedure to be used when the Model 590 is first received from the factory is discussed. This procedure assumes the Model 590 was in alignment or very close to proper alignment as received from the factory. Under some circumstances, realignment may be necessary. This requires all optical elements to be removed from the Model 590 head (Fig.9). The dye jet must be off.

(1) Set the dye laser about one foot from the argon ion pump laser, either on a stable table or a Model 592 mounting platform.

(2) Remove the output mirror, folding mirror (on Invar finger), pump mirror and end HR-mirror. Remove bi-refringent tuning mechanism as a complete unit by loosening the chromed finger screw. (Fig.11).

(3) Set pump laser power at 50-100 mW. Physically position the 590 so that the pump beam enters centered on the hole in the input bezel and exits centered on the hole below the center of the output mirror housing. Mark the place where the beam strikes on some wall or object at least one meter away. (Double coated tape is helpful under the mounting feet to prevent accidental movement of the 590.

(4) If the catcher tube is not known to be in the correct position, unclamp it to remove the rubber boot and splash shield (see Fig. 16). (Loosen the set screw in the splash shield control knob and the splash shield will slide off the catcher tube).

(5) ~~Block pump beam and raise power level of pump laser to operating level to stabilize position of the pump beam.~~ Examine pump mirror for cleanliness. (If cleaning is required, see cleaning procedure in Section 5.2.1.) Insert pump mirror with chordal stripes vertical (i.e. this mirror is used near its edge; be sure one of the two sides coated all the way to the edge is up). Tighten pump mirror lever.

(6) Move the folding mirror holder down to the end of the Invar® finger as shown in Fig.12, and swing the aperture aside to reveal a 2 mm drill hole ~3.5 cm above pump beam hole on folding mirror mount plate.

(7) Adjust vertical and horizontal pump mirror adjusting knobs (on top and side of package) to position the pump beam on the 2 mm drill hole on folding mirror mount plate. Do not further adjust these knobs until the 590 is lasing.

(8) Adjust the focus control with a 3/32 Allen head wrench so that the slide attached to the pump mirror is about mid-range (See Fig.14 12).

(9) Connect one end of the jet feed hose to the utility module, and the other end to the jet translator assembly (Figs. 16 & 17).

The translator assembly (Fig. 17) consists of a cylindrical nozzle holder supported in a plate (with an extension making a "top-hat" shape) by four pivot screws in the front (nozzle) end, and four pointing control screws in the rear (hose connector) end. The top-hat plate is secured to the base with two locking screws which go through the base to engage a retaining plate. After slightly loosening the locking screws, a parallel translation of the plates (and jet) is produced by backing off one and pushing with the opposite one of the four jet translation control screws in the base.

The flat face of the jet must be oriented rear Brewster's angle. Loosen the top two of the (front) pivot screws, and the top two (rear) pointing control screws to allow the nozzle holder to rotate. Slope the long dimension of the nozzle tip at roughly 26° above the horizontal, upward toward the output end of the laser, and along the line of two of the pivot screws (Fig.17). Slide the holder axially so that the tip of the nozzle is approximately 1.5 cm from the centerline (optical axis) of the laser head. Tighten the loose screws to clamp the nozzle holder in place.

(10) Insert the catcher tube so that the cut-out portion is centered on the laser midline. Rotate the tube so that the bottom of the cut-out slopes downward by about 40° toward the output end of the 590. The nozzle should point approximately down center of the catcher tube. The pump beam should just clear the catcher tube.

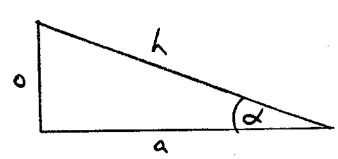
(11) Slide the 1/2-inch I.D. return hose over the end of the catcher tube by about 1 inch and connect the other end to the utility module reservoir. Adjust the return hose path so that it has at least a 5° downward slope toward the reservoir. Check that the fluid circuit is complete.

$\tan\alpha = o/a$

$o = a\tan\alpha$

$= (70\,cm)\tan(26°)$

$= 34.1\,cm$



(12) Add about 300-400 ml of the dye mixture to the reservoir. Decrease pressure adjustment to minimum. Turn the pump to JET position. Slowly increase pressure to 10 psi. Check for any leaks or back-ups in fluid return path. Add more dye fluid as necessary to keep the reservoir at least 3 cm deep. Operate at 10 psi until all signs of air bubbles in the lines are eliminated.

Increase pressure to 30-40 psi. Add fluid so that the reservoir has at least 2-3 cm of fluid. Operate jet at 30-40 psi. Water cooling the heat exchanger is important for highest power conversion efficiency and stability. At this point check the following:

(a) Jet stream passes unobstructed from the nozzle to the wall of exit hose tubing. As viewed from above, the jet stream should strike in the approximate center of the catcher tube and about ± 1 cm from where it exits the catcher tube clamp.

(b) See if the jet is stable. No air bubbles or visible fluctuations should be present. (If it is not in a stable configuration, the nozzle will have to be cleaned or changed. Consult Coherent service office listed in Section 5.7).

(13) Without changing pump cavity turn pump power down to about 10-100 mW. Unblock pump beam. The pump beam should just clear the edge of the cutout in the catcher tube. If it clears it by too much, the other edge of the cutout may block lasing action. This is the proper position of the catcher tube, and the splash shield and boot should now be replaced. First mark with a pencil the position of the catcher tube (with respect to its clamp) to insure correct installation after the shield replacement. Be sure to turn off the jet before removing the catcher tube, and always close the splash shield before turning on the jets as in Section 2.2.3(10).

The precise strike point of the jet stream in the catcher tube has a considerable influence on the amount of bubbles or turbulence generated in the stream in the return line. The viscous solution tends to hang in a film on the upper wall of the catcher tube, and if the high velocity jet stream impacts into this area, bubbles are created. Adjust the four pointing control screws (Fig. 17) to pivot the nozzle holder about the four pivot screws, to position the strike point for minimum bubbles or stream turbulence.

For maximum power and good mode, the stream must be perpendicular to the optical axis in both the horizontal and vertical plane. Final adjustments may be made at Step 24.

(14) Examine the folding mirror for cleanliness. Insert the folding mirror. Tighten lever. Move folding mirror support along Invar® finger such that it is about one-half the mirror radius from the jet. The short radius is 2.5 cm; long radius is 7.5 cm. The mirror radius is determined by the dye, and can be determined by the mirror chart at the end of Section 9. Place aperture in front of folding mirror. Turn pump power up to operating level.

(15) Adjust the three screws on the folding mirror mount plate until the fluorescent spot is 1.2 cm (short radius) or 1.7 cm (long radius) directly above the pump spot mark. Now focus the spot at 76 cm (short radius) or 64 cm (long radius) from the folding mirror by moving the mirror on the Invar® finger (Figs. 12 and 13). It is only necessary to get to within ± 20 cm at this point. Tighten the mirror holder onto the Invar finger.

(16) Adjust the pump focus control for clearest spot at the approximate focal plane. (The spot will be elongated vertically with a short radius mirror.)

(17) Now accomplish final folding mirror focussing by turning the three adjustment screws 1/6 turn in the same direction to drive the focal plane to the appropriate distance (76 cm for short radius, 64 cm for long radius). Check on the focus location by moving a piece of paper along the beam. When the spot is in focus, check to be sure it is the proper distance above the pump mark (1.2 cm for short radius, 1.7 cm for long radius).

(18) Examine the high reflecting (HR) mirror for cleanliness. Insert the HR mirror in its holder and tighten the lever. Adjust the three screws on the mirror mount plate until the spot from the end mirror is just along side the spot from the folding mirror. Now focus it by adjusting the three screws exactly as in the previous case of the folding mirror. The focal distances are the same as for the folding mirror. The two spots should be similar in size and shape and very close. Now overlap the end mirror spot onto the folding mirror spot. Check that they are both 1.2 cm (short radius) or 1.7 cm (long radius) above the pump spot.

(19) Examine the output mirror for cleanliness. Insert the output mirror in the holder, holder in the mount, and screw the bezel nut into place.

(20) Rock the output mirror plate in a vertical plane by moving the vertical adjust knob in a front-to-back motion. Rotate the horizontal knob while rocking the vertical until the reflected spot bisects the end mirror. Adjust the vertical knob so that the spot travels higher than the folding mirror aperture hole.

(21) While rocking the vertical slowly rotate the horizontal so that the reflected spot crosses the center of the aperture. When a lasing flash occurs, stop the horizontal sweep, and adjust the vertical to tilt the output plate forward until CW lasing occurs. It is useful to check by rocking as the CW lasing is approached.

(22) Using the output mirror adjusting knobs, approximately center the lasing spot on the end HR mirror (M1), adjusting vertical and horizontal pump mirror knob only as necessary to bring the power up. It may be necessary to rotate the aperture to the side for best power in the long radius case. For the short radius, it is better to leave the aperture in place in order to aperture the residual pump beam.

CAUTION

Do not stare into the port located above the jet. Beams reflected from the jet surfaces exit through this port (see Steps (24) & (25)).

(23) When the mode is centered in the end HR mirror, adjust the pump mirror focus control with a 3/32-inch Allen wrench for optimum power and mode (Fig. 16). The pump mirror controls should be readjusted after each focus control adjustment.

NOTE

If the lasing mode cannot be centered check to see that the catcher tube is not aperturing (with the edge nearest the folding mirror).

(24) To set the jet stream accurately at Brewster's angle to the dye cavity beam, proceed as follows. Hold a white card above the jet to view the spots reflected off the jet (Fig. 18). As in step (9), loosen slightly the top two of each of the pivot and pointing screws to unclamp the nozzle holder. Then rotate the holder to observe a minimum in the intensity of the spots seen on the card. Set the rotation angle at this minimum, which is Brewster's angle. A wrench placed over the feed hose-connector hex gives added leverage to simplify this adjustment. Clamp the nozzle holder back in place by tightening the four screws, and peak the output power using the pump beam controls.

(25) The optimum mode and minimum fluctuation of output power is obtained if the dye cavity focal point is located at the center of the jet, where the jet surfaces are the most flat and parallel. The cross-section of the jet stream has a "dog-bone" shape as indicated in Fig. 18. Thus the offset in the vertical plane of the two spots seen on the card indicates when the jet is centered. Loosen the two locking screws (Fig. 17) of the translator assembly, back-off one translation control screw and drive-in the opposite screw to move the jet. Observe the jet reflections and position the jet as in Fig. 18(a) where the two spots cross. (The slight offset of the spots seen in the horizontal plane is produced by a residual wedge of under 0.5° along the jet axis at the 1.5 cm operating distance from the tip). This optimum distance is determined by the development on the jet stream of surface ripples at greater distances downstream. The translation controls move the jet either approximately in the plane of the jet for transverse centering as just discussed, or perpendicular to the plane of the jet (focal depth adjustment). Tighten the locking screws when the jet is centered. Repeat Step (23), or Steps (17), (18) and (23), to restore optimum power and mode if the translation required was large enough to significantly degrade these.

(26) Insert the birefringent filter. In short radius operation this will move the lasing beam along the concave output mirror, causing the mode on the end HR to move down and possibly stop lasing. Also the birefringent filter may be adjusted to a wavelength incompatible with the dye. Set the filter to a wavelength near maximum power output for the dye employed, or if calibration loss is unimportant, rotate the filter so that the scribe mark at the edge of circular plate is vertical or horizontal.

(27) Adjust the vertical output mirror adjustment to tilt the top of the plate forward. This will center the mode or restore lasing. Return the plate to original position and begin sweeping until lasing commences.

3.2 UTILITY MODULE, OPERATION

The utility module was discussed in Section 2.2.2. It requires 115 VAC 60 Hz 1 ϕ power. (Optional 240 VAC 50 Hz operation is available). There are only two front panel controls, a switch to turn the unit on and off, and a pressure control valve to adjust jet pressure. To turn on, put switch in JET position. Pressure is adjusted with the valve and is observed on the pressure gauge. Normal operating pressure is 30 to 40 psi.