6 OPERATION

6.1 Experimental Setup

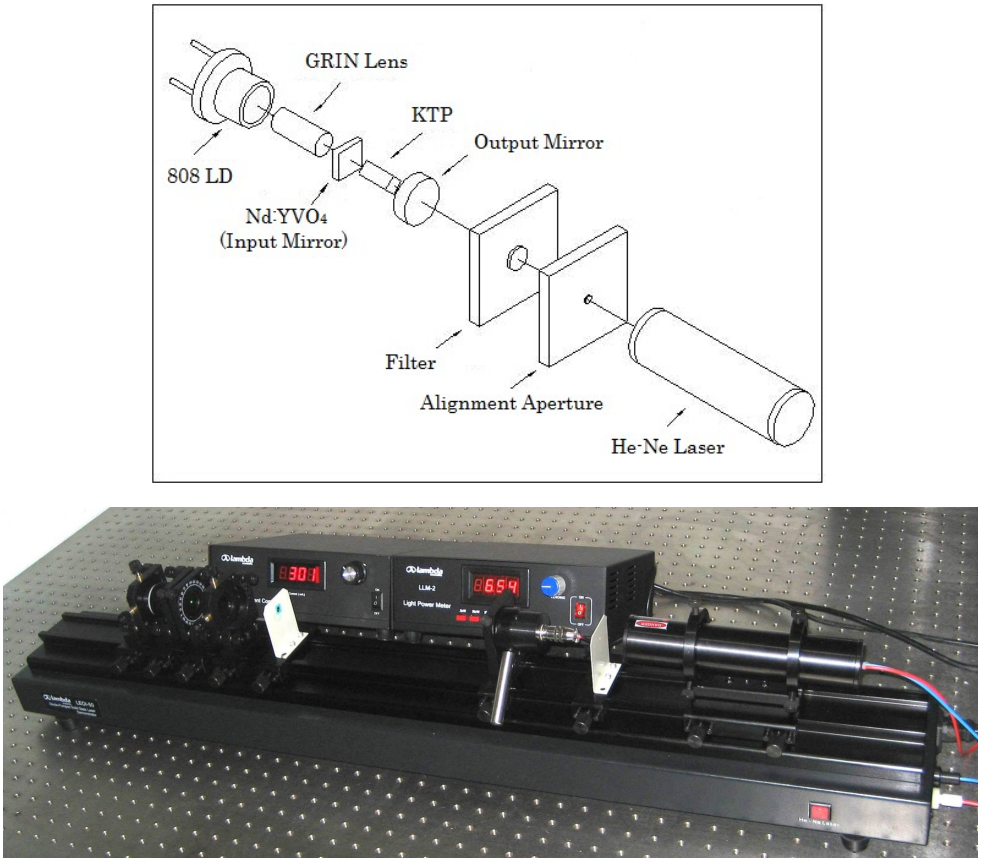


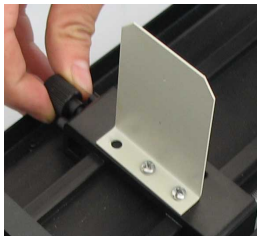
Figure 7 Schematic and photo of system configuration

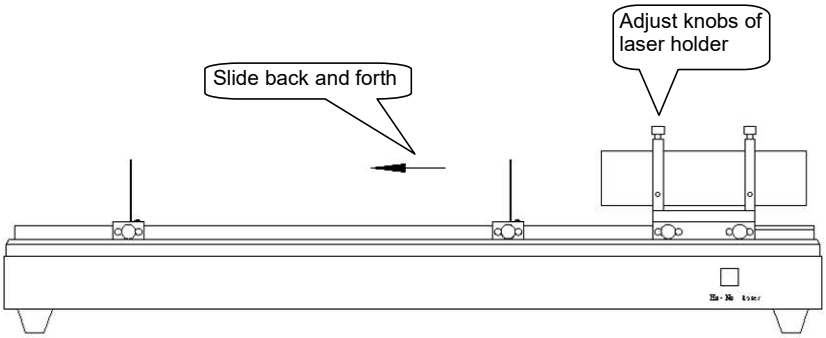
A 808-nm laser diode (LD) is used to pump a Nd:YVO4 crystal to generate 1064-nm near-infrared laser light. A KTP crystal in the resonant cavity is used to generate frequency doubled 532-nm green laser light. The gain medium, Nd:YVO_4, is a crystal (3×3×1 mm) of 3% doped cut along the axis. The absorbance of the input laser in the crystal is approximately 95%. The frequency doubling material is a KTP crystal (2×2×5 mm), which is highly transmissive at both 1064 nm and 532 nm. To achieve high pumping efficiency, a gradient index (GRIN) lens with a focal length of 3 mm is preinstalled to focus the 808-nm LD laser beam into a tiny light stripe with the beam waist located inside the Nd:YVO_4 crystal. The resonant cavity is a **hemispherical type** with the end surface of the Nd:YVO_4 crystal facing the 808-nm LD as the rear mirror, and the output mirror as the front mirror. The output mirror, made of BK7 glass with a radius of curvature of 50 mm, is highly reflective to both 808.5 nm and 1064 nm while highly transparent to 532 nm. The Nd:YVO_4 crystal should be kept within 50 mm from the output mirror to satisfy the **stability criterion** of a hemispherical resonator. The He-Ne laser is used for alignment purpose.

6.2 Experimental Procedure

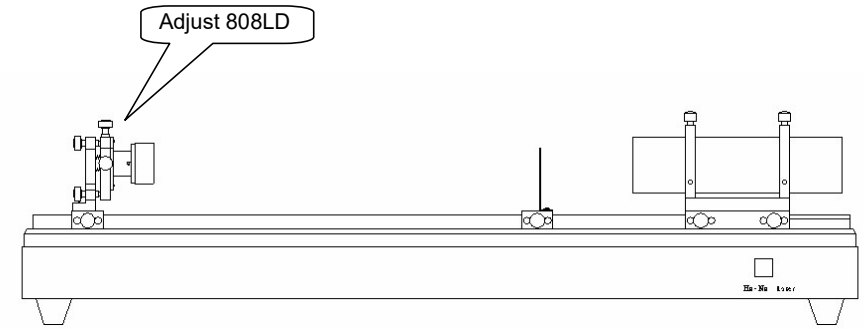
Step 1: Remove filter, output mirror, KTP crystal, Nd;YVO4 crystal, 808-nm LD with their carriers from the optical rail. Place the alignment aperture and the He-Ne laser on the rail. Secure He-Ne laser holder to the right end of the rail.

Step 2: Turn on the He-Ne laser. Slide the alignment aperture back and forth along the optical rail while adjusting the laser height and tilt (using the 6 adjustable screws on the laser holder), till the laser beam passes through the aperture at any point along the rail. Secure the aperture carrier near the aligned He-Ne laser.





Step 3: Mount 808-nm LD with carrier on the optical rail. Adjust LD position, (the GRIN lens is fixed on the LD), let the He-Ne beam point onto the GRIN lens through the alignment aperture. Adjust LD tilt angle so that the reflected beam from the GRIN lens returns to the center of the aperture.



Note: If a light spot (a laser beam that is reflected by the GRIN lens) is not found on the alignment aperture screen, use a piece of white cardboard to find it around the aperture screen.

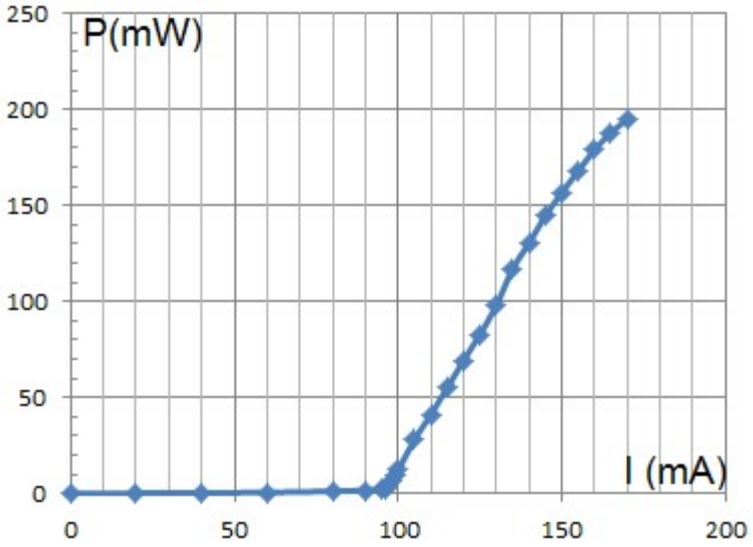
Step 4: Investigate characteristics of the 808 nm laser diode:

Turn on the LD and adjust the current potentiometer to increase current gradually. Insert the IR viewing card into optical path, next to LD and a red flat spot should be displayed on the card.

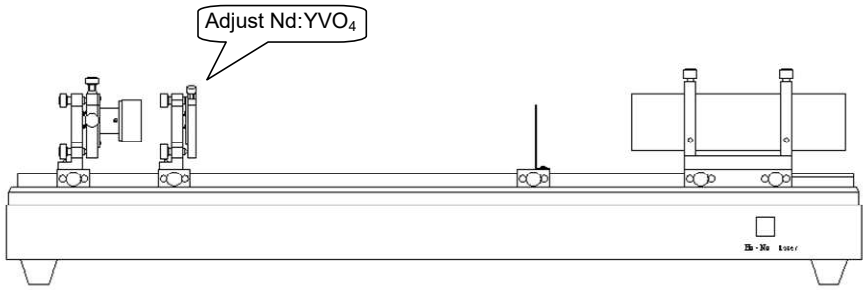
Note: Before turning on the power, set the current potentiometer to minimum, then turn on the power and gradually increase the current. Make sure the current does not exceed 500 mA.

Warning: Do not maintain a high driving current to the 808 nm pump laser over time, as otherwise the lifetime of the pump laser would be greatly reduced as there is no TE cooling to the laser.

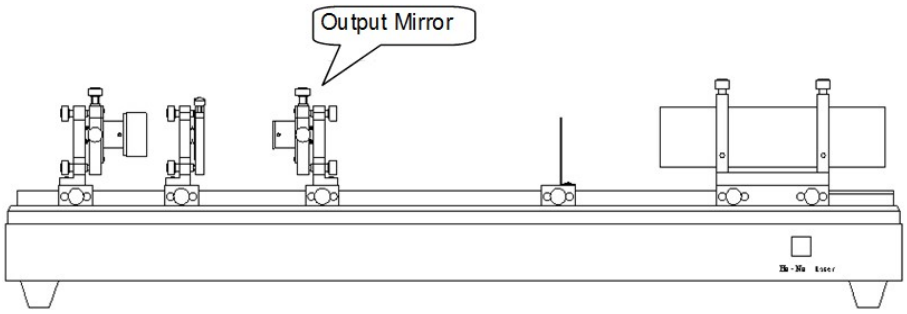
Place the optical detector head with its carrier behind the LD. Turn on the power meter. Starting from zero, gradually increase the driving current of LD. Record data set of current *I* and relative laser output power *P*. Plot *I-P* curve. Characteristics of threshold current and *I-P* relationship can be obtained (below is an example plot).



Step 5: Turn off LD and remove the power meter head from the rail. Mount the Nd:YVO_4 crystal with carrier onto the optical rail next to LD. Adjust the crystal orientation to make the He-Ne beam pass through the crystal, so the returned beam passes through the aperture again.



Step 6: Mount the output mirror onto the optical rail. Adjust the mirror (both position and tilt) to let the returned beam pass through the aperture again. There might be multiple beams reflected from the curved mirror. The beam returning from the spherical center needs to be distinguished.

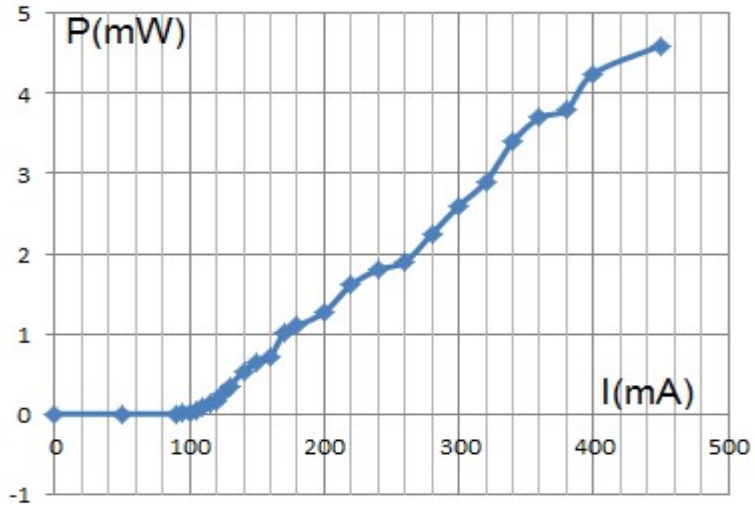


Note: The radius of curvature of the output mirror is 50 mm. To construct a stable hemispherical cavity, the distance between the front surface of Nd:YVO_4 crystal and the output mirror should be kept around 50 mm.

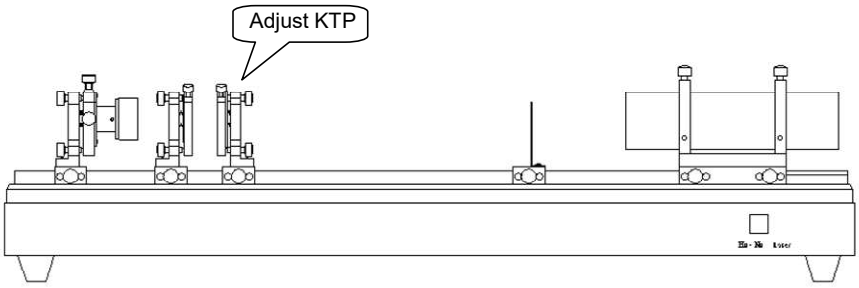
Turn on LD and set its driving current at a proper value (e.g. around 300 mA) to let the LD have a stable laser output. Carefully adjust the positon and orientation of the LD head and the distance between LD and Nd:YVO_4 crystal (note: withe care, do not allow the LD head to contact to the crystal surface), and at the same time use the IR viewing card to check if there is laser output from the output mirror (wavelength 1064 nm laser).

Once 1064 nm laser is detected, place the optical detector head immediately behind the output mirror to measure the relative power of 1064 nm laser. Again, finely adjust optical path to achieve the maximum 1064 nm laser reading *P*. Now, starting from zero, gradually increase driving current *I* of LD, record *I-P*

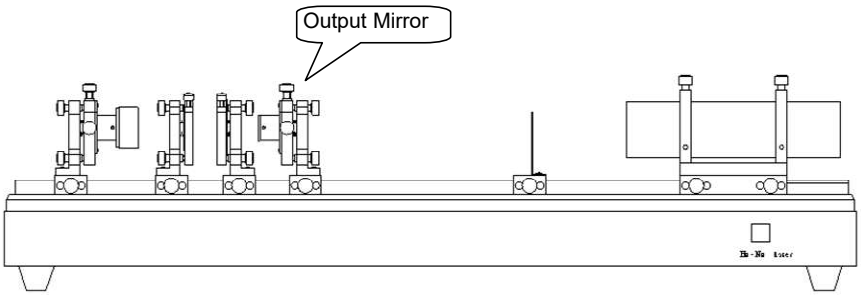
data. Laser threshold and relative efficiency can be achieved (below is an example plot). Also, the cavity length can be changed to study the stability of the cavity.



Step 7: Turn off LD and remove the optical detector head. Temporary remove the output mirror. Mount the KTP crystal on the optical rail next to the Nd:YVO_4 crystal. Adjust the crystal orientation to let the He-Ne beam pass through the crystal so that the returned beam passes through the aperture again.

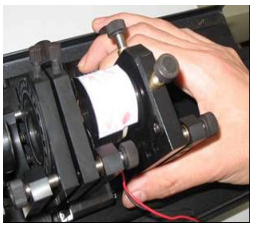


Step 8: Mount the output mirror back to the optical rail, next to the KTP crystal. Adjust the mirror (both position and tilt) to let the returned beam pass through the aperture again.



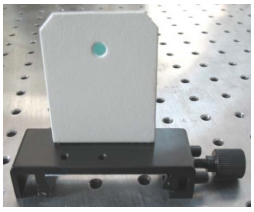
Note: The distance between the Nd:YVO_4 crystal and the output mirror should be kept around 40 mm while placing the KTP crystal between them.

Step 9: Turn on the LD and adjust the current potentiometer to increase current gradually. With proper adjustments, 532-nm green laser light will be observed. If not, then do the following:



a). Loosen the locking screw on the carrier base holding the LD and sway the carrier while watching the alignment aperture. Note: the focal point of the 808 nm laser is very close to the laser head, set the distance between the laser head and the Nd:YVO_4 crystal around 1 mm but do not contact each other to avoid damage their surfaces.

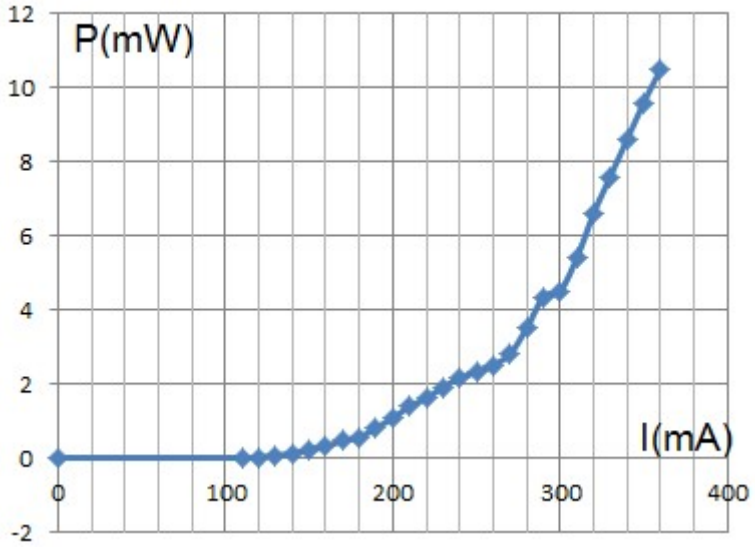
b). Unlock the rotation disk in which the KTP crystal is installed. Adjust the angle of the KTP crystal by rotating the disk to obtain a maximum intensity of the beam (for achieving the best matching angle).



Step 10: The observed green laser beam consists of two wavelengths of 532 nm and 808 nm. Place the filter back to the optical path to block the 808-nm laser light.

Step 11: Connect optical power meter. Turn on the meter and the reading of laser power output should be displayed. To maximize the power output of the 532-nm laser, try to finely adjust the tilts and distances of related components.

Step 12: Now, starting from zero, gradually increase driving current *I* of LD, record the relationship between driving current and 532 nm laser output power, i.e. *I-P* data. Laser threshold and relative efficiency can be achieved (below is an example plot).


P(mW)
I(mA)
12
10
8
6
4
2
0
-2
0
100
200
300
400