

## Module 2

The general layout of module 2 is shown in Figure 1 and it mainly serves for image relay and magnification adjustment. As Sine and Hershel condition requires a magnification of 1.33 between the focal point of O1 and O2, an extra pair of relay lens is need for such magnification adjustment purpose. The major alignment goal for module 2 is to form a 4-f system which follows similar procedures as mentioned in module 1.

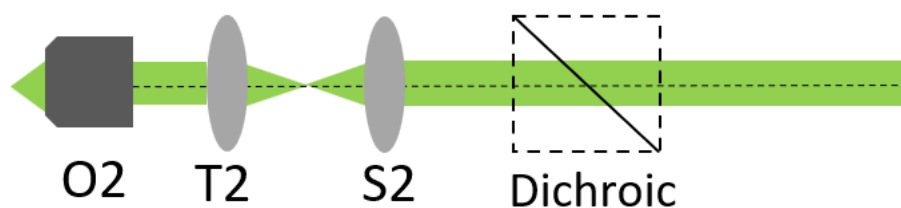


Figure 1 General layout of Module 2

For major components used for module 2, one 12'' travel track with 3 one-knob stages from Edmund Optics were used. A 30mm cage cube for rectangular optics from Thorlabs was used to house dichroic mirrors (Thorlabs, DMLP505R and DMLP605R) that matches the excitation and emission spectrum of the laser. A pair of 60mm and 100mm achromatic lens (Thorlabs, AC254-060-A and Edmund Optics, 49-284-INK) were used as S2 and T2. Finally, a 20X, high NA air objective (Nikon, CFI Plan Apo Lambda 20x/0.75 NA) were used as O2.

Alignment for module 2:

1. Mount the long travel rack onto the breadboard, the center of optics mount should be auto aligned with the center of galvo by doing so
2. Place 2 post mountable iris on the second and third one-knob stage and use them to confirm module 1 is well aligned. The laser spot reflected from galvo mirror should be travelling path is perfectly aligned with the breadboard in all xyz axis. The collimation of the laser should be checked using shear plate. Do not remove iris after this step
3. Using a lens tube to mount S2 before threading it onto the dichroic cage cube

4. Threading a set of cage rod to dichroic cage cube on the side with S2 mounted. Then mount a 30mm cage cube onto the cage rod relatively close to S2. The position doesn't need to be precise. This will be referred as "S2-dichroic" in later steps
5. Unthread T5 in module 1, the laser beam should now focused onto the galvo mirror. After that, mount S2-dichroic using post on the first one-knob stage.
6. Adjust the height and rotation of S2-dichroic until the laser beam passes through the center of both iris
7. Using shear plate to check if the laser beam after S2-dichroic is collimated. Adjust the position of one-knob stage on the track until the laser is collimated. It should be noticed that the space between S2-dichroic is very limited, adjust the spacing between the 30mm cage plate and S2 in step 4 if needed
8. Remove the iris from the second stage and placed somewhere further along breadboard's tapped hole for later reference. Thread T5 back in module 1 and mount T2 using a 60mm cage plate
9. Mount T2 on the second one-knob stage. Adjust its height and rotation until the laser beam passes both iris. Using shear plate as reference and adjust the position of the stage until laser coming out of T2 is collimated
10. Remove both iris and aligning laser in module 1. Mount a cage compatible iris onto the position where aligning laser used to be.
11. Using a C-SM1 adaptor to thread O2 onto a 30mm cage plate. Using a set of cage rod to mount the aligning laser directly on the front side of the O2
12. Mount O2 onto the third one-knob stage using post. Then turn on the laser and adjust both height and rotation of O2 until the laser beam passes the center of iris in step 10
13. Unthread T5 and use the shear plate to check laser's collimation. Adjust the stage with O2 mounted until the laser coming after the iris is collimated
14. Remove the aligning laser from O2's mounting plate. Remove the iris from step 10 and place back the aligning laser. Do not thread back T5
15. Mount the iris on the back side of O2's plate. Turn on aligning laser and readjust the height and rotation of O2 until the laser beam coming through T2 passing the center of iris

16. Remove iris from O2 and thread back T5. Module 2 is now fully aligned as a 4f system.
- The dichroic mirror can either be removed or inserted during the alignment as it does not affect the pathway of laser

Table 1 Part list for module 2

<b>Optical Part</b>	<b>Part description</b>	<b>Part number (Vendor)</b>
Dichroic mirror for GFP	505nm cut-on long-pass dichroic mirror	DMLP505R (Thorlabs)
Dichroic mirror for Tritc	605nm cut-on long-pass dichroic mirror	DMLP605R (Thorlabs)
S2	60mm achromat	AC254-060-A (Thorlabs)
T2	100mm achromat	49-284 (Edmund Optics)
O2	CFI Plan Apo Lambda 20x/0.75 NA	(Nikon)
<b>Mounting part</b>	<b>Part description</b>	<b>Part number (Vendor)</b>
Cage Cube	30mm cage cube for rectangular Optics	CM1-DCH (Thorlabs)
Travel track	12" pinion track	59-334 (Edmund Optics)
Manual track stage ×3	1 Knob stage	59-331 (Edmund Optics)
60mm cage plate	SM2 threaded, 0.9" thick	LCP34T (Thorlabs)
Lens tube	1" lens tube, SM1 threaded	SM1L10 (Thorlabs)
30mm cage plate ×2	0.35" thick, SM1 threaded	CP33 (Thorlabs)
C mount to SM1 adaptor	C mount internal to SM1 external	SM1A10 (Thorlabs)
1.5" post ×2	1/2" optical post	TR1.5 (Thorlabs)
0.75" post	1/2" optical post	TR075 (Thorlabs)
Cage rod set ×2	Length varied depends on actual need	(Thorlabs)
1" post holder	1/2" post holder	PH1 (Thorlabs)
1.5" post holder ×2	1/2" post holder	PH1.5 (Thorlabs)
Post collar ×3	Thin slip-on post collar	R2T (Thorlabs)