Optics Alignment

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Abstract

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I. INTRODUCTION

The laser optics alignment is crucial for polarized ^{3}He target optical pumping. This short note provides a quick way to align the optics. Together with some practice, everyone can be an optics alignment expert [1].

II. REQUIREMENTS

The layout of optics in target lab is shown in Fig. 1. Other than the laser, the optics setup on the table contains one lens, one splitting cube, 3 $\lambda/4$-wave plates, one 2.5 inch mirror and one 3 inch mirror. On the oven contains the target cell, a couple of 6" mirrors are installed to direct the polarized laser passing through the pumping chamber which are not shown here.

The divergent laser from fiber first get focused by the lens. Then while passing through the splitting surface of the cube, all S component and 10% of P component of the laser get reflected. The passing 95% of P linearly polarized light gets reflected by the 3 inch mirror and then transformed into circular polarized light by a $\lambda/4$-wave plate at 45 degrees, and this forms the first of two circular lasers incident on the target cell. The reflected light from the cube will pass through another $\lambda/4$-wave plate, get reflected by the 2.5 inch mirror and then pass through the $\lambda/4$-wave plate one more time. After this, the polarization of the light is rotated by 90 degrees, which means the S component turns into P component and vise versa. This time, when the light passes through the splitting surface again, the majority of P wave survives and forms the second circular polarized light after passing thought the third $\lambda/4$-wave plate. The rest light is about 5% of original laser and reflected to the tip of the fiber.

Ideally, we require all lines of laser either parallel or perpendicular to the optic components to get maximum polarization and light output. In practise, we have the following requirements for the alignment:

- Two laser's final spots should overlap well on the target cell pumping chamber,

[1] This particularly works out in the target test lab optics layout. Though the design in the hall is a little bit different, the method and main idea should be the same.

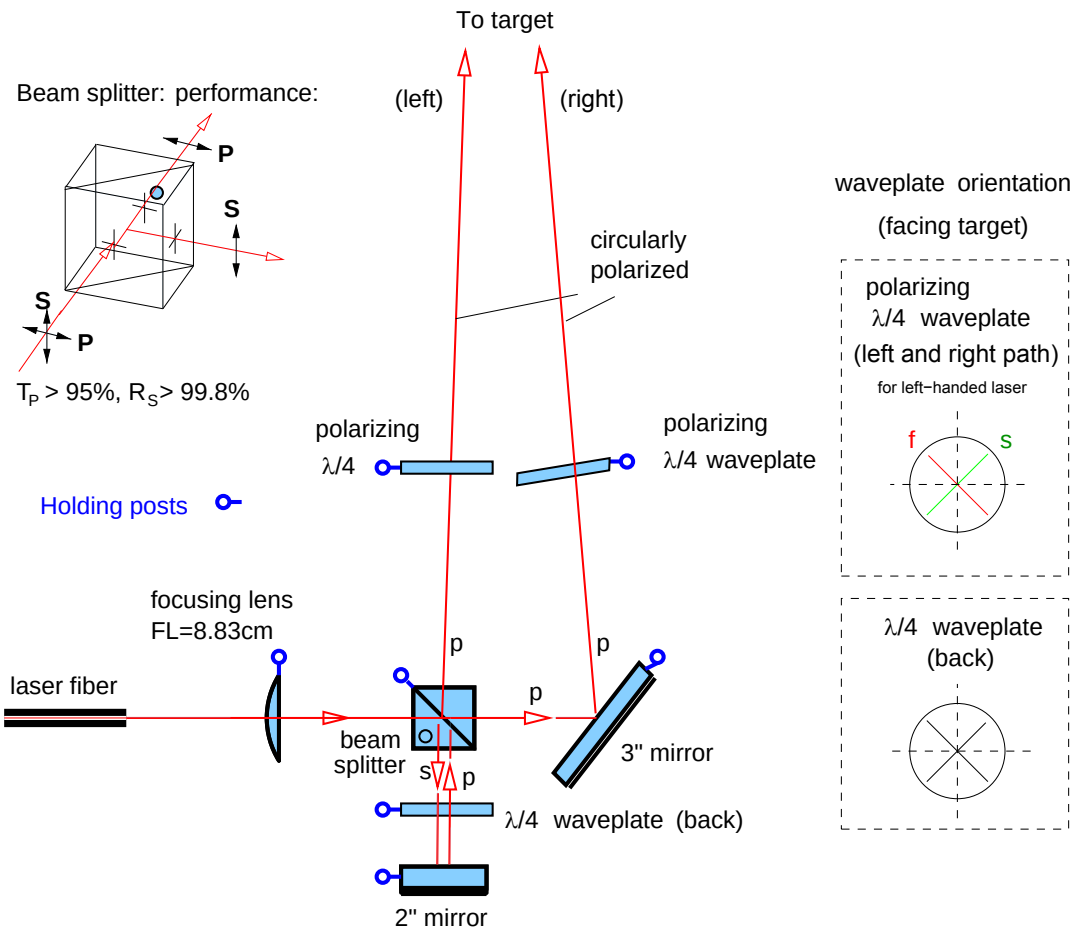

FIG. 1. The schematic of optics setup for polarizing laser.

- Both spots have clear edges, good shapes and proper size at the target and the shape of halos should be symmetric.

- The angles between the magnetic field and the laser's final directions should be less than 3 degrees to reduce the skew effect.

- An ideal alignment will have all the reflections back to the fiber tip. However to protect the fiber from being burned, we have to shift these reflections a little bit from the center to the sides of the fiber. Normally, there are six reflections: three from the $\lambda/4$-wave plates, two from the cube front and back surface, and one from the 2.5" mirror. Among these spots, the reflection from the 2.5" mirror which is the left over 5% of total laser power introduced by the cube is the brightest one.

III. SOME SIMPLE MATH

Before we can quickly finish a alignment from scratch, we need to category all the optic components:

- Components which only effect the laser directions are: lens and 3" mirror.
- Components which only effect the refections are: three $\lambda/4$-wave plates.
- Components which effect both reflections and output light are: cube and 2.5" mirror.

The difficulties of the laser alignment lie in the correlation between the final laser directions and the reflections. The most difficult part of the whole work is the alignment of the left side optics line as shown in Fig. 1. The effects of rotating the cube and the 2.5" mirror are shown in Fig. 2.

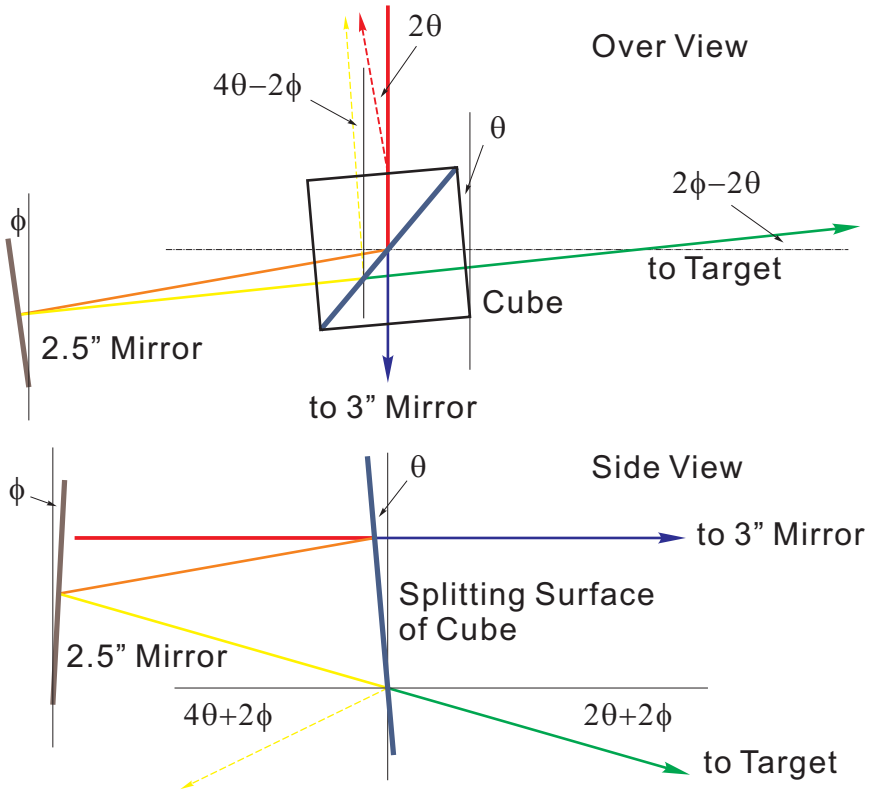

FIG. 2. Changes of laser output and reflections by rotating cube and 2.5" mirror.

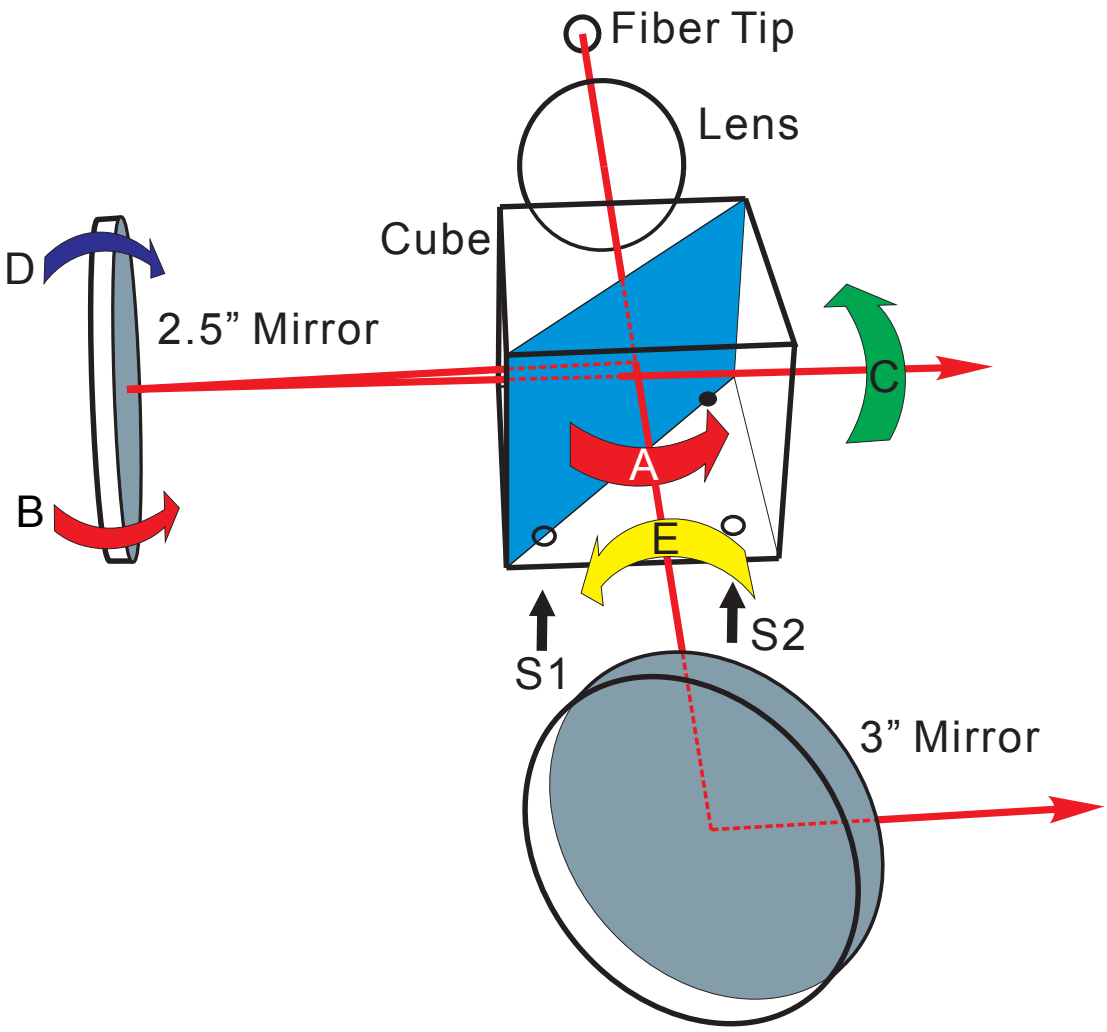

FIG. 3. Changes of laser output and reflections by rotating cube and 2.5” mirror.

IV. STEPS AND TRICKS

1. Adjust the position of the whole setup first by using an alignment laser and make sure:
   - the alignment laser passes through the center of all the components,
   - in the horizontal plane, the line between fiber tip and the cube center and the line between the cube center and the pumping chamber (6” mirror actually) is roughly perpendicular.
2. Adjust the fiber tip and lens:
   - Turn on the laser, adjusting the fib tip so that the laser is pointing to the center

of the lens and the laser profile after the lens is symmetric. Fix the fiber tip, and no more change of it.

- Tilt the lens until the laser is pointing to the center of the cube.
- Check the laser spot at the pumping chamber. Adjust the distance between the lens and the fiber tip by moving the lens to get proper spot size at pumping chamber: about the size of the pumping chamber.
- The position of the fiber and lens should be fixed by now, and they will not be involved in the following adjustments.

3. Horizontal adjustment of left line:

   - Rotate the cube, as adjustment **A** shown in Fig. 3, until the reflections from the surfaces of the cube are close to the center of the tip and slightly shifted horizontally to either left or right sides.
   - Then adjust the 2.5" mirror, as adjustment **B**, to get the proper horizontal position of the laser spot at 6" mirror. Check the horizontal position of the 2.5" mirror's reflection to see whether further adjustments are needed.
   - Once the horizontal positions of the output and reflections satisfy the requirements, The cube should be fixed in this degree of freedom, and all the work afterward is left to the two screws underneath the cube, s1 and s2, as shown in Fig. 3.

4. Vertical adjustment of left line:

   - Adjust s1 and s2 at the same time and in same directions to rotate the cube around the output light as adjustment **C** until the reflections of the cube surfaces are at the same level of the tip.
   - Tilt the 2.5" mirror as adjustment **D** until you see its reflection horizontally aligned with the fiber tip, if the spot on the 6" mirror is deviated from the center by amount of Δ at this time, keep tuning the 2.5" mirror with adjustment **D** until the deviation on 6" mirror becomes $-\Delta$, then rotate the cube as adjustment **E**, adjust s1 and s2 at the same time but in opposite directions, so that the output

laser hits the center of 6" mirror. Check the reflection again and repeat previous steps if necessary.

5. Adjust the right side optics line so that the its spot on the 6" mirror overlaps with the left line.

6. Adjust the $\lambda/4$-wave plates.

7. Finally, adjust the two 6" mirror on the oven to let the laser pass through the center of the cell, and also slightly adjust the 2.5" and 3" mirrors so that the two laser spots focused on the pumping chamber.

V. CONCLUSION

There are still some other ways to do the alignment, but the method discussed here should be a very basic and efficient way. If the 5 to 1 combiner is used, the setup will be slightly different, the single lens will be replaced by a two lens setup to focus the light coming out of the combiner,

and the basic of alignment stays the same.

ACKNOWLEDGMENTS