Schlieren With A Laser Diode Source

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ABSTRACT

The use of a laser diode as a light source in schlieren flow visualization is discussed. A laser diode schlieren photograph and a white light schlieren photograph are presented for comparison.

DISCUSSION

Gas or solid-state lasers are sometimes used to replace the more conventionally used white light sources for schlieren due to the laser's small effective source size and, hence, increased sensitivity[1]. In the past few years, long life (> 10,000 hours), continuous wave laser diodes have become commercially available which offer certain advantages over other lasers as a schlieren source. The laser diode is often packaged in a transistor case so that not only is the effective source size very small, but the laser itself is the smallest of the available lasers. The laser diode is relatively rugged and due to its size can be more easily temperature controlled, making it a useful source for hostile environments. The laser diode is also relatively inexpensive.

A typical room temperature continuous wave laser diode has an output power of 10 milliwatts at a wavelength between 800 and 900 nm with a spectral width less than 1 nm. If 50 % of the power is available for exposing a 50 cm^2 image, then exposure times less than a millisecond are possible with available high-speed infrared film. Exposure times less than a microsecond are possible with high power (>10watts) pulsed laser diodes. Exposure is easily accomplished by direct modulation of the diode current so that the laser diode on-time can be synced to a high-speed framing camera for time-resolved studies.

The schlieren system (Fig. 1) used to test the feasibility of using a laser diode as light source is designed to study phase objects such as wind-tunnel flows. The laser light is collimated and passed through the phase object and then refocused at the filter plane. The high pass filter used to visualize the phase object consisted of a high resolution photographic plate which was exposed by the laser diode at the filter plane with the phase object absent, processed, and then replaced in its original position. A lens slightly behind the filter plane was used to image the phase object plane onto high-speed infrared film. The inability to see the infrared laser light except at the focus where the power density is very large is, of course, a disadvantage in alignment. A phosphor screen which fluoresces when illuminated with light in the wavelength range of laser diodes was used for beam alignment[2]. An infrared image converter was used for focusing on the film plane. It is expected that future developments in laser diode technology will lead to commercially available devices with output in the visible spectral range which will simplify alignment. Laser diode schlieren of helium flow over a small model is shown in Fig. 2. For comparison, a white light schlieren (zirconium arc source) is shown in Fig. 3. Comparisons with other filters also verified that the laser diode is an acceptable source for schlieren flow visualization with increased sensitivity and without appreciable image degradation when com- pared to white light schlieren.

REFERENCES

1. Merzkirch, W., *Flow Visualization.* Academic Press, New York and London (1974).

2. Campbell, R. w. and Mims, F. M., III, *Semiconductor Diode Lasers.* Howard W. Sams and Co., Inc., Indianapolis (1972).

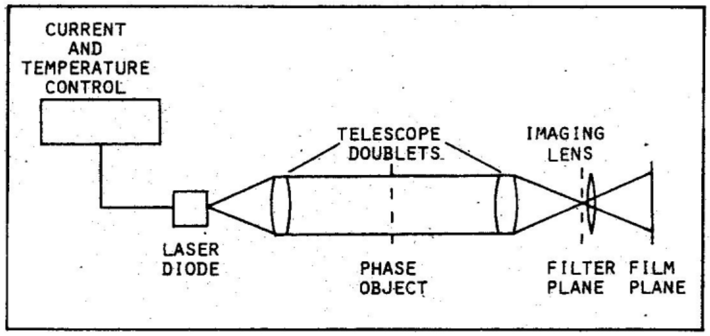

Fig. 1 Schlieren system.

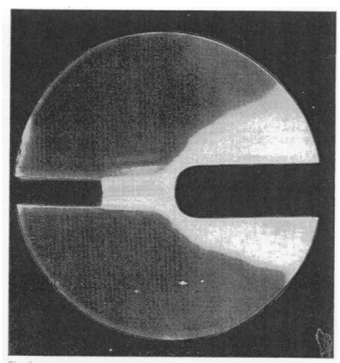

Fig. 2 Laser diode schlieren.

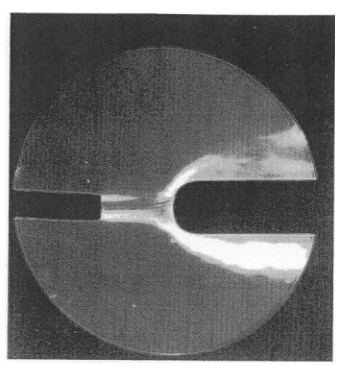

Fig. 3 White light schlieren.