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LOW POWER LASER BEAM PROFILE ANALYSIS BY DIGITAL PHOTOGRAPHIC TECHNIQUE

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ABSTRACT

Laser beam profile is an important physical parameter which is often not taken into account.

We describe a photographic technique to study Helium-Neon (HeNe) laser beam profile, testing different film sensitivities.

When laser beam strikes directly towards the camera lens, several pictures were taken at different exposition times.

Negative images of laser beam spot were recorded using a video camera with a trasillumination setup thatched to an analogic-digital converter to be computed.

Laser spot diameter profiles were scanned, and the results were plotted (grey levels against beam size).

The results were normalized to the film grossfog, and Gaussian behaviours were found as expected.

The same procedure was repeated using different films with different sensitivities, trying to select the more suitable film for our laser power.

This technique is also useful to study infrared wavelenghts beam profiles, and other low power lasers, choosing the optimal films.

Laser beam inhomogeneities can be detected, and mixed medical lasers can be checked.

It is also possible to study the emergent light through different thickness tissue slices.

INTRODUCTION

Laser beam profile is an important parameter which is often not taken into account. The major reason is that beam characterisation use to be a tedious and expensive task.

Several methods has been employed to measure spot size and gaussian profiles of laser beams using a knife-edge (1), an aperture (2), a slit (3), or a ribbon (4). All these methods have certain technical similarity wich consists of realize a direct lecture (frecuently slow) of the laser beam with a more or less complex system of aperture or collimation.

Images of the laser beam spot can be used to characterize the spot sizes, intensities and spatial patterns. Some techniques has been described using video cameras (5,6).

Photographic emulsions are a detection system used in numerous scientific fields. We present a tehcnique which allows to study HeNe and other low power laser beam profiles.

TECHNIQUE

In a single point of view our technique consists of take photographs of the laser beam when it strikes directly towards the camera lens. With this purpose a Nikon camera mod FG-20 and a suitable macro lens with a polarizer filter were used. Both laser unit and camera were placed on an optical bench, and aligned with the laser beam axis. A picture of a millimetered paper sheet was taken in order to have a reference for scaling.

Once developed, the negatives were placed over a light box and transilluminated. Then the image of laser beam spot was recorded using an RCA video camera which is thatched to an analogyc-digital converter IBAS 2000 Image processing system (IPS) to be computed.

Images were registered in a matrix of 512x512 pixels with a range of 256 grey levels (GL) between 0 GL (black) and 255 GL (white).

Profiles (beam size against GL) could be plotted, and grossfog GL could be determined by means of an unexposed sheet of film.

HELIUM-NEON PROFILES

Several probes were done with three HeNe lasers (632 nm wavelength) of 0.5 mW, 6 mW and 12.6 mW power. Ilford black and white films of 50, 125 and 400 ASA were used. Results were very poor. Even with the less sensible film, the shorter exposure times and lower power beam, spot images presented a considerable halo.

A slower emulsion (Kodalith ortho film 6556) gave us more satisfactory results with the additional advantage to be a high contrast film, giving less problems of autoabsorption.

Fig. 1. HeNe beam profiles taken with different exposure times, from 1/1000 doubling successively to 1s. Film: Kodalith ortho film 6556. Beam size axis marks: 5 mm. Grossfog 196 GL (arrow).

Photographies of the laser beams were taken at different exposure times, doubling successively from 1/1000 to 1 second. Focus was fixed at F4. Narrow Gaussian Profiles were obtained as described before and they are presented in Fig. 1.

As photography is a static collector of light photons the wideness of profiles size increases with the exposure time and light intensity. It can be seen that under 1/30 s exposure profiles wideness measure less than 5 mm which is close to the real size of the beam. A proportion between the beam intensity and profiles depth can be found only until 1/500 s exposure.

INFRARED PROFILES

Infrared wavelengths can be studied choosing the optimal film. A similar study than the described above for HeNe laser, with the same experimental set up has been made with Gallium-Arsenide (GaAs) with 904 nm wavelength, pulsed at 0.5 KHz and 5 KHz (0.26 and 2.6 mW mean power).

Fig. 2. GaAs laser beam profiles taken with different exposure times, from 1/1000 doubling successively to 1s. Grossfog 190 GL (arrow).

The film used was High Speed infrared 2481 (Kodak). Laser beam profiles were studied with identical procedure as before. Results are plotted in Fig. 2. While profiles of 0.5 KHz beam reach saturation at 1/125 s exposure, 5 KHz beam profiles reach it at 1/500 s exposure.

Some irregularities can be seen in profiles due to the own beam inhomogeneity

Taking into account that HeNe lasers use to have too much intensity for this film, High Speed Infrared may be used to easily check mixed medical laser equipments.

LASER-TISSUE INTERACTION

Photography has been proposed as a suitable method to measure isodose distributions of space irradiance in phantoms and fresh cow muscle (6).

With this technique photographs can be taken from the reverse slab when it is transilluminated with a laser beam. Scattering and attenuation can be studied by means of size, shape and intensity of several beam spots at different tissue thickness. Even more, increasing the exposure time lower intensities, deeper into the tissue can be studied.

In Fig. 3 profiles of 5 KHz GaAs laser are presented in function of tissue thickness for pig muscle and fat . The exposure time selected was 20 seconds.

It can be easily seen the different behaviour with fat tissue, with less scattering centers than muscle, where profiles show a wide size specially at first millimeters depth.

Fig. 3. Beam profiles of 5KHz GaAs laser presented in function of tissue slices Thickness. Exposure time: 20 s. Film: High Speed infrared.

CONCLUSIONS

Digitized photography is a method which allows to measure and study low power laser beam behaviour once selected the adequate photographic emulsion.

Laser-tissue interaction can be studied and related with laser beam intensity. Pictures can be also made from different points than the forward one.

Photographies are a permanent image support which can be re-studied if the digital processing system is performed or substituted and retrospective comparisons between systems and software can be made.

REFERENCES

1. SKINER, D.R. and WITCHER, R.E. J. Phys. E. 5 (1972) 237-.
2. SHAYLER, P.J. Appl. Opt. 17 (1978) 2673-.
3. McCALLY, R.L. Appl. Opt. 23 (1984) 2227-.
4. YOSHIDA, A and ASAKURA, T. A. Opt. Laser Technol. 8 (1976) 273-.
5. NISHIOKA, N.S., BUA, D.P. and DEUTSCH, T.F. Lasers Med. Sci. 2 (1987) 21-.
6. DUNCAN, M.D. and MAHON, R. Appl. Opt. 28 (1989) 4569-.
7. McKENZIE, A.L. and BYRNE, P.O. Phys. Med. Biol. 33 (1988) 113-.

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6. DUNCAN, M.D. and MAHON, R. Appl. Opt. 28 (1989) 4569-.
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