B7 非回折ビームイメージング
Imaging by a Nondiffracting Beam

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Abstract　*The imaging performance of a new nondiffracting beam technique is reported. It is found that because of the narrower width of a beam generated by this technique over a long range, it can form better resolved images over such a long range. Some preliminary experimental results of such a passive optical system indicate that imaging with no focus adjustment may be possible.*

A new technique of modifying the shape of the wavefront at the aperture of a telescope has recently been proposed [1] to generate a laser beam that can keep its beamwidth diverging very little as it propagates over a long distance of the kilometer or even 10 kilometer order, depending on the size of the telescope. A summary of this new technique will also be presented in another paper in this symposium [2].

Fig. 1 compares the beamwidths of a laser beam (x's) so generated using a 10 cm telescope with those (+'s) of conventionally generated laser beams focused at various distances. As this new nearly nondiffracting beam has narrower beamwidth over most of the propagation range shown, the images of point objects formed by this technique over that range will have better resolution than those formed with the conventional technique [3].

Fig. 2 shows the point spread function at an image plane 1 km from the optical system. It can be seen that it has some sidelobes surrounding the central peak intensity. Simulation of the images formed by this optical system can be carried out by convolving such point spread functions with target object functions. It is found that because of the contribution of the sidelobes, the images formed by this system have reduced contrast [3]. For the same reason, fine details in an object cannot be reproduced in its image using this technique. However, because this technique generates a narrow beam over a long range, simple objects can be better resolved over such a long range [3, 4].

To simulate the imaging performance of such a system in a turbulent atmosphere, a phase factor due to atmospheric turbulence can be added to that of the diffraction integral in the analysis. After carrying out simulation as before, it is found [5, 6] that the sidelobes in the point spread functions are now smoothed, as compared to the case when no atmospheric turbulence is taken into account. The images formed are now also more smooth in its gray level changes.

The case of actively projecting an image by a laser beam is considered in the above discussion. Analogously, such a wavefront modifying optical system can also be used as a receiver. Some very preliminary experimental results of such a telescopic system are shown in Figs. 3 and 4. Fig. 3 shows a picture of a building with the word "mine" on top, and is located about 2180 m away, taken with this system. Fig. 4 shows a picture of a traffic sign that is about 220 m away, taken with no change in focus, which is set at about 1250 m. For comparison, Figs. 5 and 6 show similar pictures taken with a conventional system, also focused at about 1250 m. It can be seen that while in Fig. 5, the word "mine" is of comparable clarity as in Fig. 3, the words in the sign in Fig. 6 is not recognizable at all, unlike that in Fig. 4.

It is expected that this new technique will be useful in laser sensing and laser communication.

[1] T. Aruga, *Appl. Opt.*(in press), and Japanese patent 8-23379 (1996).

[2] T. Aruga, S. W. Li and M. Takabe, paper P3, 18th laser Sensing Symposium (1997).

[3] S. W. Li and T. Aruga, *Proc. of 17th Meeting on Lightwave Sensing Technology*, pp. 73-78, (1996).

[4] S. W. Li and T. Aruga, *Proc. SPIE*, **2778**, pp. 104-105 (1996).

[5] S. W. Li and T. Aruga, *Tech. Dig. of 17th Annual Meeting of the Laser Society of Japan*, p. 205 (1997).

[6] S. W. Li and T. Aruga, *Tech. Dig. of Conf. on Lasers and Electro-Optics*, p. 189 (1997).

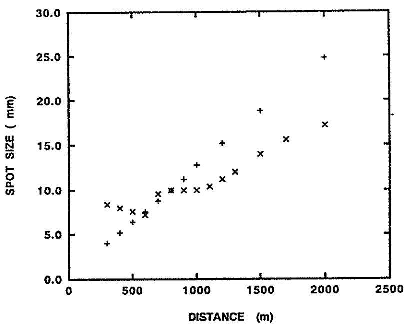

Fig. 1

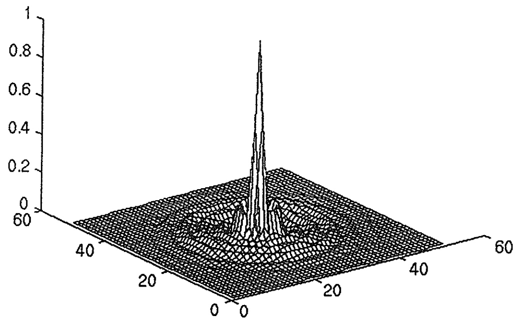

Fig. 2

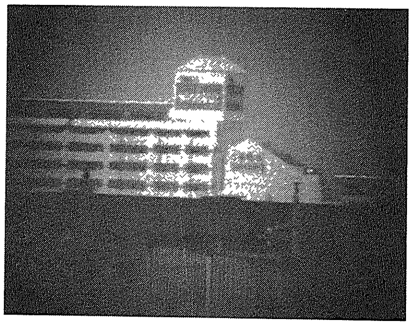

Fig. 3

Fig. 4

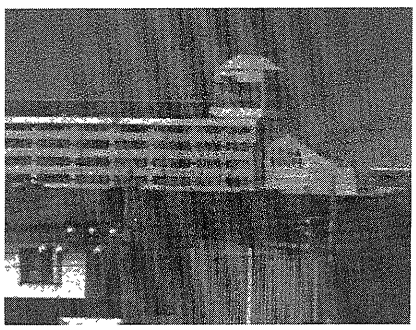

Fig. 5

Fig. 6