# INFRARED HETERODYNE LASER RADAR FOR REMOTE SENSING OF AIR POLLUTANTS BY DIFFERENTIAL ABSORPTION VIA SCATTERED ENERGY

H. Inaba and T. Kobayasi

Research Institute of Electrical Communication, Tohoku University
Katahira 2-1-1, Sendai, Japan

ABSTRACTS

The differential absorption via scattered energy (DASE) method has been analyzed by a number of groups for the remote measurement of spatial distribution of atmospheric molecules.[1-4] In this technique the range-resolved density of a specific molecules can be obtained by the difference in the elastic backscattering intensities caused by Mie and Rayleigh scattering at two laser frequencies on and off an isolated absorption line of the molecule.

Several DASE experiments have previously been performed with pulsed, frequency tunable lasers in visible region.[5-7] However, the laser radar operation in the infrared spectrum is more desirable for this scheme since strong and characteristic absorption spectra of most molecules of interest occur in the infrared along with the eye safe and the availability of coherent tunable sources arleady developed in the infrared. However, the sensitivity of the conventional direct detection technique in the infrared is considerably low as compared with that in the visible.

This paper presents a proposal and analysis of the new scheme of the laser radar using infrared heterodyne detection incorporating with DASE technique, which provides a high sensitivity enough for the range-resolved measurement of important pollutants dispersed in the air.[8]

The schematic diagram of the proposed laser radar system is shown in Fig. 1. In addition to the pulsed transmitting laser, a cw, frequency controlled local laser is utilized for the heterodyne detection of backscattered light signals. At present, several high-pressure gas lasers such as $CO_2$, CO, $N_2O$, and Xe meet actually the power requirement, stability and tunability in the infrared region for this application.

Figure 2 shows the calculated results of minimum transmitting laser energy as a function of the range in order to realize a signal-to-noise ratio of $10^2$ for detecting the Mie/Rayleigh scattering in various wavelengths. The detection sensitivity are compared for the two

detection schemes in the infrared; the heterodyne and the conventional direct detection schemes and it is concluded that improvements of $10^5$ to $10^6$ in sensitivity can be obtained with the infrared heterodyne detection over the direct detection.

The results of these analysis demonstrate that the infrared heterodyne laser radar scheme with DASE technique can offer an adequate sensitivity and range for a wide variety of pollution monitoring applications as well as for meteorological observations such as atmospheric temperature, humidity and visibility measurements. Especially, a new and quite valuable information on the height distribution of various pollutants across the temperature inversion layer can be obtained only by this method. Detailed results of the analysis and preliminary experiments will be reported to show the practical feasibility and potentiality of this laser radar scheme.


1) R.M. Schotland, Proceedings of the Third Symp. on Remote Sensing of the Environment, Univ. of Michigan, Ann Arbor, 215 (1964).

2) H. Inomata and T. Igarashi, Trans. Technical Group on Quantum Electronics of the Inst. Elect. Comm. Eng. of Japan, QE-70-36 (1970).

3) S.A.Ahmed, Applied Optics, 12, 901 (1973).

4) R.L. Byer and M. Garbuny, Applied Optics, 12, 1946 (1973).

5) K.W. Roth, V. Brinkmann, and H. Walter, Applied Physics, 3, 115 (1974).

6) W.B. Grant, R.D. Hake,Jr., E.M. Liston, R.C. Robbins, and E.K. Proctor, Jr., Applied Physics Letters, 24, 550 (1974).

7) T. Igarashi, Fifth Conference on Laser Radar Studies of the Atmosphere, Williamsburg, Virginia, U.S.A., June 4-6, 1973.

8) H. Inaba and T. Kobayasi, submitted to Nature.

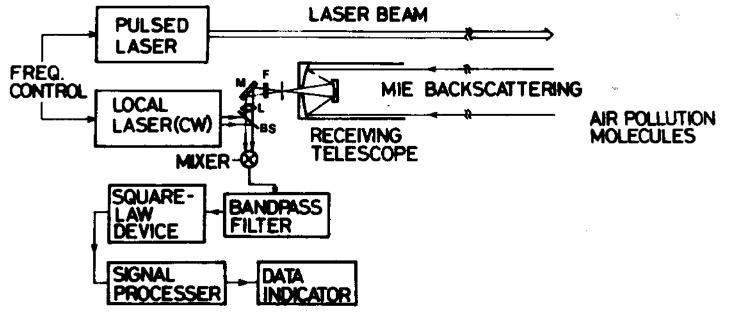


Fig. 1 Block diagram of the infrared heterodyne laser radar system incorporating with DASE technique.

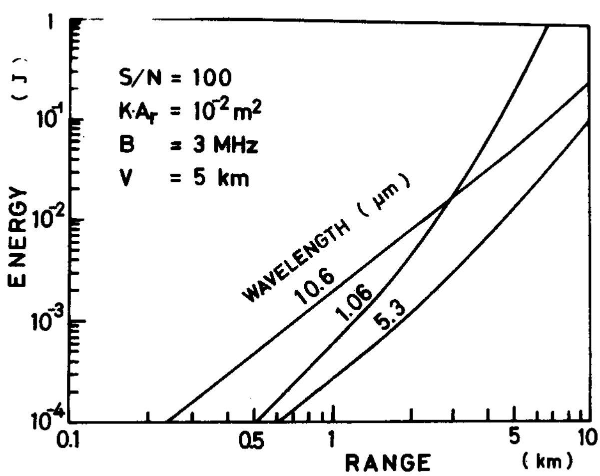


Fig. 2 The required transmitting laser energy as a function of the range.