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SCINTILLATION OF A TUNABLE DIODE LASER BEAM AROUND 7μm ABSORPTION LINES

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INTRODUCTION

We measured the scintillation for an infrared laser beam of 7 μm band in which many absorption lines exist and calculated power spectral density function (PSDF) of the scintillation around absorption lines of H_2O, N_2O, and CH_4. We have shown the measured PSDFs of the infrared laser beam are enhanced in a frequency region lower than 10^{-2} Hz and it had lower corner frequency.[1] In addition, the corner frequency shifted from 10^{-2} Hz to 10^{-1} Hz as the magnitude of the absorption coefficient becomes bigger. In these experiments, the scintillation of the visible laser beam was compared with that of the infrared laser beam, and some difference of the PSDFs was found between the visible's and the infrared's. The experimental results were obtained, however, with two independent optical paths, which were separated 240 mm from each other. The atmospheric condition of one leg may not be the same with the other. This report shows co-spectra and quadrature-spectra calculated from the scintillation of the He-Ne and that of the TDL, which were measured simultaneously on the same optical path with an *ad hoc* optical apparatus.

MEASUREMENT SYSTEM

A schematic diagram of the experimental apparatus are shown in Fig. 1. Light sources: PbSnTe tunable diode laser (TDL; Mütek Co. Ltd.) and emitting 7 μm band infrared beam and He-Ne laser (0.628 μm) were mounted on an aluminum alloy base plate. These laser beams were combined with a first beam splitter, and was launched in the atmosphere to a corner cube mirror (CCM). The return beam run parallel to the launched beam 240 mm apart in the horizontal direction to the receiver. The return beam was divided into two legs by the second beam splitter. The visible and the infrared lights were detected by a photo diode and an infrared detector (IRD), respectively. In the electronic part, mechanical and electrical chopper were employed to chop the TDL laser and the VDL laser, respectively, for the phase sensitive detection (PSD) scheme with lock-in amplifiers (LIAs). Both LIAs' outputs were sampled by a 2 channel sample-holder synchronized to the same timing clock, and each output was digitized by an A/D converter each by each. Finally, they were stored in a hard-disk controlled by a personal computer.

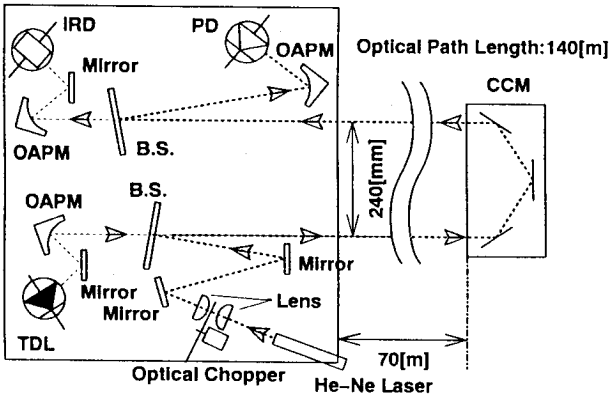

Figure 1: Schematic diagram of the optical part: Two lasers were employed as light sources. One was a tunable diode laser (TDL) emitting 7 μm band infrared beam and another was He-Ne gas laser of 0.628 μm.

EXPERIMENT

Experiments were performed in the daytime in winter of 1994. Laser beam was launched from the window of our laboratory to a CCM placed on a hill in front of the laboratory through the atmosphere, and reflected by the CCM. The round trip optical path was adjusted to 140 m long, and elevation of the beam from the ground surface was about 7 - 9 m. Atmospheric conditions, temperature, humidity and vertical wind-velocity were monitored at a position 3-m off the window. Wavelength of the emitted infrared laser beam was fixed to 7.9113 μm, which hit an H_2O absorption line.

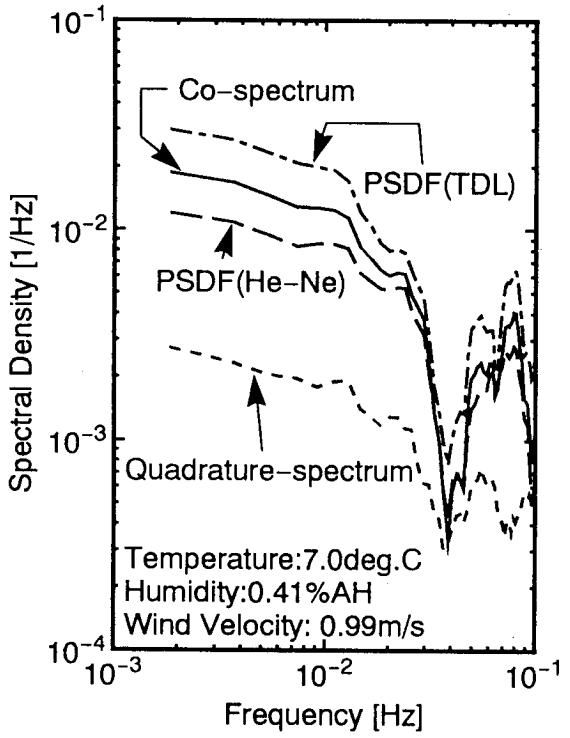

Figure 2: Power spectra (TDL, He-Ne), co-spectrum, and quadrature-spectrum in the lower frequency region of the scintillation.

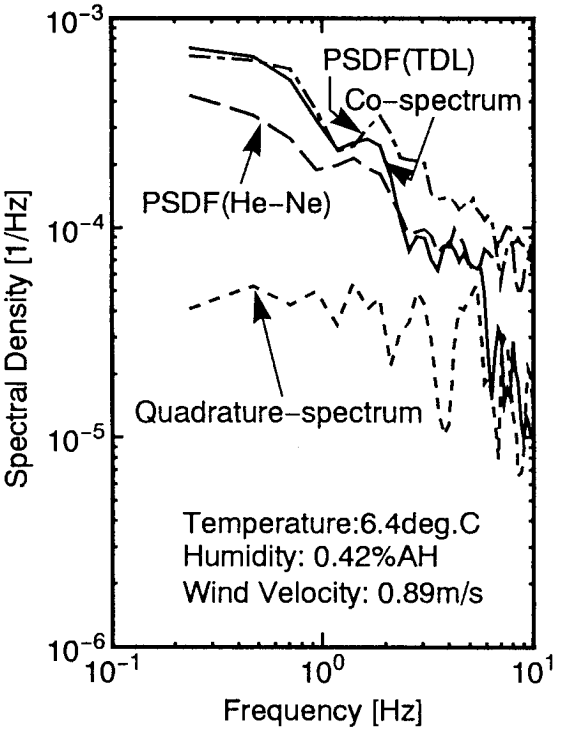

Figure 3: power spectra (TDL, He-Ne), co-spectrum, and quadrature-spectrum in the higher frequency region of the scintillation.

RESULTS AND DISCUSSION

Figure 2 and 3 show spectral density functions in the lower frequency region and higher frequency region, respectively. In both figures, the TDL's power spectra (dot-dash) are more intense than the He-Ne laser's one (broken). In this experiment, we could not use an aperture in front of detectors because the return beams' power were very weak. Both in the TDL leg and the He-Ne leg, the same off-axis-parabolic-mirrors (OAPMs) were used and they played as the received aperture. After Tatarskii's aperture-averaging theory[2], we found that the He-Ne's scintillation was more sensitive to the aperture- averaging effect than the TDL's scintillation, and the spectrum level of the He-Ne's scintillation became as same as that of the TDL's one. However, difference between these two power spectra is not constant. Especially, the difference becomes larger in the frequency region less than 10^{-2} Hz where the TDL's scintillation level is enhanced by the H_2O absorption effect we reported previously.[1] Solid and dot lines show co-spectrum and quadrature-spectrum, respectively. In both figures, the co- spectra are larger than the quadrature-spectra, except the frequency region around 0.04 Hz and 10 Hz. Correlation between the scintillation of the TDL and that of the He-Ne is strong where the co-spectrum is larger than the quadrature-spectrum. In the frequency region around 0.04 Hz, the atmospheric turbulence that affects the scintillation of both laser beams is small since the both power spectra show small level. However, around 10 Hz, the level of the co-spectrum becomes lower than that of both power spectra. This fact means that the correlation between the scintillation of the TDL and that of the He-Ne becomes weak.

CONCLUSION

The results show that the correlation between the scintillation of the TDL and that of the He-Ne is strong in the lower frequency region less than a few Hz. However, beyond this frequency region, the correlation becomes weak, where the contribution of the wavelength to the scintillation may become dominant.

REFERENCES

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2. V.I.Tatarskii, "The effect of the turbulent atmosphere on wave propagation," *Israel Program for Scientific Translation Ltd.,Jerusalem*, **Chap.4**, pp.259-334, 1971.