COMMUNICATION SCIENCES

AND

ENGINEERING

XXI. OPTICAL PROPAGATION AND COMMUNICATION

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The broad objectives of our program are to (i) formulate propagation models for important optical channels from the underlying physical processes, (ii) determine the fundamental limits on detection and communication performance that can be realized with these channels, (iii) develop techniques for optical detection and communication which achieve or approach these limits, and (iv) establish, by means of experiment, the validity of the theoretical results and guide their further development.

1. IMPROVED LOW-VISIBILITY COMMUNICATION

This investigation, part of which is carried out jointly with the MIT Center for Materials Science and Engineering, is concerned with the performance of terrestrial communication systems under conditions of low visibility. Our goal is to determine the extent to which the performance can be improved through the appropriate system design, and to develop the devices for achieving this improvement. The potential for improvement resides in the energy and information contained in the scattered component of the received field.

This year has seen the beginning of a gradual shift from exploratory propagation measurements on atmospheric channels to the development of appropriate theories to

predict the behavior of such channels. This transition had previously been precluded by the absence of both sufficient information on the approximate magnitudes of the important effects and also an adequate data base against which to check the models.

Two approaches to the modeling problem are now being actively pursued. In one the salient features of our experimental results are being used to suggest useful approximations to the transport equation.[1] One particularly promising approximation is suggested by the observation that, in the situations of interest, the scattered field is relatively insensitive to the spatial inhomogeneities of the medium. This implies that the source term in the transport equation can be neglected. The second approach has been to apply several available models to our experimental situations and compare the predicted behavior with the experimental observations. To date, models based upon single scatter, multiple forward scatter, and diffusion have been examined.[1-5] For the optical thicknesses that have been considered, the multiple-forward-scatter model is the best of the three but is not entirely satisfactory. In an attempt to obtain better results, the multiple forward scatter and diffusion approximations are now being combined in one model.

Although our previous experimental work has yielded enough data for the analytical modeling effort to begin this year, more data at shorter wavelengths and at the shorter ranges contemplated for a projected communication system were needed. Accordingly, we have continued to collect data at wavelengths of 0.53 μm and 0.25 μm.[6] Also, a new off-campus laboratory located approximately 6 km from the campus laboratory has been put into operation.

References

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2. QUANTUM COMMUNICATION THEORY

Joint Services Electronics Program (Contract DAAG29-78-C-0020)

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The long-range goal of this investigation is to realize improved optical communication, detection, and estimation in the space environment. Such improvement may be possible through the use of quantum measurements (optical receivers) that are superior to those now considered and the use of quantum states other than coherent states.

During the past year it has been shown that, for digital communication with error probability as a performance measure, the optimum quantum receiver for either pure coherent states or pure two-photon coherent states is not markedly superior to the performance that can be achieved with homodyning.[1] This resolves a question that has persisted for some time and brings our work on that issue to a close. Our other work pertains to the propagation of quantum states and the potential benefits that can accrue from using two-photon states. These issues have been addressed in a series of papers[2-4] which provide a fundamental understanding of the statistical properties of these states and a potentially practical means of generating them. In addition, the way in which their use could significantly improve the capacity of fiber data networks has been recognized and analyzed.[5]

References

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