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DEPARTMENT OF PHYSICS AND GEOPHYSICAL SCIENCES  
SCHOOL OF SCIENCES AND HEALTH PROFESSIONS  
OLD DOMINION UNIVERSITY  
NORFOLK, VIRGINIA

Technical Report PGSTR-AP76-23

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INVESTIGATION OF AEROSOL CHARACTERISTICS AND THEIR MEASUREMENT

By

Adarsh Deepak



Final Report

Prepared for the  
National Aeronautics and Space Administration  
Langley Research Center  
Hampton, Virginia

Under

Grant NSG 1090  
August 15, 1974 - August 15, 1975

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Michael P. McCormick, Technical Monitor  
Instrument Research Division



*Submitted by the*  
Old Dominion University Research Foundation  
Norfolk, Virginia 23508

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Most of the objectives of the proposed research (summarized in Section IV of the Research Proposal) to be performed under Grant NSG-1090 during 1974-1975, have been successfully initiated and performed to various degrees of completion. These are discussed under the following headings:

(1) Solar Aureole Photographic Technique for the Measurement of Aerosol Properties

The instrumentation for taking photographs of the sun and its aureole was successfully built and set up at NASA-LRC, in joint collaboration with Richard Adams of IRD. The techniques for taking good aureole photographs through various interference filters were experimented with and valuable expertise acquired. The expertise and knowledge gained in this work were directly applied by Adams to the photography experiment (MA 003), in which photographs of the sun's disc were taken during sunset/sunrise, so successfully performed on the Appollo-Soyuz Test Project in July 1975. Work on the ground-based solar aureole photography is continuing towards achieving greater sophistication in technique. The effort is also toward constructing a portable system which could be taken to the South Pole or mounted on the Space Shuttle Science Lab. Aureole photographs were taken during the presence of a stratosphere volcanic dust layer over the Hampton skies (in November 1974) which was detected by the LIDAR. Results were reported at an OSA meeting in Anaheim, California; the AGU meeting in Washington, and the IUGG Conference in Grenoble, France.

(2) The Densitometric Techniques

The Joyce-Lobel Isodensitracer was adapted to scan the aureole photographs and to obtain digital data on magnetic tape and draw traces of the isodensity contours on paper. This resulted in our developing an Isophote or Isodensity Contour Method for measuring the size distribution of aerosols provided the refractive index is given.

(3) The Video Electronic Isodensity Mapper

With the use of the Video System, isodensity contours of aureole photographs could be obtained instantly in multicolors. Efforts are continuing to improve the fidelity of the video camera system which has some minor problems.

(4) Theoretical Studies for the Measurement of Aerosol Properties

A numerical modeling computer program has been successfully developed to theoretically obtain isodensity contours which can be traced within a format identical to that of the Joyce-Lobel Isodensity contour map, so that a direct visual examining can be made to compare the theoretical contours with the experimental contours. The remarkable sensitivity of the shape of these contours to the aerosol size distribution has been convincingly shown. These results have been presented at various meetings listed in a later section.

(5) Apollo-Soyuz Test Project

An experiment was proposed for photographing the solar aureole within the earth's sunlit limb during the sunrise/sunset positions of the sun. The idea was that the knowledge of the forward scattered light (which is very sensitive to changes in the size distribution

of aerosols) would greatly supplement the results of the accepted occultation experiment in which extinction measurements of the direct sunlight were made and the data inverted to obtain the aerosol concentration and its altitude dependence.

The experiment was given a go ahead in March 1975. Efforts were immediately started for building a bracket that would hold the required neutral density disc in front of the camera. The LaRC/IRD workshop turned out an extremely good equipment which was light, compact and space-qualified that could easily be mounted in the spacecraft window. Unfortunately, due to the lack of astronauts' time for practicing with the new equipment, the experiment was reluctantly dropped at the last moment. However, all effort was not lost. It was suggested that this equipment would be ideal in carrying out limb radiance or limb solar aureole measurements from aboard the Space Shuttle.

#### (6) Multiple Scattering Experiment

A simple laboratory facility for performing controlled multiple scattering experimental studies was initiated and completed at the Physics Department, ODU, in collaboration with Dr. J. Becher who had a student work on this project, which was funded partly through the NSG-1090 funds. This involved building a wooden box (4' x 4' x 8'), blackened on the inside and with port-holes on its opposite sides for a collimated beam to traverse through the box. An exhaust system could clear out the box of all aerosol particles when desired. The box could be filled with aerosol particles of various size distribution and number concentrations. With the box filled with aerosol particles of smoke and a collimated beam of white light traversing through the

aerosol medium, the intensity of only the multiple scattered (MS) light was measured with the help of an extremely sensitive photometer. This was done while the axis of the view cone was moved a certain distance (x) away from the axis of the collimated incident beam, keeping the two axes parallel. Single scattered light could not enter the detector by never allowing the view cone to intersect with the collimated beam inside the box. Aerosol size distribution can be obtained by inverting the data of MS intensity vs. x. Preliminary experiments have been performed and work is being continued on the inversion of the data. A paper co-authored with Dr. Becher on this work will be shortly published.

(7) The Multiple-Scattering Computer Program

Dr. J. V. Dave's computer code for Multiple Scattering Calculations was written for IBM 360/65. Effort to convert it for use on the LaRC-CDC 6600 computer is nearing completion.

(8) The Generation of Mie Theory Results

J. V. Dave's code for generating the Mie theory results for scattering from a single particle has been successfully converted for use on the CDC 6600, and several results for various values of the refractive index have been generated and stored on tapes.

(9) NASA/OAST Technology Workshop (August 3-15, 1975)

Participated as one of the panel members representing NASA-LaRC on the panel on Remote Sensing and Data Acquisition. The purpose was to discuss and propose the future technology needs of NASA for the coming decade and the next twenty-five years.

PROFESSIONAL MEETINGS AND PAPERS PRESENTED DURING 1974-1975:

1. Paper presented at the 6th Intern. Conf. on Laser Radar, Sendai, Japan, September 2-5, 1974. (Read by Dr. M. P. McCormick.)
2. Paper presented at the Association for Aerosol Research Conference, Bad Soden, West Germany, October 16-19, 1974.
3. Attended the AAAS Meeting, New York, January, 1975.
4. Attended the Symposium on Meteorological-Instruments and Observations, AMS and WMO Meeting, Washington, D.C., February 10-13, 1975.
5. Attended the Shuttle Effluent Meeting, LRC, February 23-25, 1975.
6. Paper presented at the Optical Society of America Meeting, Anaheim, March 17-20, 1975.
7. Attended the 3rd Conference on Laser Engineering and Applications, Washington, D.C., May 28-29, 1975.
8. Paper presented by abstract only at the AGU Meeting in Washington, D.C., in June 1975.
9. Attended the NASA/OAST Workshop, Remote Sensing of the Environment, August 3-15, 1975. Participated as a panel member.
10. Paper accepted for presentation at the Intern. Conf. on Laser Velocimetry, Copenhagen, Denmark, August 25-29, 1975. Read by abstract only.
11. Paper presented at the I.U.G.G. Conference in Grenoble, France, on August 28, 1975.



COLLOQUIA AND SEMINARS CONDUCTED OR PARTICIPATED IN:

1. Seminar presented at Department of Astrophysics and Astronomy, U. of Nice, France (October 9-11, 1974).
2. Seminar presented at Department of Electro-Optics, DFVLR, Munich, West Germany (October 15, 1974).
3. Seminar presented at ODU-VARC campus in February, 1975.

Invitations were also received for giving seminars at the Univ. of Leningrad, Institute of Atmospheric Physics in Moscow, and Indian Institute of Technology, Kanpur, India.

PUBLICATIONS UNDER PREPARATION

1. Solar Aureole Isophote Technique for the Measurement of Atmosphere Aerosol Properties, with R. Adams.
2. Measurement of Size Distribution of Aerosols under Conditions of Multiple Scattering, with J. Becher.