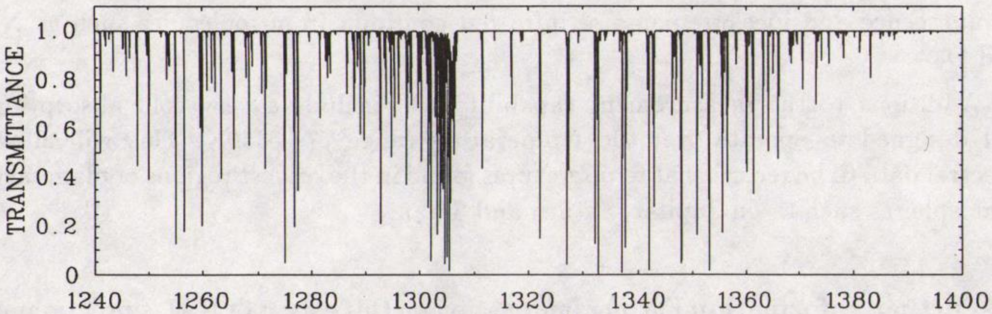
RAL DESIGN & DISCOVERY
Open Days July 1990
RUTHERFORD APPLETON LABORATORY
SCIENCE AND ENGINEERING RESEARCH COUNCIL

Laboratory Spectroscopy for Atmospheric Applications

Introduction Much of our understanding of the chemistry and physics of the earth and planetary atmospheres (such as ozone depletion and the greenhouse effect) has come from remote observations using scientific instruments on spacecraft. With all such instruments the basic measurement is of electromagnetic radiation - information about the state of the atmosphere is inferred from comparison with detailed and precise spectroscopic data on atmospheric gases obtained under known conditions. Such data are obtained in experimental laboratory studies carried out at RAL in collaborations with colleagues at Higher Education Institutes.

RAL Facilities Equipment includes a high resolution interferometric spectrophotometer (BOMEM DA3.002) which is coupled to several absorption cells (designed at RAL) into which gases may be admitted. The principal technique used is absorption spectroscopy, in which electromagnetic radiation (usually infra-red or visible) is passed through a cell containing the gas(es) under study at a known temperature and pressure. The gas absorbs some of the radiation at frequencies characteristic of the gas and its temperature and pressure, so the output from the spectrophotometer is an absorption spectrum. An example of an absorption spectrum is shown below.



The absorption cells are designed to allow a large range of relevant spectroscopic problems to be studied at appropriate physical conditions. For example there is available a wide range of pathlengths (1mm - 512m), pressures (0 - 5 Bar), temperatures (190 - 370K) and spectral regions (far IR to visible).

The long path capability has resulted from the installation of a multi-pass optical cell which has a physical length of approximately 9 metres. The cell is coolable to

190K which makes it among the best coolable long path absorption cells in the world. Further extension of the pathlength to 1km is possible.

In addition to the capability to study stable gases (such as CO_2), data can be obtained on reactive gases (such as ozone), unstable radicals (such as NO_3) and condensible vapours (such as water vapour). This is possible through extensive use of relatively inert materials such as glass and stainless steel. A limited class of chemical processes can also be studied, within constraints imposed by data acquisition times. Special provision has also been made to allow safe handling of flammable gases, such as CH_4 and H_2.

The spectrometer is computer controlled and spectral data is archived to both magnetic tape and optical disc. Reduction and analysis of the data to spectral parameters (such as line strengths, widths and absorption coefficients) is done using computer programs developed at RAL.

Recent Results Many atmospheric gases have been studied to underpin SERC's programme of remote atmospheric observations from instruments such as ISAMS, ATMOS and NIMS-Galileo. These include HCl, CH_4, NO, HNO_3, HNO_4, NO_3, NO_2, $CLONO_2$, N_2 and H_2O. The data have been used to obtain molecular parameters ranging from individual spectral line parameters (such as line strengths and widths) to absorption coefficients of spectral bands where individual lines cannot be resolved.

Future Work A number of measurement programmes already started will be continued - for example a comprehensive study of the near IR spectrum of CH_4 (methane) and CH_4 / H_2 mixtures which will be used for analysis of data from the NIMS instrument on Galileo. In addition, new programmes are being started - for example a study of the generation of vibrationally excited NO_2 by chemiluminescence and measurements of infra-red continua from molecules such as N_2 and O_2.

Additions to the measurement capability will include a very cold absorption cell designed to operate over the temperature range 77 - 350K. This will allow spectral data to be recorded at temperatures found in the coldest regions of planetary atmospheres such as on Jupiter, Saturn and Titan.

Further Information Further information on this aspect of RAL's programme can be obtained from:

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