SPACE RESEARCH IN BELGIUM
1982 - 1983

Report to COSPAR - meeting in Graz
Austria, 25 June - 7 July 1984

INTRODUCTION

This report has been prepared on behalf of the Belgian National Committee on Space Research of the Académie Royale de Belgique and the Koninklijke Academie van België, for presentation at the XXVth Plenary Meeting of the Scientific Committee on Space Research (COSPAR) at Graz, Austria, 25 June - 7 July 1984.

It summarizes basic and applied space research undertaken by Belgian teams in various research institutes and universities. The names of these institutions are listed in Appendix of this report. The work of these groups is made possible by the funds almost entirely supplied by the government.

A. BELGIAN INSTITUTE FOR SPACE AERONOMY

1. Spacelab 1 Experiments

The ESA built SPACELAB was launched on November 28, 1983 by the NASA Space Shuttle "Columbia" and operated at an altitude of 250 km, on a circular orbit with an inclination of 57°. During 10 days, 70 different experiments were performed. The institute participated in the experiments ES013 : Grille Spectrometer; ES016 : Solar Spectrum from 170 to 3200 nm and ES017 : Measurements of the Lyman α emissions.

1.1. ES013 Grille Spectrometer

Infrared absorption spectrometry of the atmosphere using the sun as a light source at sunrise or sunset has, for the past 15 years, proven to be a powerfull method for studying vertical distributions of trace species. The largest possible amount of light absorbing molecules is so observed on the optical path tangent to the earth surface at various altitudes allowing the deconvolution of very low concentrations versus altitude. Much information has already been gathered through this method from high altitude platforms such as aircraft and balloon. An orbiting platform provides access to higher altitudes and to geographic locations leading to a nearly global coverage in various seasons of great interest for geophysical purposes. While on previously used platforms the earth rotation provides the altitude scan at sunrise or at sunset it is achieved at a much higher rate from orbit by the spacecraft motion itself requiring a fast spectral scanning, thus high throughput instrument.

The ES013 grille spectrometer, a joint venture of the Office National d'Etudes et de Recherches Aérospatiales (France) and the

Belgian Institute for Space Aeronomy satisfies these requirements. The instrument description and operation can be summarized as follows :

- Optics : a two axis steerable frontal plane mirror tracks the sun in front of the 30 cm aperture, 6 meters focal length Cassegrain telescope imaging the sun on the grille which intercepts a square portion of the solar image (8 arc minutes). The spectrometer uses a 59 grooves per mm grating illuminated by a parabolic mirror oscillating at 436 Hz with an amplitude of ± 20 arc seconds, its average position being controlled within 5 arc seconds. The exit light flux, split in two beams, reaches through interference filters the two detectors (InSb, 2.5 to 5.5 μm and HgCdTe, 2.5 to 10.5 μm). The spectral resolving power was 1.3×10^4 (instrumental line width at half peak height).

- Electronics : the electronics in the Spacelab module interfaces the pallet instrument with the Command and Data Management Subsystem (CDMS) and the high rate multiplexer (HRM). Using data originating from the orbiter (time, attitude, orbit parameters) and from Spacelab (timeline, on board and ground commands, sun ephemeris) it manages the execution of the stored as well as in-flight updated measurement programs. The electronics on the pallet instrument provides the electro-mechanical control and the signal detection and formating functions. The main role of the crew for this flight was to check the instrument wave-length calibration, spectral resolution and sensitivity by monitoring the display of a calibration spectrum generated inside the spectrometer by means of a calibration lamp shining through a gas cell. The mission specialist in charge of this task performed a wavelength alignment 12 hours after launch.

The pallet instrumentation weighing 122.8 kg, stood 1.8 meter high, occupying 0.7 square meter. The weight of the module equipment was 15 kg. The data rate in operation was 51.6 kbits per second. After extensive testing in CNES (France) and ERNO (Germany), the instrument was delivered to NASA in 1982.

Due to the multidisciplinary philosophy of Spacelab One only 25 solar occultation runs were allocated. Due to the "launch window time-season" combination the runs were scheduled in the first days of the mission since the full orbit was in sunlight during the last five days. Performances took place at sunset in the northern hemisphere at latitudes ranging from 56° to 30°. The sunrise observations took place at high southern latitudes providing information pertinent to inter-hemispheric-seasonal variations of the observed atmospheric species; thermospheric CO, for instance.

In addition to solar infrared absorption features, many of which had not been observed before, telluric spectral absorption due to CO and CO_2 spectra were observed at thermospheric tangent heights (H) (H > 85 km); O_3, H_2O, CH_4 and N_2O added their contributions in the mesosphere (H > 50 km) while the strongly coupled molecules NO-NO_2 and HCl-HF were simultaneously observed by pairs in the same stratospheric air parcels.

The obtained spectra number several thousands and are currently being treated while the instrument is going through a refurbishment process. A new mission would emphasize a complete geophysical program covering a variety of observational latitudes and longitudes.

1.2. ES016 : Solar Spectrum from 170 to 3200 nm

The "Solar Spectrum" experiment took place during the "hot" phase of the mission, i.e. when SPACELAB was pointed towards the sun.

The scientific aims of this investigation are the measurement of the solar spectral irradiance and its temporal variations, especially those correlated with the 11-year activity cycle. The wavelength range

extends from the ultraviolet (180 nm) to the infrared (3000 nm). This spectral interval covers 98% of the total energy emitted by the sun and allows then comparison with simultaneous measurements of the "solar constant".

The measurement principle is based on the comparison of the signal resulting from the sun with the signal resulting from reference sources integrated in the instrument. Any modification of the radiometric sensitivity of the instrument during observation could thus be checked in real time with the reference sources. The SPACELAB is in fact the first opportunity allowing this measurement principle. Furthermore, since SPACELAB is integrated into the Space Shuttle, the instruments are recovered after the mission. For the first time, it is then possible to perform postflight calibrations of a solar spectrometer after its observations in orbit.

A totally new instrument has been designed and built to meet the scientific objectives. It is composed of three double monochromators of 10 cm focal length, using holographic concave gratings as dispersive optics. The main characteristics of the instrument are :

- The 3 double monochromators respectively cover the ultraviolet, visible and near infrared regions with overlaps in the wavelength range between the ultraviolet and visible spectrometers and between visible and infrared spectrometers.
- The six gratings are mounted on the same mechanical shaft in order to have the best reproducibility for the instrument bandpasses.
- The sunlight is diffused inside each double monochromator by means of a grind window in order to minimize the consequences coming from solar pointing inaccuracies during the solar observations.

- Each double monochromator can be illuminated, during flight, by ultraviolet and visible sources used as references with regard to the absolute calibrations being realised before and after each launch. A hollow cathode lamp calibrates the wavelength scale in orbit.
- The instrument is driven by a microprocessor which also receives telemetry command from the ground.

This project results from a close European cooperation between the "Institut d'Aéronomie Spatiale de Belgique", the "Service d'Aéronomie du CNRS" (France), the "Landessternwarte" in Heidelberg (FRG) and the "Hamburger Sternwarte" (FRG).

The experiment "Solar Spectrum" was on the European bridge of the pallet.

Three observation periods, totalizing more than 24 hours of measurements, took place the 9th and 10th day of the mission. Before that, several calibration periods, requiring no special attitude of the Space Shuttle, took place from the beginning of the mission in order to check the radiometric characteristics of the instrument during the entire time spent in space.

The preliminary results are very positive. However the measurement of the solar irradiance also implies a post-flight calibration. This operation was performed at the Kennedy Space Center in January 1984. Finally, before drawing definite conclusions on the scientific results, the instrument must be recalibrated with regard to a primary radiometric standard, namely the blackbody. This will be done by mid 1984.

1.3. ES017 : Measurements of Lyman-α emissions

Experiment ES017 is a collaboration between the "Institut d'Aéronomie Spatiale de Belgique" and the "Service d'Aéronomie du CNRS" in France. It is a spectrophotometer with a hydrogen and a deuterium absorption cell. The objective of the experiment was to detect the Lyman-α emissions of atomic hydrogen and of atomic deuterium.

For the first time, atomic deuterium has been observed around 100 km altitude. Atomic hydrogen Lyman-α emission has also been observed and the experimental data are presently analyzed.

2. The intercomparison ozone campaign held in France in June 1981

An intercomparison balloon and ground-based campaign for measuring ozone from the ground to the mesosphere was performed in the South of France from 9 June to 26 June 1981. Satellite data obtained above the sites from existing ozone experiments have also been used in this intercomparison. A total of 11 experimental groups participated in the campaign with 15 different types of instruments. Two large stratospheric balloons were launched on 19 June and 25 June with five experiments on each; on these specific days the comparison included up to 10 types of near simultaneous ozone measurements.

In particular the vertical distribution of stratospheric ozone obtained by means of large stratospheric balloons between altitudes of 20 and 40 km were compared and discussed. Vertical profiles deduced from Electrochemical Concentration Cell sondes launched from the same location by small balloons and from short Umkehr measurements made at Mt Chiran (France) are also included in this comparisons. Systematic differences of the order of 20% between ozone profiles deduced from solar U.V. absorption and in situ techniques are found.

3. MAP/GLOBUS Campaign 1983

The major scientific objectives of the campaign are : (1) the accurate measurement of ozone and its short term variability; (2) the determination of the NO_x-family (NO, NO_2, NO_3, N_2O_5, and HNO_3); (3) the measurement of related important solar fluxes (including scattered fluxes); (4) the determination of other important trace species (such as H_2O), aerosols and ion composition.

A further scientific objective is the study of atmospheric dynamics, especially of the meteorological background. Therefore special analysis has to be performed of the data of respective network stations and satellites. Local wind and turbulence measurements will also be performed.

The campaign took place in September 1983. Several large stratospheric balloons (13 in total) were launched from the CNES base located at Aire sur l'Adour (France).

The contribution of the Belgian Institute for Space Aeronomy covered on one hand ozone measurements by means of filter radiometers, ultraviolet and visible spectrometers integrated in three different gondolas. In addition, upward ultraviolet and visible radiation fluxes were measured. On the other hand, stratospheric ions and aerosols were simultaneously measured by balloon borne instruments. The Institute took also part in the modeling effort organized to support the planning phase of the campaign. It will also contribute to the modeling support in the interpretation of the experimental data. The scientific objectives of this campaign have been fulfilled to a high degree.

Eight working groups were formed to deal with each specific scientific objective. These working groups to which the institute will participate will coordinate the data evaluation which is still in progress.

4. Solar irradiance monitoring from balloons (SIMBA)

For studies of the earth's climate, the upper atmosphere and for tests of solar models, very accurate total and spectral solar irradiance data and their variation in time are needed. Such kind of observations require international cooperation in order to close the gap between the quoted accuracies and the differences between observations performed up to now. In Europe, many scientific groups are involved in such measurements and have developed different calibration and observation methods. New instruments have recently been developed for balloon and spacelab missions. This program gathers for the first time on the same European platform several instruments measuring total and spectral solar irradiance.

The main objectives and goals of this cooperative program are :

- Determination of the solar constant with an absolute accuracy of at least ± 0.2%.
- Determination of the spectral distribution with an absolute accuracy of at least 5% in the UV and 1% in the visible and near IR.
- Determination of any variation in time, with timescales of the order of hours during a flight and of years from flight to flight. The precision or shortterm stability is in the order of 0.01 to 0.5% depending on the wavelength range and the instrument.
- Determination of some stratospheric trace species such as O_3 and NO_2.

The balloon flight SIMBA performed in 1983 was a joint experiment of the following institutes : Institut d'Aéronomie Spatiale de Belgique, Bruxelles (IASB), Institut Royal Météorologique de Belgique, Bruxelles (IRMB) and European Space Technology Centre (ESTEC, Noordwijk), Observatoire de Genève (OG) and Physikalisch-Meteorologisches Observatorium/World Radiation Center (WRCD).

It took place on June 28, 1983 from the CNES launching base at Gap-Tallard (France). The float altitude was about 40 km and observations were performed from 9h 00 to 16h 00 (U.T.). The payload contained absolute radiometers to measure the total solar irradiance and solar radiometers and spectrometers to measure spectral solar irradiances and stratospheric absorption in the U.V.

The scientific objectives of this campaign have been fulfilled and the data evaluation is still in progress.

5. Multispectral photographs of the upper atmospheric aerosol layers

The aim of this experiment, which started in 1980, is the study of the stratospheric and the mesospheric aerosol layer. Seven cameras are used : 2 groups of 3 cameras loaded with black and white films and equipped with filters centered at 440 nm, 650 nm and 860 nm corresponding to blue, red and photographic infrared. The gondola may be oriented relatively to the Sun by telecommand in order to observe the totality of the limb. A microdensitometric study of the photographs leads to the determination of the sky radiance as a function of the solar zenith angle. It is possible to deduce the phase functions of the atmospheric scattering and, applying Mie-theory, the size distribution of the aerosol is obtained. A flight performed in October 1981 permitted to deduce the absorption of solar radiation and led to the discovery of a layer situated around the altitude of 65 km and which scatters and absorbs blue light and could thus be constituted of aerosol particles of an unknown type. This observation, performed from under the layer should be best confirmed and explained by future observations from space. A flight performed in May 1982, in Southern France, has permitted a study of the stratospheric dust layers generated by the explosion of the El Chichon volcano which compares in their result with simultaneous lidar observations performed in Japan, the United States and Italy. Finally, another successfull flight performed in September

1983 will permit the comparison of the results with ion measurements made on the same gondola.

6. Observations of minor constituents from the "Pic du Midi"

A high resolution interferometer was used from the Pic du Midi in the French Pyrenees (2887 m) to deduce the distribution of minor constituents in a clean and relatively dry atmosphere. The observations took place between 1980 and 1982, and led to the following conclusions : (i) stratospheric nitric acid does show significant variation from day to day but no apparent seasonal effect, (ii) the rate of growth of global chlorofluoromethane 11 ($CFCl_3$) was the same between 1980 and 1982 as measured by other authors between 1972 and 1980.

7. Stratospheric ion composition measurements

The objective of this program is to determine the positive and negative ion composition of the stratosphere at altitudes attainable by stratospheric balloons, through in situ measurements with balloon borne quadrupole ion mass spectrometers. For this purpose four balloon flights have been performed in the period 1982-1983.

The first flight took place in June 1982 from the CNES launching base at Gap-Tallard (France). A 100,000 m^3 valve controlled balloon was used and the payload consisted of two mass spectrometers. Positive ion spectra were obtained between 33 and 20 km altitude and negative ion composition data were recorded between 33 and 25 km. The analysis of the positive ion data allowed the determination of the mixing ratio of CH_3CN in the altitude region 20 to 33 km, whereas sulfuric acid number densities were derived from the fractional abundances of negative ions between 25 and 33 km.

In the second flight from the CNES launching base at Aire sur l'Adour (France) in September 1982 a 1,000,000 m^3 Wintzen balloon was used to lift off an ion mass spectrometer and a limb camera (see section 5). A float altitude of 46 km was reached and after sunset the balloon slowly descended to 42 km. Positive as well as negative ion spectra were obtained for the first time above 41 km during this flight. The data analysis again resulted in CH_3CN as well as H_2SO_4 mixing ratios between 42 and 45 km, which complemented the results of previous experiments. For the first time an estimation could be made of the SO_2 concentration at 45 km from the measured ion abundances. The high value obtained (3 ppm), being about 100 times higher than the one from model calculations, is attributed to recent volcanic eruptions.

A third flight with a 100,000 m^3 valve controlled balloon, carrying a double ion mass spectrometer, was realized in June 1983. Due to unfavourable meteorological conditions the planned flight profile could not be made. Nevertheless usefull data were obtained at float altitude, which confirmed previous measurements. Also in this flight a newly designed mass spectrometer, having a mass range up to 850 amu, was used for the first time.

Finally in September 1983 the combined payload, consisting of an ion mass spectrometer and a limb cameras assembly, was flown again with a 100,000 m^3 valve controlled balloon.

Most of the measuring time was dedicated to negative ions and data were obtained between 32 and 22 km. A detailed height profile of H_2SO_4 in this altitude domain was derived from the ion mass spectra. A preliminary comparison of these data with results of the limb camera, which gave information on the aerosol densities, indicates a correlation of the H_2SO_4 number densities and aerosols due to volcanic activities. A more detailed analysis of the aerosol data however is needed to give definite confirmation.

Parallel with the experimental program a model study was made of CH_3CN in the atmosphere. The results of this model study were compared with the total data set on CH_3CN mixing ratio as derived from positive ion spectra, obtained in the altitude region 45 down to 20 km. This comparison suggests a surface production of CH_3CN, followed by an upward diffusion and destruction by OH in the stratosphere.

In collaboration with the Université Libre de Bruxelles a laboratory study of the other possible destruction mechanism for CH_3CN, namely the reaction with Cl was undertaken. This reaction turned out to be of minor importance for stratospheric photochemistry.

8. Study of the ionosphere

A new ionospheric scattering mechanism has been analyzed. The attachment of free electrons to neutral molecules in the terrestrial D-region followed by detachment from the resulting negative ions leads to fluctuations of the electron density. Such fluctuations superimposed on thermal fluctuations, enhance the scattering cross-section for an incident electromagnetic wave. A simple analytical expression of the cross-section has been demonstrated independently by a thermodynamical method and by a stochastic formulation. Furthermore, a numerical simulation of the fluctuating electron concentration leads to a numerical cross-section profile which agrees with the theoretical expression.

9. Study of the magnetosphere

9.1. The plasmapause

In collaboration with the University of Poitiers (France) it has been shown, from observations of plasmapause positions obtained between 26th and 30th July 1977, that the process of interchange motion

of plasma elements in the magnetosphere is responsible for the formation of a density knee in the postmidnight local sector at 4-5 Earth radii. It has already been demonstrated that the plasmapause cannot be defined as the last closed equipotential surface of any electric field distribution. An indirect method has been suggested to improve empirical electric field models.

9.2. Structure of the magnetopause

Except for the simple Chapman-Ferraro and Parker magnetopause models, nearly all previous models of the solar wind-magnetosphere interaction are MHD (magnetohydrodynamic) descriptions which are limited to large-scale plasma and field characteristics. These MHD models apply to spatial scales much larger than the average ion gyroradius but are inherently unsuitable for a detailed description of the interaction region. Our models, however, utilize a kinetic theory approach in which observed plasma and field parameters are used to provide boundary conditions for the calculation of the fine structure of the interaction region.

On the other hand, recent observations made with the ISEE spacecraft near the earth's magnetopause have provided high temporal and spatial resolution plasma and field data. Many of these observations have revealed sharply varying structures (both in space and time) for plasma and field parameters inside the magnetopause. Using kinetic models of directional discontinuities we have started a comparison between the theoretical results and some selected ISEE observations. Our first results have shown that the actual electric field is generally not equal to the convection electric field which is assumed to be a good approximation of the actual electric field in the MHD theory. Consequently, electric and gradient drifts in sharp boundary layers are very different from what is usually assumed from the MHD approximation. It has also been shown that high-speed plasma flow inside current sheets can result from large electric and gradient drifts.

Furthermore, we have argued that the small-scale inhomogeneities present inside the magnetopause layer and plasma boundary layer can change drastically the usual large-scale description of magnetopause oscillations. Indeed, finite ion Larmor radius effects do not represent small corrections, i.e. the "frozen" field approximation is not valid inside these sharp boundaries, since gradient drifts are comparable with the convection term due to the electric field. Therefore it is questionable to use an MHD approach to study the physical processes occuring at the terrestrial magnetopause and in particular to study its stability.

10. Planetology

10.1. Titan

The diffusion problem of light gases in the atmosphere of Titan is reassessed after the Voyager encounter. An analytical expression of the solution of the diffusion equation is given for a spherical geometry and an isothermal atmosphere. It is used to predict an altitude profile of H_2 in the upper atmosphere of Titan. The modification of this profile by a possible return flow of H_2 from a torus to the atmosphere of Titan is addressed, and is found negligible since there is observational evidence from Voyager that the H_2 density is less than 100 cm^{-3} in the torus, at large distance from Titan. The H_2 concentration at the exobase level is 3.1×10^5 cm^{-3} and the thermal escape of H_2 is nearly equal to the limiting flux of 3.4×10^9 cm^{-2} s^{-1} at the turbopause level. Photodissociation of CH_4 has to provide for an equal supply of H_2.

10.2 Mars

The European Space Agency has considered the possibility to orbit a space probe around the planet Mars (KEPLER project).

Preliminary studies were done in order to define the mission, especially at the scientific level. The Belgian Institute for Space Aeronomy has suggested an experiment which aims to measure the minor constituents of the Martian atmosphere through absorption spectrometry. This suggestion made it necessary to analyse the implications of the orbital characteristics of the mission on the conditions of such observations.

10.3 PLANETARY INSOLATION

The daily solar radiation incident at the top of the Martian atmosphere, with and without the effect of the oblateness and for the currently adopted values of the orbital elements, has been studied as a function of season and latitude. It is found that the above mentioned effect causes non-negligible, although relatively small, variations in both the planetary-wide distribution and the intensity of the diurnal insolation. The seasonal insolations exhibit very important changes in amplitude (which e.g. at the poles may attain values of more than a factor of two) for significant large-scale variations of the orbital parameters.

It has been found that for eccentricities larger than about 0.194 there exists two periods of weak insolation on opposite sides of the Mercurian surface that alternately point to the Sun at every perihelion passage. The critical value of the orbital eccentricity past which the Sun shortly sets after perihelion is near 0.213. The large eccentricity of Pluto produces significant north-south seasonal asymmetries in the daily insolation. As for Uranus, having a similarly large obliquity, the equator receives less annual average energy than the poles.

11. Publications

ACKERMAN, M. and LIPPENS, C., Forward and back scattering of solar radiation by the stratospheric limb after mount St. Helens eruption, pp. 299-303, in : Atmospheric effects and potential climatic impact of the 1980 eruptions of mount St. Helens, NASA Conference Publication 2240, 1982.

ACKERMAN, M. and LIPPENS, C., Material from the El Chichon volcano above Spain on 3 May 1982 - One month after the eruption, Planet. Sp. Sci., 32, 17-23 (1984).

ACKERMAN, M., LIPPENS, C., MULLER, C. and VRIGNAULT, P., Blue sunlight extinction and scattering by dust in the 60 km altitude atmospheric region, Nature, 299, 17-20 (1982).

ACKERMAN, M., LIPPENS, C., MULLER, C. and VRIGNAULT, P., Twilight observations from a balloon gondola. Preliminary results, Bull. Acad. R. Belg., Cl. Sci., 68, 546-563 (1982).

AIMEDIEU, P., KRUEGER, A.J., ROBBINS, D.E. and SIMON, P.C., Ozone profile intercomparison based on simultaneous observations between 20 and 40 km, Planet. Space Sci., 7, 801-807, 1983.

ARIJS, E., Positive and negative ions in the stratosphere, Annales Geophysicae, 1, 149-162, 1983.

ARIJS, E., NEVEJANS, D., FREDERICK, P. and INGELS, J., Stratospheric negative ion composition measurements, ion abundances and related trace gas detection, J. Atm. Terr. Phys., 44, 681-694, 1982.

ARIJS, E., NEVEJANS, D. and INGELS, J., Stratospheric positive ion composition measurements, ion abundances and related trace gas detection, J. Atm. Terr. Phys., 44, 43-53, 1982.

ARIJS, E., NEVEJANS, D. and INGELS, J., Positive ion composition measurements and acetonitrile in the upper stratosphere, Nature, 303, 314-316, 1983.

ARIJS, E., NEVEJANS, D., INGELS, J. and FREDERICK, P., Positive ion composition measurements between 33 and 20 km altitude, Annales Geophysicae, 1, 163-168, 1983.

ARIJS, E., NEVEJANS, D., INGELS, J. and FREDERICK, P., Sulfuric acid vapour derivations from negative ion composition data between 25 and 34 km, Geophys. Res. Lett., 10, 329-332, 1983.

ARIJS, E., NEVEJANS, D., INGELS, J. and FREDERICK, P., Negative ion composition and sulfuric acid in the upper stratosphere, Planet. Space Sci., 31, 1459-1464, 1983.

BERTAUX, J.L. and KOCKARTS, G., Distribution of molecular hydrogen in the atmosphere of Titan, J. Geophys. Res., 88, 8716-8720, 1983.

BRASSEUR, G., ARIJS, E., DE RUDDER, A., NEVEJANS, D. and INGELS, J., Acetonitrile in the atmosphere, Geophys. Res. Lett., 10, 725-728, 1983.

BRASSEUR, G., DE RUDDER, A. and SIMON, P.C., Implication for stratospheric composition of a reduced absorption cross section in the Herzberg continuum of molecular oxygen, Geophys. Res. Lett., 10, 20-23, 1983.

KOCKARTS, G., Structure générale de l'atmosphère terrestre, pp. 29-96, dans : Physique Moléculaire-Physique de l'Atmosphère (C. Camy-Peyret, ed.) Editions du CNRS, Paris, 1982.

LAURENT, J., LEMAITRE, M.P., LIPPENS, C. and MULLER, C., Expérience de spectrométrie infrarouge pour la première mission Spacelab, Aéronautique et Astronautique, 10, 60-70, 1983.

LEMAIRE, J., A brief panorama, pp. 3-10, in : J. Lemaire and M.J. Rycroft (eds.), Solar system plasmas and fields, Advances in Space Research, vol. 2, n° 1, 1982.

LEMAIRE, J., The interpretation of ATS6 protons and electron observations within the frame of the E3H electric field model, Bull. Acad. R. Belg., Cl. Sci., 68, 821-834, 1982.

LEMAIRE, J., ROTH, M., SCHERER, M. and SCHULZ, M., Interdisciplinary study of Directional Discontinuities in the Solar Wind with ISPM, pp. 265-271, in : The International Solar Polar Mission - Its Scientific Investigations, ESA-SP-1050, 1983.

LEMAIRE, J. and SCHERER, M., Field aligned current density versus electric potential characteristics for magnetospheric flux tubes, Annales Geophysicae, 1, 91-96, 1983.

LIPPENS, C., Controlling the 1ES013 spectrometer for Spacelab and its data retrieval, Bull. Acad. R. Belg., Cl. Sci., 68, 454-469, 1982.

LIPPENS, C. and MULLER, C., Inversion of infrared spectra obtained at the "Observatoire du Pic du Midi", Bull. Acad. R. Belg., Cl. Sci., 69, 379-387, 1983.

MULLER, C., L'ozone de l'atmosphère, La Recherche, 13, 180-189, 1982.

MULLER, C., Limb sounding of the Martian atmospheric composition : O_2 and H_2O, pp. 65-68, Proceedings of the workshop : "The planet Mars", ESA-SP-185, 1982.

MULLER, C., Calculs de la diffusion Mie appliqués à l'observation de l'aérosol stratosphérique, Bull. Acad. R. Belg., Cl. Sci., 68, 333-345, 1982.

MULLER, C. and LAURENT, J., Scientific programs for the Spacelab ES013 grille spectrometer, Bull. Acad. R. Belg., Cl. Sci., 68, 431-442, 1982.

NEVEJANS, D., FREDERICK, P. and ARIJS, E., Microprocessor based data acquisition and control system for a balloon borne quadrupole mass spectrometer, Bull. Acad. R. Belg., Cl. Sci., 67, 314-332, 1982.

ROELAND, S., LIPPENS, C. and SIMON, P.C., Stratospheric ozone measurements by solar ultraviolet absorption, Planet. Space Sci., 31, 767-772, 1983.

ROTH, M., On the relevance of the MHD approach to study the Kelvin-Helmholtz instability of the terrestrial magnetopause, Bull. Acad. R. Belg., Cl. Sci., 68, 443-453, 1982.

ROTH, M., Boundary layers in space plasmas : a kinetic model of tangential discontinuities, pp. 139-147, in : W. Bötticker, H. Wenk and E. Schulz-Gulde, Proceedings of the XVI International Conference on Phenomena in Ionized Gases, Düsseldorf, 1983.

SCHERER, M., On the choice of boundary conditions for the matching of kinetic to hydrodynamic polar wind models, Bull. Acad. R. Belg., Cl. Sci., 68, 533-545, 1982.

SIMON, P.C., Current solar spectral irradiance observations : a review, p. 50, in : J. London and C. Fröhlich, IAMAP Third Scientific Assembly, Boulder, USA, 1982.

SIMON, P.C. and BRASSEUR, G., Ultraviolet absorption measurements in the atmosphere of Mars. pp. 69-71, Proceedings of the workshop : "The Planet Mars", ESA-SP-185, 1982.

SIMON, P.C. and BRASSEUR, G., Photodissociation effects of solar U.V. radiation, Planet. Space Sci., 31, 987-999, 1983.

SIMON, P.C., PASTIELS, R. and NEVEJANS, D., Balloon observations of solar ultraviolet irradiance at solar minimum, Planet. Space Sci., 30, 67-71, 1982.

SIMON, P.C., PASTIELS, R., NEVEJANS, D. and GILLOTAY, D., Balloon observations of solar ultraviolet irradiance during solar cycle 21, p. 95, in : J. London and C. Fröhlich, IAMAP Third Scientific Assembly, Boulder, USA, 1982.

VAN HEMELRIJCK, E., The oblateness effect on the solar radiation incident at the top of the atmospheres of the outer planets, Icarus, 51, 39-50, 1982.

VAN HEMELRIJCK, E., The oblateness effect on the solar radiation incident at the top of the atmosphere of Mars, pp. 59-63 in Proceedings of the workshop : "The planet Mars, ESA-SP-185, 1982.

VAN HEMELRIJCK, E., The insolation at Pluto, Icarus, 52, 560-564, 1982.

VAN HEMELRIJCK, E., An estimate of the solar radiation incident at the top of Pluto's atmosphere, Bull. Acad. R. Belg., Cl. Sci., 68, 675-698, 1982.

VAN HEMELRIJCK, E., The oblateness effect on the extraterrestrial solar radiation, Solar Energy, 31, 223-228, 1983.

VAN HEMELRIJCK, E., The effect of orbital element variations on the mean seasonal daily insolation on Mars, The Moon and the Planets, 28, 125-136, 1983.

VAN HEMELRIJCK, E., On the variations in the insolation at Mercury resulting from oscillations in the orbital eccentricity, The Moon and the Planets, 29, 83-93, 1983.

VERCHEVAL, J., Les implications des caractéristiques orbitales du projet européen KEPLER, Bull. Acad. Roy. Belg., Cl. Sci., 58, 665-674, 1982.

WISEMBERG, J. and KOCKARTS, G., A new ionospheric scattering mechanism, J. Atmos. Terr. Phys., 45, 47-53, 1983.

B. ASTROPHYSICAL INSTITUTE OF THE UNIVERSITY OF LIEGE

1. Space Telescope

1.1. Photon detector assembly (PDA)

During the year 1982, the first model of the PDA has been tested. This test sequence was mainly devoted to the calibration of the Engineering Model 1 (EM1) and to the check of all the interfaces, as the model was not fully representative.

The first model which has been calibrated was the Proto Flight Model 1 (PFM1) device. It has been operated successfully under vacuum conditions and the calibration has demonstrated the capability of the unit. This sequence occured in April 1983. Due to planning constraints, the best sequence on the second flight model PFM2 has been cancelled.

At the end of 1983, the new calibration sequence of the first spare model (PFM3) has been prepared. This will be submitted in February 1984 to thermal cycles and will be fully calibrated in the wavelength range 115-660 nm.

1.2. Faint object camera (FOC)

All the preparations and the calibration of the hardware was completed in August 1983, whilst the calibration of the FOC was performed at ESTEC in October 1983.

As it was the first time that all equipments were assembled (FOC-facility-calibration hardware), a series of problems have occured. Unfortunately, the channel n°2 of the FOC, i.e. the Photon Detector

Assembly (PFM2 PDA) has shown a big breakdown when operated under vacuum. This major fact, added to the lack of flux in Vacuum Ultra-violet (VUV), has induced the possibility of a second calibration later in the planning (nominally mid 1984).

2. Halley multicolour camera (HMC)

The contribution to the development of the Multicolour camera is limited to qualification and functional tests at component and system levels. Among these tests are the qualification tests of the Charge Coupled Device (CCD) detectors. In that respect, a complete test bench has been developed, which allows to operate the device in thermal vacuum at temperatures down to - 30°C and to stimulate it. The measurements performed are essentially : (1) optimisation of the voltages, (2) quantum efficiency, (3) intensity transfer function, (4) modulation transfer function. These measurements have been performed on 18 TI CCD of 390 x 584 pixels. The measurements have been repeated in Time Delay Integration (TDI) made on the same devices after masking. The next step in the test plan of the detection chain is the verification of the performances of the Focal Plan Unit including two bi-dimensional CCD's and one linear Reticon. These tests have been performed in October 1983 on the electrical model of the Focal Plane Unit (FPU). A further step is the calibration and the vacuum and thermal tests of the camera itself. For this operation, the encounter phase of the Spacecraft with the Halley Comet has to be simulated. A space simulator representing the attitudes of the spacecraft relative to the comet has been built. It is a complex instrument controlled by computer fed by the equations of the cinematics and dynamics of the encounter. The HMC engineering model submitted to the different sequences believed to be representative of the future mission, has demonstrated a satisfactory behaviour.

3. Research on thermospheric and mesospheric odd nitrogen

A new bi-dimensional model has been developed to calculate the simultaneous transport by thermospheric winds of NO, $N(^4S)$ and $N(^2D)$. The results show that the $N(^2D)$ atoms and the associated 5200 A airglow are efficiently carried by winds outside the auroral-source region. The precipitation measured on a rocket flight in Cape Parry (Canada) has been simulated with the model. Comparison with the model calculations indicates that the wind speed required to fit the measurements is in good agreement with the thermospheric three-dimensional circulation current models. Other observations made with the VAE experiment on board the Atmosphere Explorer D satellite confirm the influence of horizontal transport on the morphology of the $N(^2D)$ high latitude distribution.

The various rocket measurements of nitric oxide using the NO γ resonance scattering and ion composition have been reviewed and their seasonal/latitudinal variation has been compared with the results of a one-dimensional model of the odd nitrogen distribution between 50 and 250 km. Solar activity, latitudinal variation of the eddy diffusion coefficient K and local time are sources of NO concentration variability. It has been shown that the importance of the NO downward flux ϕ from the thermosphere to the mesosphere is strongly altitude and latitude dependent and has been estimated from the measured vertical profiles. It has been found that the ϕ/K ratio at 85 km varies from 20 cm^{-4} at low latitudes to over 10^3 cm^{-4} at high winter latitudes. These values and the trends observed are in agreement with the predictions of a two dimensional zonally averaged model of odd nitrogen between 70 and 350 km.

4. Publications

CUCCHIARO, A. et al., The ultraviolet stellar classification program, ESA SP-176, May 1982, p. 327.

CUCCHIARO, A. and MALAISE, D., Dynamic coma models for comet Bennett 1970 II, Astron. and Astrophys., 114, 102, 1982.

GERARD, J.C., The Martian airglow and scattered sunlight : future observations from a spinning orbiter, Proc. of "The Planet Mars" - Workshop, Leeds, ESA-SP-185, 73-81, 1982.

GERARD, J.C., DENEYE, E. and SINGH, V., Rocket measurements and modelling of the nitric oxide distribution in the lower thermosphere and mesosphere, Proc. 6th ESA symposium on European rocket and balloon programmes, ESA SP-183, 123-130, 1983.

GERARD, J.C. and ROBLE, R.G., Transport of aurorally produced $N(^2D)$ by winds in the high latitude thermosphere, Planet. Space Sci., 30, pp. 1091-1105, 1982.

SINGH, V. and GERARD, J.C., The thermospheric heating efficiency under electron bombardment conditions, Planet. Space Sci., 29, 885-892, 1982.

C. ASTROPHYSICAL INSTITUTE OF THE VRIJE UNIVERSITEIT BRUSSEL

1. Multispectral analysis of the Be-X-ray binary A0535 + 26

The observations of the Be X-ray binary A0535 + 26 with Ultraviolet Explorer, were combined with infrared observations at Gornergrat, with groundbased photometry, groundbased spectroscopy and X-ray observations.

These observations at various wavelength regions, and repeated at different times resulted in a geometrical and evolutionary model for this pulsating X-ray transient. Changes in the photometry revealed the presence of a shell expelled by the Be-star, giving rise later on to an X-ray outburst. The erratic behaviour of the period changes are interpreted in terms of absence of a disk.

An evolutionary model for this type of X-ray sources starting from an initial massive system of 15 M_o + 10 M_o, with a period of 8 days is presented. The system changed from detached to semi-detached, later into a contact phase during a very short period of a couple of thousand years, again to a semi-detached and finally to a detached phase.

Possibly during the contact, disks could be formed, and such systems may then be identified with binaries like 0 Per. The remnant of the mass losing star continues its evolution and finally explodes.

The period of the system has meanwhile increased and has after explosion a value of the order to 100 days. A possible disk will not be capable to resist the supernova explosion.

2. Wolf-Rayet runaway stars

High and low resolution spectra of the candidate RW runaways HD 50896, HD 192163 and HD 97548 were obtained during two shifts on 21 and 22 December 1982, and again during two shifts on 19 and 20 December 1983 at Villafranca.

The IUE (International Ultraviolet Explorer) observations of 1983 were carried out simultaneously with EXOSAT. The EXOSAT observations of HD 192163 in NGC 5888 were carried out by Dr. Wendker, Hamburg.

In the theoretical evolutionary scenario for massive close binaries the following sequences occur : after mass loss by stellar wind and mass transfer from primary to secondary a Wolf-Rayet binary is left; after further evolution of the helium remnant, it explodes, giving rise after a possible "Sleeping stage", to an OB-runaway, to an X-ray binary. The optical, luminous companion of the compact object (neutron star) loses a part of its matter as well, producing in this way a helium star, orbited by a neutron star. Such a star should show all the characteristics of a Wolf-Rayet star.

The runaway character is produced by the supernova explosion, driving the star away from its place of birth.

Normally the Wolf-Rayet star, with a stellar wind of 2-3 times 10^{-5} M_o yr^{-1} produces X-rays. It has been generally thought that these X-rays should not be observable since they were thought to be extinguished by the strong stellar wind. Recent calculations show however that this is not the case, and that the X-rays should be detected.

Simultaneous observations with IUE (to determine the exact stellar wind mass loss rate) and EXOSAT (to determine the X-ray flux) should allow us to solve this problem : if a neutron star is present, the Wolf-Rayet star should produce X-rays, and an important X-ray flux should be detected. Absence of X-rays and the presence of periodic variations could be an indication of a binary with as companion for the WR component a low mass star (B or later).

3. In order to detect a relationship between the mass loss rates and stellar parameters as luminosity, mass and radius, a detailed determination of the mass loss rate should be performed, as exactly as possible to avoid scatter, due to errors. An important source of error in this respect are the ionization fractions of the ions, used for the derivation of the mass loss rates, which can vary drastically through the wind. A careful analysis of spectra of IUE, obtained by the Astrophysical Institute or from the IUE databank, will allow to estimate reasonably well these ionization fractions, and hence to determine better mass loss rates.

4. <u>UV observations with BUSS (Balloon Ultraviolet Stellar Spectrograph)</u>

The BUSS experiment has a higher resolution than IUE and concentrates to the nearer UV ($\lambda >$ 2000 A). Both these aspects enhance the possibilities in studying stars showing a slower outflow and having strong resonance lines of one time ionized metals. The supergiant α Cyg, A2Ia, is the most prominent example of such a star. A detailed comparison with the spectrum of η Leo has allowed to predict accurately the contribution of photospheric components to P Cygni profiles and weaker ones, that are more sensitive to changes in M, have been included in the modelling of the stellar wind. A lower mass loss rate than previously determined from strong P Cygni profiles alone is found (1 to 5 x 10^{-9} M_o yr^{-1}).

5. Publications

BURGER, M., de JAGER, C., van den OORD, G.H.J. : 1982, The pulsation of the outer layers of the Beta Cephei star σ Sco. Astron. Astrophys. 109, 289.

BURGER, M., de JAGER, C., van den OORD, G.H.J., SATO, N : 1982, The pulsation of the outer layers of the Beta Cephei-type variable BW Vul. Astron. Astrophys. 107, 320.

de LOORE, C. : 1982, The evolution of massive stars : The production of binary Wolf-Rayet Stars. Proceedings IAU Symp. n° 99 "Wolf-Rayet Stars : Observations, Physics and Evolution", eds. C. de Loore and A.J. Willis, Reidel, Dordrecht, p. 343.

de LOORE, C. : 1982, Stellar winds. Third European IUE Conf. ed. P. Benvenuti, Madrid.

de LOORE, C. : 1983, "Wolf-Rayet binaries and X-ray binaries", in Wolf-Rayet stars : precursors of supernovae, Proc. Coll. Meudon, ed. M.C. Lortet, III51-III76.

de LOORE, C. : 1983, "Geometrical and evolutionary models for close binaries derived from multispectral observations", Proc. Workshop Strasbourg.

de LOORE, C. : 1983 , "Evolution of massive stars" in : Spectral Evolution of Galaxies, Workshop held in Rutherford Appleton.

de LOORE, C., BURGER, M., van DESSEL, E.L., MOUCHET, M. : 1982, Be components in X-ray binaries. Proceedings IAU Symp. n° 98 "Be stars", eds. M. Jaschek and H.G. Groth, Reidel, Dordrecht, p. 347.

de LOORE, C., DOOM, C. : 1983, "Evolutionary Scenarios for the Formation of Wolf-Rayet Binaries", in : M.C. Lortet and A. Pitault (eds) "Wolf-Rayet Stars : Progenitors of Supernovae?", Proc. of Workshop held at Meudon, 20-22 april 1983, p. II3-II16.

de LOORE, C., MAEDER, A. : 1982, Stellar evolution after IUE : massive stars during core hydrogen burning and massive close binaries. Third European IUE Conf., ed. P. Benvenuti, Madrid.

de LOORE, C., MOUCHET, M., van DESSEL, E.L., BURGER, M. : 1982, Mass determination of massive X-ray binaries. The Messenger March 1982.

DOOM, C., DE GREVE, J.P. : 1982, The occurence of different Wolf-Rayet phases in massive close binaries (abstract). Proceedings IAU Symp. n° 99 : "Wolf-Rayet Stars : Observations, Physics and Evolution", eds. C. de Loore and A.J. Willis, Reidel, Dordrecht, p. 403.

GIOVANNELLI, F., de LOORE, C., BARTOLINI, C., BURGER, M., FERRARI-TONIOLI, M., GIANGRANDE, A., GUARNERI, A., PERSI, P., PICCIONI, A., van DESSEL, E.L. : 1982, Ultraviolet, optical and infrared observations of HDE 245770/A 0535 + 26. Third European IUE Conf., ed. P. Benvenuti, Madrid.

HENSBERGE, H., LAMERS, H.J.G.L.M., de LOORE, C., BRUHWEILER, F.C. : 1982, Mass loss from α Cyg (A2Ia) derived from the profiles of low excitation Fe II lines. Astron. Astrophys. 106, 137-150.

MAEDER, A., de LOORE, C. : 1982, Stellar evolution after IUE : renewal in our knowledge of massive and Wolf-Rayet stars. Third European IUE Conf., ed. P. Benvenuti, Madrid.

ROBBRECHT, W., de LOORE, C., OLSEN, G. : 1982, A Hot corona model for O-stars and WR stars. Proceedings IAU Symp. n° 99 "Wolf-Rayet Stars : Observations, Physics and Evolution", eds. C. de Loore and A.J. Willis, Reidel, Dordrecht, p. 209-213.

ROBBRECHT, W., de LOORE, C., OLSEN, G. : 1983, "Coronae and Winds in Evolving Stars", Astron. Astrophys. 121, 286.

SYBESMA, C., de LOORE, C. : 1982, The detection of compact companions in OB-runaway stars. Astron. Astrophys. 111, 229.

VANBEVEREN, D., VAN RENSBERGEN, W., de LOORE, C. : 1982, The theoretically expected X-ray luminosity and the binary nature of Wolf-Rayet runaway stars. Proceedings ESO Workshop "The Most Massive Stars", pp. 199-205 in Astron. Astrophys. 115, 69-78.

D. DEPARTMENT OF ASTROPHYSICS OF THE STATE UNIVERSITY OF MONS

The activity of the Department has been mainly devoted to the physical interpretation of soft X-ray spectra of active solar regions and to the study of stellar atmospheres of B and A type stars using ultraviolet spectra obtained either by satellite or with the Balloon Ultraviolet Stellar Spectrograph (BUSS).

1. Solar soft X-ray spectra

The physical interpretation of X-ray solar spectra postulated the elaboration of an atomic plasma model, including the various physical processes responsible for radiant energy emission. In collaboration with groups of atomic physics at the Meudon and Nice observatories, many atomic parameters (transition and autoionisation probabilities, excitation rates, ...) pertaining to the implied mechanisms were computed. The use of these results in the plasma model lead to the detailed computation of synthetic spectra of ions of high abundance in the active solar regions (Mg X-XI, CA XVIII-XX, Fe XXIV-XXVI).

A method has been proposed to determine the physical conditions in the emitting region by fitting synthetic to observed spectra. The best fit is obtained for a set of temperature, density, and abundance ratio. This method has been applied to various observations of solar flare or solar active regions made with the Solar Maximum Mission satellite (1,2(Fe XXV); 3(Ca XIX) or with rocket spectrographs (4, 5, 6 (Mg XI)). This technique allowed to follow for the first time the temporal variations of physical conditions in a solar flare. It seems that the latter are constantly near the state of ionisation equilibrium.

2. A-type stars

In a collaboration with the Vrije Universiteit Brussel, the ultraviolet spectrum of α CVn at a 0.1 A resolution, obtained with the BUSS has been investigated. This spectrum extends from 1975 to 3378 A, with an interruption due to an atmospheric absorption band. The wavelength of 2167 absorption lines has been measured and many of them have been identified as due mainly to metals (Fe, Cr and V mostly). A 1.9 A shift in the reduced wavelength has been noticed and confirmed.

The set of lines has been submitted to a series of tests for statistical identifications thanks to the "Wavelength Coincidence Statistics" by Cowley et al. (Michigan). It has been modified in order to adapt it to spectra cut into different spectral orders, sometimes not immediately connected. One major difficulty is to collect lists of laboratory wavelengths in this spectral region. The statistical identification has been carried out for 98 elements in 4 ionisation stages at least when atomic data were about complete.

A collaboration was also started with a comparative study of ultraviolet spectra obtained by BUSS and by IUE (International Ultraviolet Explorer), when the WCS is used.

3. B-type stars

The BUSS IX and X flights brought back 9 UV spectra of stars in the B1-B8 range. Some of the spectra have been reduced and calibrated at Utrecht. These spectra show however several blanks and their scientific interest is therefore rather meager. Of special interest is the shell star 48 Librae which shows a well developed envelope spectrum. Bad news came from the data reduction team about the BUSS XI flight, which did not reach a sufficient altitude.

However, observations with IUE have been continued very successfully both on peculiar southern hot objects and on giants and supergiants of the Magellanic Clouds. Investigation on the absorbing properties of interstellar matter in the Clouds is in progress.

4. Publications

VOLONTE, S., Electronic excitation and dielectronic recombination in highly ionized plasmas. "Trends in Physics, 5th Gen. Conf. EPS, Istanbul", ed. Dorobantu, I.A., Control Institute of Physics (1982) pp. 401.

DUBAU, J., VOLONTE, S., Raies satellites de recombinaison di-électronique, Ann. Phys. (1982), 7, 455.

BELY-DUBAU, F., DUBAU, J., FAUCHER, P., GABRIEL, A.H., LOULERGUE, M., STEENMAN-CLARK, L., VOLONTE, S., ANTONUCCI, E., RAPLEY, C.G., Dielectronic satellite spectra for highly-charged helium-like ions - VII. Calcium spectra - Theory and comparison with SMM observations, Mon. Not. R. Astr. Soc. (1982) 201, 1155.

FAUCHER, P., LOULERGUE, M., STEENMAN-CLARK, L., VOLONTE, S., Dielectronic satellite spectra of Mg XI with inner-shell and helium-like excitation rates. Application to solar observation, Astron. Astrophys. (1983) 118, 147.

STEENMAN-CLARK, L., BELY-DUBAU, F., FAUCHER, P., LOULERGUE, M., VOLONTE, S., Analysis of high resolution solar Mg XI X-ray spectra, accepted in Physica Scripta (1984).

FAUCHER, P., VOLONTE, S., Improved effective rate coefficients for Mg XI and Ca XIX, accepted in Astron. Astrophys. (1984).

NANDY, K., THOMPSON, G.I., MORGAN, D.H., WILLIS, A.J., WILSON, R. and HOUZIAUX, L., Visible and UV observations of the giant early-type members of the Large Magellanic Cloud, Monthly Not. R. Astr. Soc. (1983) 205, 231-239.

HOUZIAUX, L., A puzzling object : V 348 Sgr., The Messenger, n° 33 (1983).

NANDY, K. and HOUZIAUX, L., Spectrophotometry of early-type supergiants in the LMC. Proceedings of the IAU symposium "Structure and Evolution of the Magellanic Clouds", 233-234, 1983.

HOUZIAUX, L. and HECK, A., Carbon abundance in the WC 11 star CPD-56°8032, in Wolf-Rayet Stars : Observations, Physics, Evolution, 139-145, 1982.

E. ROYAL OBSERVATORY OF BELGIUM

Space Geodesy and fundamental astronomy

1. Observations

The Doppler station operating on the frequencies 150-400 Mhz and 162-324 Mhz has performed continuous observations during the whole period.

The station referenced as TRANET 021 is integrated since 1972 in the tracking network managed by DMAHTC (Defence Mapping Agency Hydrographic and Topographic Center). A new equipment is operated since January 1982 and a new antenna has been installed in July 1983. With the antenna change, the station number became 547.

The objectives of the Royal Observatory are related to the detection of the polar motion and the irregularities of the Earth rotation.

The number of observed passes is given in the following table :

Type of Satelitte	Number of passes	Objectives
TRANSIT	7.695	Polar Motion Earth gravity field
BEACON	886	Study of the low atmosphere
GEOS-3	1.814	Earth gravity field Geoïd configuration

2. Analysis

- Three models of Doppler analysis were compared with the same data set (Usandivaras and al., 1982).
- In the whole data set acquired in Brussels between 1972 and 1981, periodic variations of the height of the station were identified. They reflect an apparent variation of the orbit induced mainly by the ionospheric measurement errors. The periods are respectively 4 months, 365 days and 11.7 years (P. Pâquet and al., 1982; V. Dehant and al., 1983).
- The Royal Observatory is part of the European Consortium taking in charge the analysis of the African Doppler campaign organized by the Commission "International Coordination of Space Techniques for Geodesy and Geodynamics" (IAG and COSPAR). A first set of results were presented during the IUGG-General Assembly (August 1983).
- In collaboration with several European groups, the Royal Observatory participates to the study of a European geodetic satellite called POPSAT (Wakker K. and al., 1982).

3. Publications

DEHANT, V. and PAQUET, P., (1983), Modelling of the apparent height variations of a Tranet station, Bulletin Géodésique 57, pp. 354-364.

PAQUET, P. and DEHANT, V., The coordinates evolution of a TRANET station over 9 years, Proceed. of the Third Int. Geod. Symp. on Sat. Doppler Positioning, LAS CRUCES, 1982.

USANDIVARAS, J. and PAQUET, P., Comparisons of the results of three models of analysis applied on the Doppler data set provided by the AIG-SSG 2.24. Proceed. of the Third Int. Geod. Symp. on Sat. Doppler Positioning, LAS CRUCES, 1982.

WAKKER, K., HARTL, P., BARLIER, F., PAQUET, P., KANIUTH, K., AARDOOM, L., CUNO, J., MULLER, H. and NOUEL, F., Investigations of an active satellite system for earth kinematics and positioning. IEEE Digest Vol. I, Int. Geosc. and Remote Sensing Symposium, 1982.

F. ROYAL METEOROLOGICAL INSTITUTE OF BELGIUM

1. Solar constant and Earth's Radiation Budget

The absolute radiometer for experiment 1ES021 on Spacelab 1 has been delivered in May 1982 to NASA after an intercomparison with experiment N008 at Table Mountain Observatory (JPL/NASA). Integration, tests and flight operations simulations have been performed in succession till the launch on 28th November 1983.

The Solar Constant 1ES021 experiment was operated on day 7 and continued to day 9 with three hours of additional Solar observations provided by the extension of the mission. The final data analysis is in process and very accurate observations of the "Solar Constant" are expected.

The experiment 1ES021 is actually refurbished to be flown as part of the corepayload of the Earth Observations Missions (EOM) program of NASA in June 1985.

The flight model n° 2 of experiment 1ES021 has participated in June 1983 in a stratospheric balloon flight jointly organized by the World Radiation Center Davos, the "Observatoire de Genève", the Belgian Institute for Space Aeronomy and the Royal Meteorological Institute of Belgium.

The payload included a set of different absolute radiometers, Sun photometers and spectrometers to measure the total and spectral irradiance of the Sun.

The balloon was launched by the CNES from the GAP-TALLARD base; the duration of the flight at an altitude higher than

39 km was more than 5 hours. The measurements of the Solar irradiance at the balloon level obtained by the different absolute radiometers are in very good agreement; the reduction to air mass zero is still in process.

The activities in relation with the Earth Radiation Budget Experiment (ERBE) of NASA proceed as planned.

2. Publications

CROMMELYNCK, D., "Fundamentals of absolute pyrheliometry and objective characterization", Earth Radiation Science Seminars. NASA Conference Publication 2239, 1982.

G. DEPARTMENT OF METALLURGY OF THE CATHOLIC UNIVERSITY OF LEUVEN

Melting and solidification of metallic composites

1. General purpose

The aims are (i) identification of forces causing the displacement of particles in a metallic melt, (ii) the study of the role of interfacial phenomena on the preparation and properties of metallic composites and (iii) investigation whether space environment can be used to develop new composite materials.

2. Background

Until now most metallic composites are prepared by powder metallurgical techniques. However, methods by which the dispersion material is introduced and uniformly dispersed in a metallic melt before casting also seem attractive. One advantage in some systems may be a better bonding between matrix and particles. The lack of straightforward method to produce a metallic composite by casting is due to the fact that there are several phenomena which before or during the solidification can determine the final location of the particles in the solidified metallic matrix such as sedimentation, skeleton formation, particles being pushed forward by the solidification front.

In preparatory ground experiments attention is focussed on the influence of the interfacial energy between the matrix material and the dispersed particles (as determined by wetting experiments), on the eventual skeleton formation by the dispersoids (leading to a thixotropic behaviour of the melt) and on the interaction of the advancing solidification front with the dispersed particles.

3. Texus experiments

Important information was obtained from the experiments carried out in the sounding rocket called TEXUS (Technologische Experimente Unter Schwerlosigkeit). The TEXUS sounding rocket is a suborbital vehicle in which low gravity conditions exist during the unpowered coast phase after launch and before reentry into the atmosphere. The accelerations remain below about 10^{-4} g during six minutes. From the TEXUS 6 experiment (launch : May 1982), can be concluded that in samples of copper containing a dispersion of coarse silicon-carbide particles, mechanisms leading to an exudation of the particles to the outer surface or to gas holes were dominant. The TEXUS 7 experiments (launch : May 1983) showed that the transport of non wetted particles in a liquid metal can be controlled by the choice of the crucible wall material, the sample design and the size of the sample : an almost complete retention of the dispersed particles in the metal is possible.

4. Spacelab investigations

The experiments consist of the melting and the solidification under microgravity of metallic composite materials ($Al-Al_2O_3$, Al-SiC, $Cu-Al_2O_3$, Cu-SiC, Cu-Mo and Cu-W) which are prepared by a powder metallurgical technique including a hot extrusion step.

The first run with six different aluminium matrix samples has been performed during the Spacelab 1 flight. The temperature-time profile would be in accordance with the required conditions; however the exact data are not yet available. Unfortunately, due to severe problems with the Isothermal Heating Facility, nine runs of different investigators could not be performed during this flight, including the second run of the department with six copper matrix samples. From the

visual inspection, the dimensional control and several radiographs of the unopened cartridge, it appeared that no special problems occurred during processing in space. This was confirmed after opening the cartridges : the six samples remained completely inside the crucible holes, their shape appeared good and they could easily be removed out of the crucible.

By radiography of the samples it was possible to localize the shrinkage voids and the scarse gas holes in some samples. After macroscopic inspection of the outer surface, which revealed that no dispersed particles separated from the metallic melt, the samples were sectioned in the longitudinal direction by spark cutting.

The metallographic preparation and evaluation is now in progress. Some mechanical properties and the fracture behaviour will also be determined. All these results will be compared with those of the lg-reference samples, which will be processed very soon on earth under identical conditions as during the Spacelab flight except for the gravity level.

5. Publications

FROYEN, L. and DERUYTTERE, A., Metallic composite materials and microgravity, Proceedings of the 4th European Symposium on Materials Sciences under Microgravity, Madrid, Spain, 5-8 April 1983, ESA SP-191, p. 31-36.

DERUYTTERE, A. and FROYEN, L., Melting and solidification of metallic composites, Proceedings RIT/ESA/SSC Workshop, Järva Krog, Sweden, 18-20 January 1984, ESA SP-219, p. 65-67.

H. DEPARTMENT OF CHEMICAL PHYSICS OF THE UNIVERSITE LIBRE DE BRUXELLES

An experiment has been performed during the sounding rocket TEXUS 8 flight in May 1983. In an observation cell 3 cm x 2 cm x 1 cm, a stable observable liquid-gas interface was created under microgravity conditions. It was attached at the four lateral walls, at the limit of anticreeping barriers. A temperature gradient was established along the interface. The fluid was a 6.24 10^{-3} molal aqueous n-heptanol solution. This system has the property to present a surface tension minimum as a function of the temperature. In the TEXUS 8 flight, the temperatures (45°C and 65°C) imposed at the boundaries of the interface were higher than the temperature corresponding to the surface tension minimum. In agreement with the existence of this extremum around 40°C, we have recorded a Marangoni convection cell rotating in the unusual direction : the liquid was growing up along the cold wall and in the surface, the liquid flowed from the cold to the hot wall.

The same experiment on Earth gives rise to a Marangoni cell superposed on a buoyancy cell, the two movements being contrarotative.

A similar experiment is being prepared for the next TEXUS 9 flight. The aims are to examine the structure of the remaining convection when the temperatures imposed at the boundaries of the interface are respectively higher and lower than the temperature of the minimum. The path of tracer particles will also be followed as in TEXUS 8, but furthermore, the temperature field will be determined by recording differential interferograms.

The time under microgravity during the TEXUS flights is too short to make sure that the velocities determined in those experiments

are steady values. Experiments to be performed during the D_1 mission of Spacelab are prepared in order to follow the evolution of systems towards their steady states.

An experiment for flight on Eureca 1 is also under preparation. It will use the Solution Growth Facility (SGF), and will permit to measure Soret coefficients with high accuracy, avoiding the disturbing effect of gravity.

Publications

AZOUNI, N.A. and PETRE, G., Inversion of the Marangoni convection with increasing temperature. Aqueous fatty alcohol solution/air interface. Proceedings of the 4th international conference on Physico Chemical hydrodynamics, N.Y., com. 24.B (1982).

LEGROS, J.C., LIMBOURG-FONTAINE, M.C. and PETRE, G., Influence of a surface tension minimum as a function of temperature on the Marangoni convection. Acta Astronautica, 11, 143 (1984).

LEGROS, J.C., PETRE, G. and LIMBOURG-FONTAINE, M.C., The influence on the Marangoni effect of a surface tension minimum as a function of temperature in microgravity conditions. ESA SP-191 (Madrid), 201 (1983).

LIMBOURG-FONTAINE, M.C., PETRE, G. and LEGROS, J.C., Texus 8 Experiment : Effects of a surface tension minimum on Thermo-capillary convection. Submitted to PCH.

PETRE, G., LIMBOURG-FONTAINE, M.C. and LEGROS, J.C., Study of the surface tension minimum of aqueous alcohol solutions and movements at the interface air/solution. ESA SP-191 (Madrid), 199 (1983).

PETRE, G., LIMBOURG-FONTAINE, M.C. and LEGROS, J.C., Preliminary results of Texus 8 experiments on effects of surface tension minimum. 34e Congrès de la Fédération Internationale d'Astronautique Budapest com. IAF 83-151 (1983).

I. DEPARTMENT OF ORTHOPAEDIC SURGERY AND TRAUMATOLOGY OF ERASME HOSPITAL, UNIVERSITE LIBRE DE BRUXELLES

Study of bone demineralization in microgravity

1. Realization of a simulation model on rats

An arthrotomy is realized on one knee of rats with a section of the ligaments. During the following 30 days, an overloading of the tibia of the healthy hind limb and an unloading of the controlateral tibia is obtained.

On this disuse osteoporosis model, the most performing techniques to evaluate bone demineralizations have been selected and improved before to be used to analyse bone samples collected from rats after orbiting on the Biocosmos flight at the end of 1983.

2. Preventive therapy

Using the same model, the effect of electromagnetic fields on bone metabolism is studied as a possible substitute for mechanical physiologic stimuli of 1 G environment.

3. "In vivo" bone strain measurements

The architectural and functional characteristics of bones can be considered the statistical consequence of the mechanical stimulation governing bone remodelling.

To obtain an objective measurement of bone strain variation in microgravity and in 1 G environment an implantable transducer is realized. Acute implantation on human and chronic implantation on dogs gave satisfactory results during ground exercises.

4. Publications

HINSENKAMP, M., Mechanical mediator of bone demineralization in weightlessness : a bioelectromagnetic hypothesis, In : Space Physiology, 1983 International Colloque from CNES, CEPADUES Ed. : 247-253, 1983.

HINSENKAMP, M., ROOZE, M., Morphological effect of electromagnetic stimulation on limb skeleton of the new born mouse, Acta Orthop. Scand., Suppl. 196, 39-50, 1982.

HINSENKAMP, M., SCHOUTENS, A., VERHAS, M., VERSCHAEREN, A., Rat model of tibial unloading and over-loading, In : Space Physiology, 1983 International Colloque from CNES, CEPADUES Ed. : 291-198, 1983.

ROOZE, M., HINSENKAMP, M., "In vitro" histochemical modifications induced by electromagnetic stimulation, Acta Orthop. Scand., Suppl. 196, 51-62, 1982.

J. DEPARTMENT OF NEUROPHYSIOLOGY, UNIVERSITY OF ANTWERP

The Spacelab 1 life-sciences experiment ES030 was a joint project between the Clinical Research Center at Harrow (U.K.), supported by the British Medical Research Council and the University of Antwerp Neurophysiology Laboratory, sponsored by the Belgian National Science Foundation (NFWO).

The purpose of the experiment was the continuous recording of the EKG (electrocardiogram) during the Spacelab 1 flight and the recording of the sleep patterns during the early and the later part of the flight with Medilog electrophysiological tape-recorders. Three parameters were recorded during sleep : the EEG (electro-encephalogram), the EOG (eye-movements) and the EMG (muscle activity).

In the evaluation of the Spacelab data two variables were to be taken into account : a 12 hr. time shift for the payload specialist (PS1) who carried out this experiment and zero gravity. Therefore, several baseline nights were recorded prior to flight (F) :

1. before the 12 hr. time shift : at F-120, -60, and -30 days.
2. after the shift : at F-5 days. A 12 hour time-shift started for PS1, two weeks prior to the launch, the rationale of it being that most of the biological rhythms take from one to two weeks to adapt to such a shift. After return (R), baseline nights were again recorded at R+2 and R+4, but we must bear in mind that the effects of return to gravity were cumulated with the effects of a return to local time, i.i. again a 12 hr time-shift. Only part of our requirements were fulfilled, i.i. the sleep parameters have been recorded in the early part of the flight only.

The rapid eye-movement sleep epochs (Rems) were perfectly clear and provided most of the information. The eye-movements of Rem-sleep have proven to be an extremely sensitive parameter of the brain-activity for their frequencies express the synergetic function of the brain indeed. The results of the SL1 experiment are currently being interpreted.

Appendix

- Belgian Institute for Space Aeronomy, Avenue Circulaire 3, B-1180 Brussels.
- Astrophysical Institute of the University of Liège, B-4200 Ougrée-Liège.
- Astrophysical Institute of the Vrije Universiteit Brussel, Pleinlaan 2, B-1050 Brussels.
- Department of Astrophysics of the State University of Mons, Avenue Maistriau 19, B-7000 Mons.
- Royal Observatory of Belgium, Avenue Circulaire 3, B-1180 Brussels.
- Royal Meteorological Institute of Belgium, Avenue Circulaire 3, B-1180 Brussels.
- Department of Metallurgy of the Catholic University of Leuven, de Croylaan 2, B-3030 Leuven.
- Department of Chemical Physics of the Université Libre de Bruxelles.
- Department of Orthopaedic Surgery and Traumatology of Erasme Hospital, Université Libre de Bruxelles.
- Department of Neurophysiology, University of Antwerp.