ISSN 0772 - 9804

SPACE RESEARCH IN BELGIUM 1984 - 1985

Report to COSPAR - meeting in Toulouse
France, 30 June - 12 July 1986

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 XXVIth Plenary Meeting of the Scientific Committee on Space Research (COSPAR) at Toulouse, France, 30 June - 12 July 1986.

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 institute participated in the experiments ES013 : Grille Spectrometer; ES016 : Solar Spectrum from 170 to 3200 nm and ES017 : Measurements of the Lyman-α emissions, which were performed during the flight of Spacelab One, launched on November 28, 1983 by the Nasa Space Shuttle "Columbia".

1.1. ES013 Grille Spectrometer

The infrared limb sounding grille spectrometer was flown successfully and the years 1984 and 1985 were essentially devoted to the interpretation of the results and to the preparation of a second flight of the instrument.

The ES013 grille spectrometer, a joint venture of the Belgian Institute for Space Aeronomy and the Office National d'Etudes et de Recherches Aéronautiques (France), was designed for several flights and its refurbishment proved to be a nominal operation. The instrument was brought back from Kennedy Space Center to the ETCA company in Charleroi where tests showed the same performance as before the flight. A visual inspection had confirmed the absence of mechanical damage. The instrument control and data management boxes were then opened and thoroughly checked while lifetime limited electronic components were replaced.The scientific programs, implanted in the experiment dedicated processor, were modified according to the experience gained in the first flight. A final test series proved the instrument to be ready for shipping back to Kennedy Space Center at the end of 1984. In 1985, the instrument was tested again in Kennedy Space Center and bolted on the Earth Observation Mission Spacelab pallet for further testing before flight.

Vertical distributions of minor constituents were published for NO, NO_2, CO, CO_2, CH_4, N_2O and H_2O. The data are not yet interpreted in the case of O_3, HF and HCl. Nitric oxide is observed as having two maxima of concentration, one in the mesosphere and the other in the stratosphere near 40 km. Carbon monoxide and carbon dioxide are observed up to the thermospheric altitude of 120 km. These results are in agreement with mass spectrometric data in the thermosphere, and balloon-borne instruments in the stratosphere; it has been shown that they can also be represented by theoretical models based on the interaction processes between solar ultraviolet radiation and CO_2 and on a set of different values of OH and CO number densities.

Water vapor has been found to present a rapid mixing ratio decrease above the mesopause in middle Northern latitudes and, as carbon monoxide, shows important variations with latitude. Modelling of the observed vertical profiles of H_2O is in progress.

The objective of the next flights will be mainly to perform new observations of the same constituents in the spectral intervals where the first flight has shown an optimal signal to noise ratio. These should constitute a complete geophysical program with a latitude and longitude coverage as wide as possible with emphasis on the polar regions. The inclination of the orbit will be 57° for the first EOM flight and most probably 28° for the second.

An extension of the program will be to propose the grille spectrometer for flight on the European Retrievable Carrier (EURECA). In the case of acceptance, a new instrument, designed for a six months working period will be built and coupled to an ultraviolet, a visible and a near infrared array spectrometer, developed in close cooperation with several other European investigators.

1.2. ESO16 : Solar Spectrum from 170 to 3200 nm

The "Solar Spectrum" experiment was integrated on the European bridge of the Spacelab pallet. Solar spectral observations were made on December 5 and 6, 1983, during the so-called full sunlit orbit. The altitude of the orbit was 250 km with an inclination of 57°. They lasted in total 13 hrs divided in two groups of respectively 7 and 6 hrs.

26 solar spectra were finally recorded from real time data and from playback of NASA tape recorder. Among those spectra, 7 were rejected because of atmospheric absorption. Indeed, the shuttle orbit was nearly above the terminator, between day and night, and the Sun did not set behind the earth. Unfortunately, for few so-called full solar orbits, the line of sight between the space shuttle and the Sun was passing through the earth's atmosphere. Consequently, strong absorption was occasionally observed, mainly in the ultraviolet. All spectra for which the tangent height of the line of sight was below 100 km were considered as unreliable for extraterrestrial spectral irradiance measurements because of possible atmospheric absorptions. The repeatability of undisturbed spectra was within $\pm$ 2 percent. Calibrations were performed with the blackbody at the Heidelberg Observatory. New irradiance values obtained between 200 and 360 nm with an accuracy of $\pm$ 5% are in good agreement with those published previously by the LASP rocket program and calibrated with respect to the SURF (NBS).

1.3. ESO17 : Measurements of Lyman-α emissions

This experiment is a collaboration between the Belgian Institute for Space Aeronomy and the Service d'Aéronomie du CNRS (France).

A spectrophotometer was flown on Spacelab 1 to study various mechanisms of Lyman-α emission in the upper atmosphere. The use of

absorption cells filled with H_2 and D_2 gases allowed the discrimination of a number of weak Lyman-α emissions heretofore masked by the strong atomic hydrogen geocoronal emission due to resonance scattering of solar photons. Three topics have been investigated during the mission. The first optical detection of atomic deuterium at 110 km altitude has an intensity of 330 rayleighs indicating an eddy diffusion coefficient of 1.3×10^6 cm^2 s^{-1}. Auroral proton precipitations are seen on both the night and the day side. An emission located above 250 km altitude outside the auroral region is tentatively interpreted as the result of charge exchange of magnetospheric protons with geocoronal atoms.

2. EURECA-ORA project

ORA is an occultation radiometer, which has been accepted by ESA (European Space Agency) for the first EURECA (European Retrievable Carrier) flight, scheduled in 1988.

EURECA is a European satellite, which will be launched by the shuttle and put into orbit at an altitude of about 500 km (orbit-equator angle ≃ 28°). After 6 months of flight EURECA will be retrieved and brought back to earth by the Shuttle.

The ORA radiometer will measure the solar radiation as absorbed by the atmosphere during sunrise and sunset, at 10 wavelengths. An inversion of the occultation data should allow the determination of profiles of water vapour, CO_2, NO_2, O_3 and aerosols in the mesosphere and stratosphere.

ORA is a collaborative program between the Belgian Institute for Space Aeronomy and the Department of Atmospheric Physics of the University of Oxford. The Belgian Institute for Space Aeronomy is responsible for :

- the complete mechanical design of ORA;
- the complete electronic design and
- the optics for 8 wavelengths in the visible part of the solar spectrum.

A breadboard electronics was realized during 1984-1985 and an engineering model (EM) is at present under construction in the Belgian company ETCA.

A prototype of the mechanical design has been vibrated and is now rebuilt, based on the results of this vibration test.

A prototype of the optics has also been tested and an engineering model of it will soon be realized.

The integration of the EM is foreseen in 1986. Its delivery to MBB-ERNO for integration tests on the Eureca carrier is scheduled for November 1986.

3. MAP/GLOBUS Campaign 1983

The major scientific objectives of this campaign were the accurate measurement of ozone and its short term variability, the determination of the NO_x family (NO, NO_2, NO_3, N_2O_5 and HNO_3) and the determination of other important trace species (such as H_2O, aerosols and ions).

This campaign was performed in September 1983 from Aire sur l'Adour (France). Major scientific results will be published in a special issue of Planetary and Space Science. The Belgian Institute for Space Aeronomy was involved in nitric dioxide and ozone measurements from stratospheric balloons. The main conclusions are the following :

1° Comparison between NO_2 mixing ratios measured from balloons shows some agreement between remote sensing technics on one hand and in situ

methods on the other. The two sets of data which agree at 20 km in the lower stratosphere are diverging at higher altitudes by a factor 2 around 27 km and a factor 4 around 33 km. The NO_2 column densities observed at sunset from the ground are in agreement with plane and balloon determinations, provided that the average mixing ratio below 16 km was indeed lower than 1.5×10^{-10}. The diurnal variation of the NO_2 column as determined from ground observations during the second half of September differs from the one seen in the stratosphere. A first comparison between NO_3 nighttime remote measurement and preliminary in situ results show a disagreement by a factor 2.

2° Remote sensing measurements of ozone in ultraviolet, visible and infrared domains performed in September 1983 by means of stratospheric balloons during the MAP/Globus campaign in France were carefully analysed. Comparison of data shows important aerosol contribution in the measured optical depth in the Chappuis bands giving overestimated inferred ozone concentrations for altitudes below 28 km. At higher altitudes discrepancies between remote sensing results and in situ soundings are difficult to explain.

4. MAP/GLOBUS Campaign 1985

Although observed for more than 10 years in the stratosphere the NO_x species photochemistry is far from being totally understood. This comes mainly from inaccuracies and contradictions in the experimental data set which do not allow the modelers to verify their simulations. A large effort has been made during the last 3 years to improve the situation. Multi-instrumented balloon flights and coordinated field campaigns have been organized in order to evaluate the results' accuracy. The Balloon Intercomparison Campaign (BIC) held in 1982 and 1983 in the United States, was a large international cooperative effort. It has provided a valuable step in the understanding of remote sensing instruments of all technics available today. Globus in the Middle Atmospheric Program frame which was held in 1983 in Europe, has provided significant results in NO_x in situ measurements evaluation.

The Globus NO_x campaign will take the benefit of the past efforts in order to make a new step in the NO_x understanding. Its goal is to obtain experimental information on total NO_x concentration in the stratosphere, on species diurnal variations, and on the partition between the species.

The campaign held in Southern Europe, in September 1985, at the CNES range of Aire sur l'Adour for the balloon flights, at Pic du Midi, Jungfraujoch, Haute Provence, Bordeaux and Biscarosse Observatories for ground measurements. More than 20 research groups supported by their national institutions in the United States, Japan and Europe were committed. The field observations will be pursued in 1986 by a cooperative effort with modelers for the interpretation of the results. Seven balloon flights were performed, divided in four groups. The first one included three correlated flights in order to cover nearly 24 hrs. of NO_x measurement at different altitudes. The data evaluation is in progress.

5. Stratospheric Ion Composition Measurements

The objective of this program is to determine positive and negative ion composition of the stratosphere between 20 and 45 km, through in situ measurements with balloon-borne ion mass spectrometers. The final goal of these measurements is to obtain a better understanding of the ion-molecule chemistry of the stratosphere and to deduce density profiles of trace gases such as acetonitrile (CH_3CN) and sulfuric acid (H_2SO_4), which play an important role in this chemistry. In the period 1984-1985 two activities were performed within the framework of this program, namely :

- continuation of the in situ measurements and
- study and interpretation of the previous results and comparison with model studies.

5.1. In situ measurements

Where previous in situ measurements had given an insight in the positive and negative ion composition between 20 and 35 km and between 42 and 45 km, a gap was still existing in the altitude region 35-42 km. To obtain data in this region a balloon flight was planned in 1984 with a 800,000 m^3 balloon. Due to technical problems encountered in ballooning techniques, this flight had to be replaced by one with a 350,000 m^3 balloon. It was realized on September 27, 1984 from the launching base of the Centre National d'Etudes Spatiales at Aire sur l'Adour (France). The valve controlled balloon reached a float altitude of 39 km and descended at 1.4 m s^{-1} to an altitude of 27 km. The payload consisted of three mass spectrometers; one built in a liquid helium cryopump and two built in liquid neon cryopumps. Performance of the liquid neon cryopumps was unsatisfactory; ion spectra were obtained at float altitude for a short time only. Performance of the third spectrometer was very satisfying and detailed positive ion spectra were obtained between the altitudes of 39 and 27 km. Analysis of these data bridged gaps in our knowledge of positive ion chemistry and trace gas distribution in the altitude range of 22 and 45 km.

5.2. Data Analysis and Model Studies

Negative ion composition data

The data on negative ion composition, obtained during balloon flights in the period 1982 and described in an earlier COSPAR report, have been analyzed more thoroughly. The study resulted in the deduction of a sulfuric acid vapour profile between 22 and 45 km and a better understanding of the negative ion chemistry.

Positive ion composition and model studies

One of the most striking results of the positive ion composition data is the detection of acetonitrile in the stratosphere.

In order to understand the obtained density profile of CH_3CN a model study of the behaviour of this molecule in the stratosphere was undertaken.

One of the major uncertainties in previous models being the reaction of CH_3CN with Cl atoms, an experimental study of this reaction was undertaken in collaboration with the Université Libre de Bruxelles. The result as well as new data on CH_3CN in the troposphere allowed to develop an updated model of CH_3CN. The calculated CH_3CN densities were used to develop a model for positive ion distributions between 15 and 50 km altitude, based on the most recent thermochemical and kinetic data. These ion abundances were compared with in situ results and the good agreement showed that the basic idea of CH_3CN being produced at the earth's surface and being destroyed by oxidation reaction with OH and O atoms in the atmosphere is most probably a good representation of reality.

6. Study of the ionosphere

a) Lower ionosphere theoretical study

Signal flow graphs theory developed several years ago for chemical reactions have been used to construct equivalent models for the negative ions - electron chemistry in the terrestrial D-region. The eleven negative ions model involving practically fifty chemical reactions has been reduced to a most practicable equivalent model containing only three equivalent species, the electron, the "mean" negative ion, the "mean" positive ion. Only five equivalent reactions are needed to describe exactly the behaviour of the three species. This equivalent model was used to describe and to simulate density fluctuations around the photochemical equilibrium.

b) Incoherent scattering theory in the D-region

The use of high frequency radars working as incoherent radars is a well-known technique to study the ionosphere and the atmosphere above 100 km. Nevertheless at D-region altitudes technical and theoretical problems are encountered by using this experimental technique. The technical problems are related to the low electron concentration. The most important theoretical problem comes from the experimental fact that the available power is much higher than the predicted one. If classical methods are used to convert the received power into electron density then this electron density can be two orders of magnitude higher than the actual value. The new incoherent scattering mechanism proposed by WISEMBERG and KOCKARTS (see Report to Cospar 1983) gives an explanation of this high power level. In order to explain the width of incoherent spectra with the theory it was shown that the negative ions chemistry organized the density fluctuations in the ionospheric medium in such a way that we have to take into account the effect of a new characteristic length. This chemical characteristic length strongly affects the width of the incoherent spectrum.

7. Study of the Magnetosphere

The formation of multiple plasmapauses has been explained in terms of a plasmasphere peeling off mechanism based on plasma interchange motion. The growth rate of this Rayleigh-Taylor type of instability driven by enhanced centrifugal force, has been shown to be limited by finite value of the integrated Pedersen conductivity in the mid-latitude ionosphere.

The smoothing and gradual disappearance of plasma density gradients is also shown to be limited by a maximum plasma interchange velocity which is inversely proportional to the minimum value of integrated Pedersen conductivity.

It has also been shown that a solar wind plasmoid, penetrating impulsively across a tangential discontinuity of the magnetopause, is decelerated adiabatically when it enters regions where the magnetic field intensity is increasing. As a result of grad-B, curvature drifts and polarization drifts, the electrons and ions in the plasmoid move in opposite direction and produce a polarization electric field which deflects the whole plasmoid in a direction opposite to the curvature drifts of the ions. The unexpected deflection observed for an AMPTE ion cloud is consistent with that predicted by the kinetic theory calculations.

8. Study of the solar wind

The modeling of current sheets is one aspect of the inter-disciplinary study of directional discontinuities in the solar wind with the future Ulysses mission. One of the objectives of this Inter-disciplinary Study is a detailed comparison of theoretical calculations with magnetic field and particle flux measurements. Preliminary computer simulations of the microscopic structure of a typical current sheet in the solar wind have shown that the theoretical thickness of these transitions is expected to be of the order of 20 proton gyroradii or less.

9. Planetary Insolations

The influence of global dust storms, characterized by various optical depths, on the mean seasonal daily insolations at the martian surface, has been studied as a function of latitude. The variations in the solar radiation distributions are important, mainly at the poles where e.g. the mean annual and summer daily insolations decrease by nearly a factor of 3000 as the optical thickness goes from 0 to 3. At equatorial latitudes the corresponding loss is much smaller, reaching a value of approximately 40. Concerning the mean wintertime solar

radiations it is found that the decrease is even more spectacular especially at high latitudes.

The insolation at Pluto backward and forward from the present-day epoch and also near the current one has been investigated. The calculations clearly demonstrate how the insolation on Pluto might considerably differ between the actual orbital configuration and alternatives in the past or in the future.

10. Publications

ARIJS, E. and BRASSEUR, G., Acetonitrile in the stratosphere and implications for positive ion composition, J. Geophys. Res., 91, 4003-4016, 1986.

ARIJS, E., NEVEJANS, D. and INGELS, J., Mass spectrometric measurements of stratospheric ions, Adv. Space Res., 4, 19-28, 1984.

ARIJS, E., NEVEJANS, D., INGELS, J. and FREDERICK, P., Recent stratospheric negative ion composition measurements between 22 and 45 km, J. Geophys. Res., 90, 5891-5896, 1985.

BERTAUX, J.L., GOUTAIL, F., DIMARELLIS, E., KOCKARTS, G. and VAN RANSBEECK, E. : First optical detection of atomic deuterium in the upper atmosphere from Spacelab 1, Nature, 309, 771-773, 1984.

BERTAUX, J.L., GOUTAIL, F. and KOCKARTS, G. : Observation of Lyman-α emissions of hydrogen and deuterium, Science, 225, 174-176, 1984.

BOSSY, L. and LEMAIRE, J., Geophysical and Solar Activity Indices, EOS, 65, 1237, 1984.

BRASSEUR, G., R. ZELLNER, A. DE RUDDER and E. ARIJS, Is hydrogen cyanide (HCN) a progenitor of acetonitrile (CH_3CN) in the atmosphere, Geophys. Res. Lett., 12, 117-120, 1985.

CORCUFF, Y., CORCUFF, P. and LEMAIRE, J., Dynamical plasmapause positions during the July 29-31, 1977 storm period : a comparison of observations and time dependent model calculations, Annales Geophysicae, 3, 569-579, 1985.

EBEL, A. and SIMON, P.C., IAGA/IAMAP Joint Symposium on the Middle Atmosphere, EOS, 65, 167-170, 1984.

FREDERICK, J.E., BLAKE, A.J., FREEMAN, D.E., NICHOLLS, R.W., OGAWA T. and SIMON, P.C., The penetration of ultraviolet solar radiation into the middle atmosphere. Conclusions and recommendations of MAP study group 7, MAP Handbook (ed. C.F. Sechrist, Jr.) 17, 109-111, 1985.

INGELS, J., D. NEVEJANS, P. FREDERICK and E. ARIJS, Stratospheric positive ion composition measurements between 22 and 45 km - An updated analysis, J. Geophys. Res., 91, 4017-4024, 1986.

KOCKARTS, G., VAN RANSBEECK, E., BERTAUX, J.L., DIMARELLIS, E. and GOUTAIL, F. , Mesure de l'hydrogène et du deutérium depuis Spacelab 1, Physicalia Mag., 6, 105-116, 1984.

LAURENT, J., LEMAITRE, M.P., BESSON, J., GIRARD, A., LIPPENS, C., MULLER, C., VERCHEVAL, J. and ACKERMAN, M., Middle atmospheric NO and NO_2 observed by means of the Spacelab one grille spectrometer, Nature, 315, 126-127, 1985.

LEMAIRE, J., Simulation of solar wind-magnetosphere interaction, pp. 33-46, in : Holtet, J. & Egeland, A. (Eds.), Morphology and dynamics of the polar cusps, D. Reidel Publ. Co., Dordrecht-Holland, 1984.

LEMAIRE, J., Formation and deformations of the plasmapause during a substorm event, pp. 239-260 in : Proceedings of the Conference on "Résultats du projet ARCAD 3 et des programmes récents en physique de la magnétosphère et de l'ionosphère", Toulouse 22-25 May 1984, Cepadues Ed., 1985.

LEMAIRE, J., Plasmoid motion across a tangential discontinuity with application to the magnetopause, J. Plasma Physics, 33, 425-436, 1985.

LEMAIRE, J., Frontiers of the plasmasphere, Thèse d'Agrégration de l'Enseignement Supérieur, UCL, 17 juin 1985, Ed. Cabay, Aeronomica Acta A, 298, 1985.

LEMAITRE, M.P., LAURENT, J., BESSON, J., GIRARD, A., LIPPENS, C., MULLER, C., VERCHEVAL, J. and ACKERMAN, M., Sample performance of the Grille Spectrometer, Science, 225, 171-172, 1984.

LIPPENS, C., MULLER, C., VERCHEVAL, J., ACKERMAN, M., LAURENT, J., LEMAITRE, M.P., BESSON, J. and GIRARD, A., Trace constituents measurements deduced from spectrometric observations on-board Spacelab, Adv. Sp. Res., 4, 75-79, 1984.

MULLER, C., Calculs du profil de Voigt appliqués aux raies infrarouges de la stratosphère et de la mésosphère, Bull. Acad. R. Belg., Cl. Sci., 60, 675-684, 1984.

MULLER, C., LIPPENS, C., VERCHEVAL, J., ACKERMAN, M., LAURENT, J., LEMAITRE, M.P., BESSON, J. and GIRARD, A., Expérience "Spectromètre à Grille" à bord de la première charge utile de Spacelab, J. Optics, 16, 155-168, 1985.

MULLER, C., VERCHEVAL, J., ACKERMAN, M., LIPPENS, C., LAURENT, J., LEMITRE, M.P., BESSON, J. and GIRARD, A., Observations of middle atmospheric CH_4 and N_2O vertical distributions by the Spacelab 1 grille spectrometer, Geophys. Res. Lett., 12, 667-670, 1985.

NEVEJANS, D., INGELS, J. and ARIJS, E., Measurement and identification of stratospheric ions with balloon-borne instruments, MAP Handbook, 15, Ballooning Techniques, edited by D.G. Murcray, Urbana (Ill.), pp. 124-138, 1985.

OLBREGTS, J., BRASSEUR, G. and ARIJS, E., Reaction of acetonitrile and chlorine atoms, J. of Photochem., 24, 315-322, 1984.

ROTH, M., A computer simulation study of a typical current sheet in the solar wind, in "The Sun and the Heliosphere in Three Dimensions", Proceedings of the XIXth ESLAB symposium, Les Diablerets, Switzerland, 4-6 June 1985, Edited by R.G. Marsden, Astrophysics and Space Science Library, D. Reidel Publishing Company, 167-171, 1986.

THUILLIER, G., GOUTAIL, J.P., SIMON, P.C., PASTIELS, R., LABS, D. and NECKEL, H., Measurement of the solar spectral irradiance from 200 to 3000 nm, Science, 225, 182-184, 1984.

VAN HEMELRIJCK, E., The influence of global dust storms on the mean seasonal daily insolations at the martian surface, Earth, Moon, and Planets, 33, 157-162, 1985.

VAN HEMELRIJCK, E., Insolation changes on Pluto caused by orbital element variations, Earth, Moon, and Planets, 33, 163-177, 1985.

VERCHEVAL, J., LIPPENS, C., MULLER, C., ACKERMAN, M., LEMAITRE, M.P., BESSON, J., GIRARD, A. and LAURENT, J., The ES013 Grille Spectrometer : a first space flight, Physicalia Mag., 6, 77-89, 1984.

VERCHEVAL, J., LIPPENS, C., MULLER, C., ACKERMAN, M., LEMAITRE, M.P., BESSON, J., GIRARD, A. and LAURENT, J., CO_2 and CO vertical distribution in the middle atmosphere and lower thermosphere deduced from infrared spectra, to be published in Annales Geophysicae (1986).

WISEMBERG, J., Influence des ions négatifs sur la diffusion incohérente d'une onde électromagnétique dans la région D de l'ionosphère terrestre, AERONOMICA ACTA A 302, 1985.

B. ASTROPHYSICAL INSTITUTE OF THE UNIVERSITY OF LIEGE

1. Space Telescope : Photon Detector Assembly (PDA)

During 1984, the PFM3 Model of the PDA (first spare unit) was calibrated after having been submitted to thermal vacuum cycle. It has been installed in the Faint Object Camera (FOC) in replacement of the PFM2.

Finally, in October 1985, the last model (second spare unit) PFM4 was also calibrated. This sequence was repeated in November, as the Focus conditions were not judged satisfactory.

During the last sequence, the very good response of this unit has been demonstrated.

2. Giotto Space Probe : Halley Multicolor Camera (HMC)

The contribution to the development of the Halley multicolor camera has been conducted in several areas.

The first one has been the improvement of the instrument called HMC space simulator. This instrument was built in order to :

- represent the attitude of the space probe relative to the comet; driven by a computer, it had to simulate different encounter schemes following appropriate cinematic and dynamic laws.
- calibrate the camera.

The second one was the verification of the performances and the calibration of the focal plane unit of the camera including narrow band

filters, two-dimensional CCD detectors and one linear detector. These tests have been performed on the flight model and flight spare unit in September 84 and February 85 respectively.

A third activity has been to remove the complete simulation system mentioned hereabove from its nominal location (IAL facilities) to the prime investigator laboratories (MPAE) to perform more easily extensive certification tests on the engineering model of the camera (from July to December 84). Finally, the models of the complete system (camera plus associated electronics) have been tested and calibrated under thermal vacuum conditions : the engineering model in May 84, the flight model in February 85 and the flight spare unit in May 85.

3. The Vacuum Optical Bench Focal

During the years 1983-1985 a new large vacuum optical facility was built.

Focal is a vacuum facility designed for the optical tests of large payloads.

To achieve these objectives, the following points have been considered :

- The speed of the operations for opening or closing the chamber, because some optical tests require only rough vacuum conditions to avoid air turbulence but frequent access to the tested device;
- Cleanliness of the chamber at low pressure by cryogenic pumping;
- Mechanical stability outside and inside the chamber : the payload is tested on an optical table supported by a seismic concrete block;
- Cleanliness of the room in two different stages : class 10,000 for the main room and class 10 in a small restricted area by a laminar flow wall.

The vacuum chamber is a cylindrical stainless steel vessel having 5 m diameter and 6 m length closed by two convex covers giving a useful length of 7 m. The vessel is pumped down by one liquid helium cryopump of 12,000 l/s integrated inside the chamber.

One optical table of 6,8 x 1,8 m is installed in the chamber, supported by six feet passing through the wall of the vessel and insulated from mechanical vibrations by bellows. The feet of the bench are fixed in a trussed concrete block of 350 tons. The vibration level reached on the bench is lower than 10^{-5} g.

Thermal facilities allowing to control 10 independent shrouds or groups of shrouds at 10 different temperatures are installed. The thermal fluid is nitrogen made by a mixture of hot gas (120°C) and liquid.

The temperatures of the tested payload are measured by 360 thermocouples and stored on computer.

Thermal vacuum test of the Hipparcos payload

The hereabove described facility has been used and will be used up to 1987 to test the Hipparcos payload.

The Hipparcos astrometry satellite requires a structural stability which is related to its objectives : define the relative position of 100,000 stars with an accuracy of 1 milliarcsec during 2.5 years. This goal implies mechanical stabilities which are also of the order of milliarcsec for the angles and tenth of nm for the distances between different optical components.

This stability is measured in a realistic vacuum thermal environment in Focal, making full use of the inherent stability of the facility.

4. Determination of the global distribution of thermospheric nitric oxide

Nitric oxide γ band profiles obtained with the UVNO experiment on board the Atmosphere Explorer-D Satellite have been analyzed to determine the vertical and latitudinal distribution of NO above 90 km. Assuming spherical symmetry of the distribution, an Abel inversion method is used and the concentrations are deduced between the South (summer) pole and approximately 60°N. The local time of the observations is confined to ~ 0900. These measurements may be considered as typical of solstice periods during solar minimum conditions.

The vertical distribution is characterized by a peak between 100 and 110 km but the shape of the NO profile is found to vary with latitude. More nitric oxide is obtained at high than at low latitudes and it is shown that the results are better organized in terms of geomagnetic rather than geographic latitudes. In particular, the presence of an E region maximum associated with the summer auroral zone is clearly illustrated. It was also shown that the contamination by the 214,3 nm doublet from the $N^+(^5S)$ state is negligible in the AE-D observations if the $N^+(^5S)$ quantum is as low as 5-10% as indicated by previous measurements.

5. Role of NO on thermospheric dynamics

The importance of the 5,3 μm nitric oxide cooling in the lower thermosphere has been investigated with a coupled two-dimensional dynamical-chemical model extending from pole to pole and from 70 km to the upper thermosphere. The odd nitrogen latitudinal distribution is

calculated consistently with the temperature and major constituent structures for the same geographical conditions as the AE-D observations. It is found that the NO infrared cooling competes with downward molecular diffusion in the upper thermosphere and reaches a maximum of ~ 500K/day near 170 km at high summer latitudes. The dynamical effect of the cooling is to reduce the latitudinal temperature gradient and the meridional and zonal wind velocities. Changes in the neutral concentrations are as predicted, especially near the summer pole.

6. Spacelab 3 observations

The first flight of the ATMOS instrument (Atmospheric Trace Molecule Spectroscopy) took place on board of Spacelab 3. Between April 29 and May 2, 1985, seven sunrises (near 50 degrees south latitudes) and thirteen sunsets (near 30 degrees north latitudes) were covered with this fast scanning Fourier Transform Spectrometer able to record the solar spectrum from 2 to 16 micrometers in the occultation mode, in one second. The series of spectra deduced from the interferograms allow to study the concentration of more than 30 species from 10 to 150 km altitude. As co-investigator to that program, the Institute of Astrophysics is currently involved in the analysis of the 0,015 cm^{-1} resolution spectra to deduce the concentrations versus altitude of the following molecules : $ClONO_2$, HO_2NO_2, CH_3Cl, HF, HCl, CH_4, COF_2, CF_4, $CFCl_3$, CF_2Cl_2, CHF_2Cl, CO, HNO_3 and O_3.

7. Stratospheric balloon observations

The University of Liège balloon instrument was launched for the 20th time from the National Scientific Balloon Facility, Palestine, Texas (USA). It provided excellent solar observations made in the occultation mode during the sunset of May 15, 1985 and the following sunrise. The main purpose was to measure the concentration of hydrochloric acid in the stratosphere while another payload from the Jet

Propulsion Laboratory, Pasadena, California (USA) measured ClO.

Besides HCl, the molecules HF, CH_4 and H_2O were observed; the analysis of the data is presently in progress and will provide concentration profiles for the mentioned molecules between 15 and 40 km altitude.

The results obtained during the international balloon intercomparison campaigns of 1982 (BIC1) and 1983 (BIC2) have been further intercompared and finalized; the observations have supplied inputs to a remote sensing observational effort regarding the molecules HCl, HF, H_2O, CH_4 and HNO_3.

8. Ground based observations

The Institute of Astrophysics of the University of Liège and the Royal Observatory of Belgium operate, since many years, a solar laboratory installed at the International Scientific Station of the Jungfraujoch (3580 meters altitude) in the Swiss Alps. The two main instruments of this laboratory are : a) a vacuum prism grating spectrometer used in a double pass arrangement with intermediate slit and now equipped for infrared observations (in the 1 to 5 micrometers domain, resolution 0,015 cm^{-1}); b) a Fourier Transform Spectrometer completed in 1984, allowing observations in the domains 1 to 6 and 6 to 13 micrometers with a resolution of 0,005 cm^{-1}.

Observations have been made with both instruments during the already mentioned first ATMOS flight, and regularly since then, in the frame of a collaboration with the J.P.L. to increase the accuracy of the air mass calibration of each ATMOS spectrum. The adopted scheme is to measure simultaneously N_2 and CO_2 lines from the Jungfraujoch, at various solar elevations and in different conditions of temperature and pressure. The N_2 lines equivalent widths give exactly the air mass

corresponding to each observation, and are used to calibrate the equivalent widths of CO_2 lines present in the ATMOS spectra.

The Jungfraujoch laboratory was also asked to participate, as ground support, to the 1983 and 1985 MAP/GLOBUS campaigns. Very good data on HF, HCl, CH_4, H_2O, O_3, NO_2 and N_2O were obtained with the grating spectrometer in 1983. In the September-October 1985 NO_x campaign, both Jungfraujoch spectrometers were used to measure N_2O and the diurnal variations of NO and NO_2.

9. Publications

CRAVENS, T.E., GERARD, J.C., LECOMPTE, M., STEWART A.I. and RUSCH, D.W., The global distribution of nitric oxide in the thermosphere as determined by the Atmosphere Explorer D Satellite, J. Geophys. Res., 90, 9862-9870, 1985.

GERARD, J.C. and EDENEYE, E.J.F., The transport of thermospheric nitric oxide into the mesosphere, Ann. Geophys., 2, 187-190, 1984.

GERARD, J.C., ROBLE, R.G., STEWART, A.I. and RUSCH, D.W., The global distribution of thermospheric odd nitrogen for solstice conditions during solar cycle minimum, J. Geophys. Res., 89, 1725-1738, 1984.

ZANDER, R., Observational aspects related to the evolution of our atmosphere, in aspects of chemical evolution. XVIIth Solvay conference on chemistry, April 23-24, 1980, G. Nicolis Ed., pp. 79-84, John Wiley and Sons, 1984.

ZANDER, R., A summary of the balloon intercomparison campaigns. Proc. Working Meeting "STRATOSPHERE", 1-12, A. Ghazi Edit., Commission of European Community, May 1984.

ZANDER, R., The University of Liège participation to the balloon intercomparison campaigns, Proc. Working Meeting "STRATOSPHERE", 13-24, A. Ghazi Edit., Commission of European Community, May 1984.

ZANDER, R., Theoretical interpretation of spectral measurements of trace gases in the 8 to 13 micrometers region, Proc. of the Symposium on Radiation in the Atmosphere, Perugia, Italy, August 1984.

ZANDER, R., Infrared atmospheric measurements from the ground, Proc. Nat. Bureau of Stand., Workshop on Atmospheric Spectra, Gaithersburg, Md., 1983, A. Weber Edit., pp. II-B21 to II-B32, CMA Publications, 1985.

C. DEPARTMENT OF ASTROPHYSICS OF THE STATE UNIVERSITY OF MONS

1. Solar soft X-ray spectra

Research on spectra of highly ionized ions has been pursued. The previously developed method of fitting synthetic to observed spectra has been applied to observations of non eruptive spectra of Mg XI obtained during rocket flights. This method enabled us to determine the electron temperature and ionic abundances in the emitting regions.

A detailed study of eruptive spectra of Ca XX obtained onboard the P 78 satellite (NRL, Washington) has been carried out in collaboration with Nice and Meudon groups. The observation-theory agreement is excellent for all the spectra. However the weak component of the Ca XX Ly alpha doublet is underestimated by theory. This is currently under investigation. The results of these computations have been applied to Mg XII for interpreting eruptive spectra obtained with the INTERCOSMOS 7 satellite. The variations of the intensity ratio of the Ly-alpha doublet components in Mg XII have been interpreted in terms of variable optical depths due to the non-spherical geometry of the emitting plasma.

2. A-type stars

In collaboration with the Vrije Universiteit Brussel and the Space Research Laboratory of Utrecht, more than 2550 absorption lines have been identified in the spectrum of α^2CVn. The spectrum was obtained during the ninth BUSS balloon flight.

3. Interstellar matter

The International Ultraviolet Explorer satellite provided more observations of early-type stars spectra of the Magellanic Clouds. It has been shown that O and B supergiants in the Large Cloud have smaller equivalent widths for Si IV 1400 Å and C IV 1550 Å lines than galactic supergiants of similar spectral type. The diffuse interstellar absorption band at 4430 Å is found in SMC stars having a strong ultraviolet 2200 Å feature as well as for stars having no 2200 Å feature. If the interpretation of the usual SMC interstellar extinction law in terms of a very small proportion of graphite grains is valid then this result suggests that the 4430 Å band is not directly associated with graphite. New IUE spectra have been obtained for the hot R Cr B star V348 Sgr. Spectrometric variations have been discussed.

4. Publications

BLANCHET, L., CORNILLE, M., DUBAU, J., LION, J. and VOLONTE, S., Di-electronic satellite spectra of Ca XX resonance lines in solar flares, Astron. Astrophys, 15, 417, 1985.

FAUCHER, P., VOLONTE, S., Improved effective rate coefficients for Mg XI and Ca XX, Astron. Astrophys., 135, 152, 1984.

HECK, A., HOUZIAUX, L., MANFROID, J.N., JONES, D.H.P. and ANDREWS, P.J., Photometric variations of the irregular variable V348 Sgr., Astron. and Astrophys. Suppl. Series, 61, 375-385, 1985.

HENSBERGE, H., VAN SANTVOORT, J., VAN DER HUCHT, K.A., MORGAN, T.H., The mid-ultraviolet spectrum of α^2C Vn = HD 112413 = HR 4915, Astron. Astrophys., in press.

HOUZIAUX, L., NANDY, K. and MORGAN, D.H., The interstellar 4430 A band in the small Magellanic Cloud, Monthly Notices of the Royal Astron. Soc., 215, 5P-9P, 1985.

NANDY, K., THOMPSON, G.I., MORGAN, D.H. and HOUZIAUX, L., Spectrophotometry of early-type supergiants in the large Magellanic Cloud, Monthly Notices R. Astron. Soc., 210, 131-139, 1984.

STEENMAN CLARK L., BELY-DUBAU, F., FAUCHER, P., LOULERGNE M., VOLONTE, S., Analysis of high resolution solar Mg XI X-ray spectra, Physica Scripta, T7, 67, 1984.

SYLVESTER, B., FAUCHER, P., JAKIMIEC, J., VRUTOV, V.V., McWHIRTER, R.W.P., SYLVESTER, J., TOMEZAK, M., VOLONTE, S., ZHITNIK, I.A., Investigation of the Mg XII 8.42 Å doublet in solar flare spectra, Solar Phys., accepted in November 1985.

D. ROYAL OBSERVATORY OF BELGIUM

Space Geodesy - Earth Rotation

1. Observations

The Royal Observatory of Belgium has a tracking station of the NNSS TRANSIT satellites currently used for terrestrial navigation, monitoring of the polar motion and deployment of geodetic networks.

The station is part of the TRANET network managed by DMAHTC (Defense Mapping Agency Hydrographic and Topographic Center). In 1984 the station was completely automated with the support of a PDP computer.

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

Type of satellite	Number of passes	Objectives
TRANSIT	17159	Polar motion Support to geodetic networks Earth gravity field
BEACON	4397	Earth gravity field

2. Analysis

- The Royal Observatory of Belgium is part of the European Consortium taking in charge the analysis of the African Doppler campaign (ADOS) organized by the Commission "International Coordination of Space Techniques for Geodesy and Geophysics (IAG and Cospar). Coordinates of 98 sites were computed in 1984 and 150 in 1985.

- On the basis of the observations of the TRANSIT satellites performed in Brussels, the station coordinates were recomputed from each consecutive 10 days of observation.
- The Earth pole position, as determined from different techniques during the dedicated campaign of observation MERIT, has been investigated.
- A review of the TRANSIT and GPS systems has been given as well with a description of the software implemented at the Royal Observatory.
- In collaboration with several European groups, the Royal Observatory participates in the definition of a Solid Earth space mission expected to be sponsored by the European Space Agency.

3. Publications

PAQUET, P., Les systèmes TRANSIT et GPS, Navigation et localisation de précision, Mathématiques spatiales pour la préparation et la réalisation de l'exploitation des satellites, Obs. Roy. de Belg., Com. Ser. B-132, Ser. Geophys. 146, 1984.

PAQUET, P., Past and future of space radioelectric measurement, Geodesia, N° 85-3, 1985.

PAQUET, P., BOUCHER, C. and CRITCHLEY, J., ADOS computations (30 June 1984), Progress report of the European Consortium, Bulletin of the Commission for Space Techniques and Geodynamics (IAG), N° 7, Dec. 1984.

PAQUET, P., DJUROVIC, D., TECHY, C., Agreement in polar motion measurements during the Merit Campaign, Proceed. of the MERIT Workshop, Ed. I. Mueller, Ohio State University, 1985.

PAQUET, P, VERBEIREN, R., DEHANT, V., Résultats des observations Doppler effectuées à Uccle de 1972 à 1983, Bull. Astron. Obs. Roy. de Belgique, Vol. IX, N° 6, 1984.

E. ROYAL METEOROLOGICAL INSTITUTE OF BELGIUM

1. Atmospheric Ozone Monitoring

1.1. Remote ozone observations from the ground

During the whole period daily measurements of the reduced height of the ozone layer were performed by means of a Dobson spectrophotometer and a partially automated Brewer spectrophotometer. The results are regularly published in "Ozone Data for the World" by the Atmospheric Environment Service in Canada.

A spectral analysis of the time series of ozone observations at Uccle and Arosa revealed several hitherto unpublished highly significant periodicities in the range from about 15 days to one year. The results were prepared for publication.

1.2. Balloon-borne in situ ozone observations

Due to a severe cut in the funds, the program for routine ozone soundings was still interrupted in 1984 and only started again in February 1985.

On the other hand additional soundings were performed for a validation program of the Stratospheric Aerosol and GAS experiment (SAGE II) aboard the ERBS satellite. However, no correlative studies have been made up to now, because the exchange of SAGE II data has not yet started.

In November 1984 and April 1985 the ozone sondes were also used to offer complementary parameters (ozone concentration, temperature,

geopotential) for an experiment of the Belgian Institute for Space Aeronomy dealing with photographic observations of stratospheric aerosols.

All the ozone measurements that were made at Uccle during the MAP/GLOBUS measuring campaign in September 1983 were analysed and will be integrated in two joint papers.

A study was made about systematic distortions of ozone profiles measured with electrochemical ozone sondes and the way in which these distortions can be taken into account : by deconvolution of the ozone profiles, correction for the change of air temperature inside the sampling pump and correction for the change of sensitivity of the sensor. The results of this study were published.

2. Ionospheric remote observations

Beside the traditional vertical sounding operations and the real time evaluations of some ionospheric parameters, the external Geophysical section proceeded during 1984 with an international campaign of transatlantic oblique soundings started at the end of 1983.

During November 1985, a new system called ARTIST was put into operation. It uses the powerful computation capability of an up to date personal computer (IBM AT) to overcome the human factor by a complete software real time processing of the sounding results. The ionospheric electron density profile is available in one minute after the sounding has been completed. This feature with the remote data transfer and remote control, opens a new era for the Dourbes station.

3. Solar constant and earth's radiation budget

The value of the solar constant observed by the 1ES021 experiment on Spacelab 1 on 8th December 1983 is 1361,5 $\pm$ 2,3 Wm^{-2}.

The experiment 1ES021, refurbished to be flown on the Earth Observation Mission 1, has now been rebuilt to improve its data acquisition accuracy and resolution.

It will contain a dedicated processor to manage the operations of the experiment and the interface with the spacecraft. It has also been provided with two highly stabilized Sun photometer channels.

The new version of experiment 1ES021 (SOLCON) will be delivered to NASA at the beginning of 1986 for the flight of EOM 1/2.

The observation of the solar irradiance as well as Sun oscillations and variations will also be performed from the EURECA platform as a collaboration between the Royal Meteorological Institute, the World Radiation Center Davos and the Space Science Department of ESA.

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

3. Publications

AHMED, M., REINISCH, B., BIBl, K., SOICHER, H., GORMAN, F., JODOGNE, J.C., BOSSY, L., KING, J. and GILBERT, J., A transatlantic digital HF radio links experiment, Proceedings of a Symposium on the effects of ionosphere on C^3I Systems, 1984, Editor J. Goodman, Naval Research Laboratory, Washington, D.C. 20375.

CROMMELYNCK, D. and DOMINGO, V., L'expérience 1ES021 "Constante solaire" sur Spacelab 1, Physicalia Magazine, 6, pp. 117-131, 1984.

CROMMELYNCK, D. and DOMINGO, V., Solar irradiance observations, Science, 225, pp. 180-181, 1984.

CROMMELYNCK, D. and DOMINGO, V., Observation of the solar constant during the first flight of Spacelab 1, W.M.O., Instruments and Observing Methods Nr. 15, Noordwijkerhout, Netherlands, 1984.

DE MUER, D., Vertical ozone distribution over Uccle (Belgium) after correction for systematic distortion of the ozone profiles, Atmospheric Ozone, pp. 330-334, D. Reidel Publishing Company, Dordrecht, 1985.

DE MUER, D. and MALCORPS, H., The frequency response of an electrochemical ozone sonde and its application to the deconvolution of ozone profiles, J. Geophys. Res., 89, 1361-1372, 1984.

REINISCH, B., BIBL, K., AHMED, M., SOICHER, H., GORMAN, F. and JODOGNE, J.C., Multipath and Doppler observations during transatlantic digital HF propagation experiments, Proceedings nr. 363 of AGARD Symposium, p. 12-1 to 12-11, 1984.

F. DEPARTMENT OF METALLURGY AND MATERIALS ENGINEERING OF THE CATHOLIC UNIVERSITY OF LEUVEN

Melting and solidification of metallic composites

This work aims at contributing to a better control of the melt metallurgical manufacturing of composite materials, in which ceramic or metallic particles are combined with a metallic matrix into a macroscopically homogeneous structure.

The transport mechanisms of the particles (sedimentation, flotation, convection) have been studied on the systems Al-Al_2O_3, Al-SiC, Cu-Al_2O_3, Cu-SiO_2, Cu-SiC, Cu-W and Cu-Mo both at 1 g and at the reduced gravity in space vehicles (SPACELAB, TEXUS).

Most starting materials for this study of the phenomena in metallic suspensions were made by powder metallurgy, because a well defined initial state was obtained in this way. The volume fraction of the dispersed phase was kept low.

Experiments performed in SPACELAB 1 (SL 1) and TEXUS 9 have shown that, provided the boundary conditions imposed by interfacial energy requirements are fulfilled, it is possible to fabricate homogeneous composites in space.

During the SL 1-mission six particulate composites with Al-matrix were melted, held during 40 min. at 800°C and solidified in the Isothermal Heating Facility (experiment 1ES 315/1). In comparison with the ground processed reference samples it appears that the space processed samples are much more homogeneous, both in the case of coarse and of fine dispersed particles. This higher homogeneity naturally leads

to an important increase of the uniformity of the macro-Vickers hardness. It also appears that the abrasive wear resistance of the Al-SiC composite after melting and solidification in space is as good as in samples prepared by powder metallurgy. The particle rearrangements in the 1 g-reference and the µg-samples can be explained on the basis of interfacial energy considerations beside sedimentation and convection.

During the TEXUS 9 experiments, it was shown that a liquid copper matrix with 0,5 vol % molybdenum particles can remain stable, provided a longitudinal thermal gradient is present in the sample.

Finally during the D1-SPACELAB mission six copper based composites were melted and solidified. The evaluation of these samples is still in progress.

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

1. Marangoni Convection around a surface tension minimum

In the Texus 9 experiment performed in May 1984, the geometry of the cell was the same as for the experiment Texus 8 performed in 1983. The liquid was an aqueous solution of heptanol 6.10^{-3} m presenting an air/liquid surface tension minimum at 40°C (T min).

The imposed temperatures were 35 and 50°C, respectively lower and higher than T min. The expected "opening" of the interface has not been observed. The recorded motions are slow and located in the hot part of the observation volume. Differential interferometric measurements indicate that the convection is not oscillatory.

The evaluation of the results obtained during the D1 Spacelab mission in November 1985 is under progress. During these experiments the Marangoni convection in a heptanol solution was studied. The long duration of the experiment allows to study steady state in contra-distinction with the Texus experiments.

Preparation of a Texus 13 experiment to be launched in May 1986 is progressing.

2. KC 135 Parabolic flights

A. Flights on 13-14 December 1984

During this mission 40 parabolic trajectories providing µg periods of 30 s were performed. Various simple and qualitative experiments have been realized related to :

i. antiwetting properties of Teflon coated surfaces used as anti-creeping barriers (coatings by Fluomicron Coatings, Antwerp) against water, water + dodecylammonium chloride, liquid parafine;

ii. stability of large flat liquid/gas interfaces;

iii. crystallisation or organic compounds;

iv. possibility to create a flat liquid/gas interface in a volume previously partly filled under normal gravity conditions;

v. cells to be used in the Fluid Physics Module during the D1 mission have been tested.

B. Flights on June 28 and July 1, 1985

During these 40 parabolic trajectories, experiments on wetting and thermocapillary motions were performed :

i. creation of liquid/gas interfaces by the sliding of a non wetted cover was realized with success;

ii. preliminary studies of the Bénard instability problem have been performed in the perspective of the D2 mission
   - with a flat geometry
   - on a sphere

iii. improved experiments were performed to study gaseous bridges created in a liquid phase.

3. Soret Coefficient Measurement

The Soret coefficients of 20 different liquid binary mixtures will be measured during the long duration flight of the EURECA 1 platform. (SG 123 experiment). This mission is planned for March 1988.

The Soret coefficient measures the proportionality between the imposed gradient of temperature and the gradient of concentration induced in a binary system. The establishing relaxation time of this

phenomenon is very long and slow convective motions can deeply influence the concentration distribution.

The small residual microgravity level during the EURECA 1 mission will allow to eliminate the perturbating motions induced by buoyancy, and then to allow the measurement of Soret coefficients with high accuracy.

4. Publications

LEGROS, J.C., Convection, tension superficielle, microgravité, Acad. Royale Belg., Bull. Classe des Sciences (to be published).

LEGROS, J.C., LIMBOURG-FONTAINE, M.C., Liquid/gas interfaces under microgravity conditions, ESA Journal (to be published).

LEGROS, J.C., Problems related to non linear variations of surface tension, Proc. 36th Congress IAF, 1985 (Stockholm).

LEGROS, J.C., GOEMAERE, P. and PLATTEN, J.K., The Soret coefficient and the two-component Bénard convection in the benzene-methanol system, Phys. Rev. (A), 32, 1903-1905, 1985.

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, 143-147, 1984.

LEGROS, J.C., PETRE, G. and LIMBOURG-FONTAINE, M.C., Convection thermocapillaire en apesanteur, Revue IRE, 9, 20, 1985.

LEGROS, J.C., PETRE, G. and LIMBOURG-FONTAINE, M.C., Study of the Marangoni convection around a surface tension minimum under microgravity conditions, Adv. Space Res., 4, 37-41, 1984.

LEGROS, J.C., PETRE, G., LIMBOURG-FONTAINE, M.C., VILLERS, D. and PLATTEN, J.K., Thermocapillary convection around a surface tension minimum : a microgravity experiment (Texus 8) and numerical simulation, ELGRA News, 6, 41-49, 1984.

LIMBOURG-FONTAINE, M.C., PETRE, G. and LEGROS, J.C., Texus 8 experiment: effects of a surface tension minimum on thermocapillary convection, PCH, 6, 301-310, 1985.

LIMBOURG-FONTAINE, M.C., PETRE, G., LEGROS, J.C. and VAN RANSBEECK, E., Thermocapillary movements around a surface tension minimum under microgravity conditions. I. Technical description of the STEM experiments (D1 Spacelab mission), Acta Astronautica, 13 (to be published).

PETRE, G., LIMBOURG-FONTAINE, M.C. and LEGROS, J.C., Preliminary results of Texus 8 experiments on effects of surface tension minimum, Acta Astronautica, 12, 203-206, 1985.

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

Study of Bone Demineralisation in Microgravity

1. Introduction

The effect of the local mechanical environment on bone remodelling was observed by Wolff in 1892 and scientifically demonstrated from that time. Microgravity produces a quite original situation in which the weightbearing bones are relieved from the weight of the body. The only remaining forces acting on bone are the ones due to the muscular traction required for joint mobilisation or stabilisation almost without any restraints.

Indirect techniques such as calcium balance, bone densitometry, etc. have shown that microgravity produces bone demineralization mainly localised on weightbearing bones.

It is impossible to simulate microgravity on earth to reproduce an equivalent restriction of bone strains. Also the brief period of microgravity allowed by the parabolic flights are not sufficient for muscular reconditioning and proprioceptive control which could also be disturbed by cerebellar reequilibration.

The study of bone demineralization in microgravity will allow us to realize a dosimetry of the mechanical strains on bone and to determine preventive treatment of bony losses which could endanger the mechanical resistance of the skeleton after prolonged flight (more than 6 months). This is fundamental to the knowledge of bone remodelling and will have multiple clinical applications.

This aim requires two different approaches : (1) an etiological study implying the measurements of the modification of bone strains, both quantitatively and qualitatively during one week's flight and (2) a phenomenological study requiring the analysis of the modifications of the bone structure itself, which needs at least two or, ideally, three weeks flight.

2. On Ground preliminary Studies

2.1. "In vivo" bone strain measurements

Two bone strain transducers were realized. One is designed for short term experimentation and for human tibial implantation. The second is designed for long term implantation in animals. Both transducers were already implanted in humans and animals on earth and have allowed satisfactory measurements. General agreement has been reached with ETCA to realize the conditioning and the interface of the recording instruments for the space flights.

2.2. Study of bone remodelling on simulation model

Up to now rats were the only animals used to study bone alterations in space. We designed a simulation model of disuse osteoporosis using this animal. The best performing techniques to evaluate bone demineralization were selected and improved on this model before being used to analyse bone samples collected after orbiting in microgravity.

2.3. Preventive therapy

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

3. Study of bone remodelling after space flight

Macroscopical, histological and biomechanical studies of tarsal and metatarsal bones from 7 rats which flew on Cosmos 1667 and from 3 control groups of 7 rats each are presently being carried out.

4. Organisation of Congress

The first International Congress devoted to "The Gravity Relevance in Bone Mineralization Processes" was organized by the Department of Orthopaedic Surgery and Traumatology of the University Hospital Erasme from 18 to 20 th January, 1984. It was sponsored by ESA as a workshop, with a multidisciplinary participation of 76 international specialists on bone physiology and biomechanics. A large consensus of the biomechanical hypotheses appeared.

5. Publications

BOURGOIS, R., BURNY, F. and HINSENKAMP, M., Evaluation of the gravity relevance of bone stresses by "in vivo" measurements, in : The Gravity Relevance of Bone Mineralization in Weightlessness, ESA.SP-203, 47-52, 1984.

HINSENKAMP, M., Electromechanical hypothesis of bone demineralization in weightlessness, in : The Gravity Relevance of Bone Mineralization in Weightlessness, ESA.SP-203, 53-58, 1984.

HINSENKAMP, M., Structure osseuse et microgravité, in : Life Sciences Research in Space, ESA.SP-212, 209-214, 1984.

VERHAS, M., HINSENKAMP, M., DOUROV, N. and SCHOUTENS, A., Animal models of disuse osteoporosis, in : The Gravity Relevance of Bone Mineralization in Weightlessness, ESA.SP-203, 79-81, 1984.

APPENDIX

A. Belgian Institute for Space Aeronomy, Avenue Circulaire, 3, B-1180 Brussels.

B. Astrophysical Institute of the University of Liège, B-4200 Ougrée-Liège.

C. Department of Astrophysics of the State University of Mons, Avenue Maistriau, 19, B-7000 Mons.

D. Royal Observatory of Belgium, Avenue Circulaire 3, B-1180 Brussels.

E. Royal Meteorological Institute of Belgium, Avenue Circulaire, 3, B-1180 Brussels.

F. Department of Metallurgy and Materials Engineering of the Catholic University of Leuven, de Croylaan, 2, B-3030 Leuven.

G. Department of Chemical Physics of the Université Libre de Bruxelles.

H. Department of Orthopaedic Surgery and Traumatology of Erasme Hospital, Université Libre de Bruxelles.