Space Research

2000 – 2001

in Switzerland

Sounding rocket (Kiruna, Sweden)

Schweizerische Akademie der Naturwissenschaften SANW
Académie suisse des sciences naturelles ASSN
Accademia svizzera di scienze naturali ASSN
Academia svizra da las scienzas natiralas ASSN
Swiss Academy of Sciences SAS

Contents

I Introduction

The Committee for Space Research of the Swiss Academy for Natural Sciences coordinates and stimulates space research in Switzerland. It also maintains contacts with international organisations and in particular with ESA's science programme and COSPAR. It produces every second year a report on space science activities in Switzerland. This booklet contains this report for the period 2000-2001.

As Switzerland has no national space programm, most of its space activities are routed through the European Space Agency (ESA). ESA inspires the vision for Europe's future in space and, through a diverse range of programmes, develops the strategies needed to see it realised. As a founder member of ESA, Switzerland is strongly involved in these programmes and thanks to this participation the Swiss science and space technology is very competitive. For their research the Swiss scientists develop sophisticated instruments, software or they use existing instruments or archives of different missions. All these space science activities are performed in the framework of a board international cooperation.

Space reasearch in Switzerland is undertaken by many groups in the universities, federal institutes of technology and some private companies. The funding for this research comes mainly from these institutions, but also from the Swiss national science foundation and the federal governement. The research is not organised centrally, it is rather the sum of the efforts of the individual groups. It is hoped that the present report will give to the readers an idea of the richness of this research branch and help them to identify the actors in Switzerland.

From the general point of view, the space science activities, from universe and solar system exploration to earth observation in passing by material and life sciences in microgravity, are for Switzerland very important elements of its science policy. Beyond their scientific objectives, these activities are also wonderful technology development drivers. Thanks to ESA science programmes Swiss scientists have been able to take part in very ambitious missions. In this highly competitive and demanding sector, both basic and applied research take on great significance.

The bulk of the report is given by a number of contributions from individual research groups from many institutions in Switzerland. Each has reported on their own research projects. These reports are expected to give the readers enough information to find the projects of interest to them and to locate the main institutes involved in Switzerland. Further information can be sought from the quoted literature or directly with the involved groups. The scattered nature of our space activities and the sometimes fuzzy boundaries of the subject also make it difficult to be complete in this report. Readers in Switzerland who may find that their activity was missed are invited to contact the commission for space research, c/o ISDC, 16,ch d'Ecogia, CH-1290 VERSOIX.

The entries in the report reflect the individual projects. Readers must be aware that single reports may cover projects of very different scopes, from the analysis of a set of data to the development of an instrument or large fraction thereof or to the development of a whole data centre. The length of an entry is in no way to be used as a measure of the magnitude of a project.

The nature of the report, distributed in a large number of entities, reflects the structure of the community, scattered in many groups and projects with loose connections. This is a strength in that it lets the richness of many initiatives develop, it is also a weakeness in that it makes the emergence of large coordinated efforts difficult. In the field of space science, where satellites are always large projects (measured by a small national community), care must be brought to not scatter too much our efforts. The Swiss community is considering this very question at the time of writing of this report.

Information on addresses of individuals and institutions may be obtained from the Swiss Space Office, Hallwylstrasse 4, CH-3003 BERNE.

1.1 Astrophysics, Solar System Planets, Magnetosphere and Material Science Research

This research activities cover a wide range of projects from astronomy in all wavelengths, the study of comets, of the Sun and the interplanetary medium, of the Moon and Mars. For astronomy, Swiss scientists use coherently and efficiently as well ground based facilities as space instruments. Most of space project are implemented within the ESA science programme (Herschel, Planck, Integral, Soho, Rosetta, Mars Express, etc.). There are also groups which have developed collaborations out of the frame of ESA programme or missions. In addition to that, we have to mention two space centres in Switzerland. One is the International Space Science Institutes (ISSI) in Bern which has developed its successful activities around the interdisciplinary interpretation and in depth studies of data from multi-experiment, multi-spacecraft programmes. The other one is the Integral Science Data Center (ISDC). Located close to the Geneva Observatory, the ISDC is the world data center of the imaging and spectroscopy gamma ray astronomy satellite of ESA Integral. The Swiss scientists will also make use of the International Space Station (ISS) for experiments like SOVIM (PMOD Davos), ACES (Neuchâtel Observatory) or AMS (Geneva University). They will be placed on board of the ISS few years from now.
The diversity and requirement of projects where Swiss scientists are involved, sometimes in collaboration with Swiss industry, allows them to push back the limits of their knowledge and their technical skill. Moreover they also play an important role for the formation of young engineers and scientists.

1.2 Earth Observation Research

The Swiss Actors in the Earth Observation field are collaborating with agencies, institutes, laboratories, museum, research centres and companies within Switzerland and around the world. These activities can be grouped under the following areas :

- the basic research with technical and preparatory studies for the development of new techniques of extraction of information from existing data, or the creation of virtual reality in 3D landscape;
- the research activities for real time near real time application. Faster processing is a clear objective as is the technology transfer from University to value added companies. The pre-operational or prototype systems thus created carry often the potential for real operational services;
- the operational applications and services. The objective is to develop an operational product and service or continue to offer such service. Some of them have good commercial prospects, other serve world-wide research communities;
- the instruments development;
- and finally the ASAR expert support laboratory (RSL).

1.3 Microgravity Research

The International Space Station is today a reality but the assembly operations have temporarily limited the flight opportunities for experiments in weightlessness and reduced the Swiss participation in ESA-NASA programmes. Nevertheless, the Swiss scientists have taken benefit of other facilities like the sounding rockets to perform their experiments mainly in life sciences.

II Astrophysics

2.1 Cryogenic Receivers for the HIFI Spectrometer

Institute / Laboratory	**:**	Institute of Astronomy, ETH Zurich
In cooperation with	*:*	SRON, Groningen, The Netherlands
Principal Investigator	**:**	Th. de Graauw
Co-investigators	**:**	A. O. Benz and W. Baechtold (ETHZ)
Field of research	**:**	Astrophysics

Method

Development and construction of own instruments :

Construction of development model of the Common Optics Assembly. Low noise and low power amplifiers (HEMTs) and assembly box for intermediate frequency amplification.
Satellite

Purpose of research

The HIFI instrument on HERSCHEL (forth cornerstone of ESA) will measure spectral lines of cosmic molecules in the range 150 to 800 microns, a wavelength range that cannot be observed from Earth.

The satellite will be located far away from Earth and have the advantage of zero contamination by terrestrial water and oxygen absorption. It will be ideal to search for water in star forming regions and protoplanetary accretion disks and for molecular lines in regions of the spectrum that are inaccessible from the ground.

Time-line from to

Planning	=>	1999 - 2000
Construction	=>	2000 - 2005
Measurement phase	=>	2007 - 2011
Data evaluation	=>	2007 - 2020

Actual status

The project has been accepted as a Swiss PRODEX contribution to HERSCHEL in 1999. The development of HEMT amplifiers at ETH (Microwave Lab.) has started. The demonstration model of the IF2 Box containing amplifiers, isolators and other devices has been developed and tested. It will be delivered to the principal investigator (SRON) in April 2002.

The designs of the Common Optics Assembly and Mixers Assemblies have started at TPD (Delft, Netherlands) and SRON with contributions from ETH (Inst. Astronomy). An ITT for construction in Swiss industry of the cryogenic qualification model has been issued by ESA in mid March 2002. Actual construction in industry will start after April 2003.

Phase B of our contribution will finish in February 2003, when the development model of the Common Optics Assemply will be delivered to SRON.

Abbreviations

HIFI	=	Heterodyne Instrument for the Far Infrared
HEMT	=	High Electron Mobility Transistor
SRON	=	Space Research Organization of the Netherlands

2.2 Symbiotic Binaries

Institute / Laboratory	**:**	Institute of Astronomy, ETH Zürich	
Principal Investigator	**:**	Prof. H. Nussbaumer	
Co-investigators	**:**	Dr. T. Dumm Dr. H. Schild Dr. R. Walder Dr. D. Folini Dr. Brian Espey Dr. Stephan McCandliss	Dr. Peter Hauschildt Prof. Henny Lamers Prof. Francis Keenan Prof Gary Ferland Mr. Travis Barman
Field of research	**:**	Astrophysics	

Method

Research based on direct observations with existing instruments or retrieval from the archives :

ISO, HST, IUE, FUSE. We also heavily rely on ground based telescopes at ESO.

Purpose of research

We study symbiotic binary systems. Mass exchange and stellar radiation are the crucial processes of interaction. Heavy mass-loss is certain from the cool giant, and it is also observed in some of the hot white dwarf companions. Mass-loss is detected either directly as a stellar wind, or it manifests itself in the nebular environment. We study the physical properties of the stellar atmospheres, the rate and mechanisms of stellar mass loss, the processing of dust in the interaction zone and the fate of the matter lost. As mass loss may occur on both stars, we are faced with the hydrodynamical problem of colliding winds and their shock zones, and in some cases there may be mass-accretion on the white dwarf from the wind of the red giant. The study of the corresponding physical properties and processes demands observationally a wide wavelength coverage, space observations are therefore crucial.

Actual status

Symbiotic stars contain a red giant and an active white dwarf. The interaction of both winds creates a highly structured nebular environment. Because of the wide range of temperatures, from dust (at around 1000 K) to high temperature wind-wind collision fronts (higher than 1'000'000 K), we need to cover the spectral domain from X-Ray to the infrared. The red giant and dust envelope is studied preferentially with ISO and from ESO ground based telescopes, whereas the hot companion as well as the nebular structure are studied with observations from IUE, ORFEUS, ISO, and HST. We have been successful with an application for observing time on HST for the observing cycle 9 (8 primary orbits) and cycle 11 (18 primary orbits), as well as for observing time on FUSE for observing cycle 2 and cycle 3.

Three most relevant publications

1. Sion E. M., Mikolajewska J., Bambeck D., Dumm T., 2002, AJ 123, 983 :
   An IUE and HST.

   Archival Study of the Hot White Dwarf in the Symbiotic Variable RW Hydrae.

2. Schild H., Dumm T., Mürset U., Nussbaumer H., Schmid H. M., Schmutz W., 2001, A\&A 366, 972 :
   High resolution spectroscopy of symbiotic stars.

   VI Orbital and stellar parameters for AR Pavonis.

3. Dumm T., Folini D., Nussbaumer H., Schild H., Schmutz W., Walder R., 2000, A&A 354, 1014 :
   A wind accretion wake in RW Hydrae ?

   Schild H., Eyres S. P. S., Salama A., Evans A., 2001, A\&A 378, 146 ISO observations of symbiotic stars. I. HM Sge.

Abbreviations

ESO	=	European Southern Observatories
HST	=	Hubble Space Telescope
ISO	=	Infrared Space Observatory
IUE	=	International Ultraviolet Explorer
FUSE	=	Far Ultraviolet Spectroscopic Explorer

2.3 Particle Acceleration and Coronal Heating

Institute / Laboratory	**:**	Paul Scherrer Institute, Laboratory for Astrophysics
In cooperation with	*:*	SRON, Utrecht, The Netherlands Center for Astrophysics, Cambridge, USA California Institute of Technology, Pasadena, USA
Principal Investigator	**:**	M. Güdel (PSI)
Co-investigators	**:**	M. Audard (PSI) K. Smith (PSI) J. J. Drake (CfA) V. Kashyap (CfA) R. Mewe (SRON) A. Raassen (SRON) A. Beasley (Caltech)
Field of research	**:**	Astrophysics

Method

Research based on existing instruments :

XMM-Newton, Chandra, EUVE, BeppoSAX, Very Large Array (VLA), Very Large Baseline Array (VLBA)
Theory, Satellite

Purpose of research

We study and simulate observational parameters that probe the role of particle acceleration and flare energy release in coronal heating of magnetically active stars. Differential emission measure distributions probe the distribution of plasma in temperature both during flares and during quiescence. Such distributions can be modeled by performing hydrodynamic computer simulations of flare-heated magnetic coronal loops.

The accelerated electrons reveal themselves by their observable gyrosynchrotron emission at radio wavelengths. The correlation between radio signatures and X-Ray responses yields insight into the role of accelerated particles for coronal heating. Lastly, the statistical distribution of flares in energy as detected in long time series at EUV and X-Ray wavelengths are key to our understanding of the importance of flare energy release for the coronal energy budget.

Time-line from to

Planning	=>	1996 - 2000
Measurement phase	=>	1996 - 2002
Data evaluation	=>	1998 - 2004

Actual status

We use new X-Ray satellites such as XMM-Newton and Chandra in coordination with ground-based radio observatories (VLA, VLBA) to study correlations between coronal high-energy emissions originating, respectively, from hot plasma and from high-energy (accelerated) electrons.

Approximately one dozen targets have been observed, with the majority of the data sets analyzed. Several targets show a clear temporal correlation between radio enhancements and X-Ray modulations. In several cases, we ascribe the temporal correlation to chromospheric evaporation, i.e., the loading of coronal magnetic fields with plasma by the process of electron bombardment of the chromosphere and subsequent heating. The visible consequence is a characteristic delay of the X-Ray emission relative to the (primary) radio gyrosynchrotron radiation, an effect known to solar astronomers as the `Neupert Effect'. Modeling of the energy content and energy transfer allows us to study the efficiency of chromospheric evaporation.

In another approach, we have studied the statistical distribution of flares on active stars in energy in order to determine the role of small-scale flares ("microflares") in the coronal energy budget. Using very long time series obtained with the EUVE and BeppoSAX satellites, we found that the flare energy distribution favors an important contribution of small flares to the overall coronal heating, to an extent that all of the coronal energy release could be due to flares.

A recent observation of Proxima Centauri with the X-Ray and optical instruments onboard XMM-Newton is being analyzed both with respect to the Neupert effect and the statistical role of flares, thus giving evidence that chromospheric evaporation of statistical flares is of fundamental importance for the mass loading of magnetic fields in active stellar coronae.

Three most relevant publications

1. Audard M., Güdel M., Drake J.J., Kashyap V.L. (2000) :
   Extreme-Ultraviolet Flare Activity in Late-Type Stars.

   Astrophysical J. 541, 396.

2. Güdel M., Audard M., Skinner S.L., Horvath M. (2002) :
   X-Ray Evidence for Flare Density Variations and Continual Chromospheric Evaporation in Proxima Centauri.

   Astrophysical J., 580, L73.

3. Güdel M., Audard M., Smith K.W., Behar E., Beasley A.J., Mewe R. (2002) :
   Detection of the Neupert Effect in the Corona of an RS CVn Binary System by XMM-Newton and the VLA.

   Astrophysical J., 577, 371.

Abbreviations

BeppoSAX	=	Satellite per Astronomia in Raggi X (X-ray satellite, Italy / Netherlands)
EUVE	=	Extreme Ultraviolet Explorer (NASA)
VLA	=	Very Large Array (radio; USA)
VLBA	=	Very Large Baseline Array (radio; USA)
XMM-Newton	=	X-Ray Multi Mirror Mission (ESA Cornerstone)

2.4 The Sun in Time

Institute / Laboratory	**:**	Paul Scherrer Institute, Laboratory for Astrophysics
In cooperation with	*:*	Villanova University, Villanova, PA, USA SRON, Utrecht, The Netherlands California Institute of Technology, Pasadena, USA
Principal Investigator	**:**	M. Güdel (PSI)
Co-investigators	**:**	M. Audard (PSI) R. Mewe (SRON) E.F. Guinan (Villanova) E. Gaidos (Caltech)
Field of research	**:**	Astrophysics

Method

Research based on existing instruments :

XMM-Newton, Chandra, ROSAT, ASCA, BeppoSAX, FUSE, VLA
Theory, Satellite

Purpose of research

By studying a sample of stars with masses and sizes like the Sun's, but with different rotation periods and thus ages, we can infer the role of declining rotation periods on the operation of the magnetic dynamo in a star like the Sun.

By implication, we derive information about the young Sun which are of prime importance for the formation of planetary atmospheres and the prebiotic Earth.

The project will indicate to what extent the overall magnetic activity level reflects in the coronal heating efficiency, the coronal temperature structuring, and coronal abundances.

Time-line from to

Planning	=>	1996 - 2001
Measurement phase	=>	1996 - 2003
Data evaluation	=>	1996 - 2005

Actual status

From the analysis of a comprehensive sample of ROSAT, ASCA, and EUVE data, we previously derived the temperature stratification of the coronal plasma at different stages of a solar-mass star's evolution. New observations now obtained with XMM-Newton and Chandra complement this picture.

Characteristic temperature decay laws suggest that coronal heating works with an increasing efficiency for increasing activity levels. X-Ray spectroscopic means are now providing insight into coronal densities and composition. We find a tendency for higher densities in younger, more active solar analogs. Their much higher X-Ray output is thus partly to be ascribed to denser coronal plasma. The coronal composition shows a marked evolution from an iron-poor to an iron-rich state. More precisely, all elements with a low first ionization potential (FIP) appear to be underabundant relative to the high-FIP elements in very young, magnetically active stars, while the inverse is true for older solar analogs.

The cause for this behavior is unknown, it is suspected, however, that the large number of relativistic electrons in magnetically active stars build up electric fields that prevent the escape of ionized low-FIP elements from the chromospheric levels to the corona.

Three most relevant publications

1. Gaidos E.J., Güdel M., Blake G. A. (2000) :
   The Faint Young Sun Paradox : " *An Observational Test of an Alternative Solar Model* ".

   Geophys. Res. Lett. 27, 501.

2. Güdel M., Audard M., Sres A., Wehrli R., Behar E., Mewe R., Raassen A.J.J., Magee H.R.M. (2002) :
   XMM-Newton Probes the Solar Past : Observations of Solar Analogs at Different Ages in 35th ESLAB Symposium.

   Eds. F. Favata & J.J. Drake (San Francisco : PASP), 497.

3. Raassen A.J.J., Mewe R., Audard M., Güdel M., Behar E., Kaastra J.S., van der Meer R.L.J., Foley C.R., Ness J.-U. (2002) :
   High-Resolution X-Ray Spectroscopy of Procyon with Chandra and XMM-Newton.

   Astron. Astrophys., 389, 228.

Abbreviations

FIP	=	First Ionization Potential
XMM-Newton	=	X-Ray Multi Mirror Mission (ESA Cornerstone)
VLA	=	Very Large Array (radio; USA)

2.5 Coronal and Flare Structures on Magnetically Active Stars

Institute / Laboratory	**:**	Paul Scherrer Institute, Laboratory for Astrophysics
In cooperation with	*:*	SRON, Utrecht, The Netherlands California Institute of Technology, Pasadena, USA
Principal Investigator	**:**	M. Güdel (PSI)
Co-investigators	**:**	M. Audard (PSI) K. W. Smith (PSI/ETH Zürich) R. Mewe (SRON/Utrecht) A. J. Beasley (Caltech)
Field of research	**:**	Astrophysics, Simulation, Theory

Method

Research based on existing instruments :

XMM-Newton, Chandra, coordinated with ground-based instruments (VLA, VLBA).
Simulation, Theory

Purpose of research

Several extremely active stars with saturated coronae are observed in different X-Ray and multi-wavelength campaigns in order to study the physics and structure of large coronal flares, and the geometric structure of active coronae. Multiwavelength studies allow us to probe different layers of the atmosphere and different physical mechanisms.

The principal methods applied include the inversion of rotational modulation and stellar eclipses, direct imaging by Very Long Baseline Interferometry, and modeling using explicit density measurements from X-Ray spectroscopy.

Further, theoretical modeling of observed X-Ray flares provides important constraints on extent and heating of the coronal flare plasma.

Time-line from to

Planning	=>	1996 - 2000
Measurement phase	=>	2000 - 2003
Data evaluation	=>	2000 - 2005

Actual status

We have obtained a number of data sets from XMM-Newton of rapidly rotating and eclipsing X-Ray stars/binaries that proved ideal to study coronal structure. The close binary YY Gem within the Castor system consists of two almost identical M dwarfs that eclipse each other every 9.5 hours.

A full orbit was covered by XMM-Newton. A 3-D (non-unique) inversion of the light curve shows inhomogeneous coronal structures on both stars, with a concentration at mid-latitudes, compatible with spot modeling. The inferred scale height of the corona is compatible with the spectroscopically measured temperatures, and the inferred densities are compatible with the spectroscopically measured values. A study of large flares with XMM-Newton with spectroscopic methods gave clear evidence for efficient heating up to 100 MK and a change in the elemental abundances. Low-first ionization potential elements are enhanced during the flares, while high-FIP elements are not.

A first study of the totally eclipsing binary alpha CrB in which a solar-like star is occulted by an X-Ray dark star provides evidence for inhomogeneous structuring of the corona. A full 2-D image reconstruction is in progress and will yield an unprecedented view of the structure of a magnetically active stellar corona. A number of accompanying radio observations using Very Long Baseline Interferometry techniques are presently being analyzed. They promise to give information on the actual extent of magnetic fields during different states of activity.

Three most relevant publications

1. Audard M., Güdel M., Mewe R. (2001) :
   The XMM-Newton View of Stellar Coronae : Flare Heating in the Coronae of HR 1099.

   Astron. Astrophys., 365, L318.

2. Güdel M., Audard M., Briggs K., Magee H., Maggio A., Mewe R, Pallavicini R., Pye J. (2001) :
   The XMM-Newton View of Stellar Coronae : X-Ray Spectroscopy of the Corona of AB Doradus.

   Astron. Astrophys., 365, L336.

3. Güdel M., Audard M., Magee H., Franciosini E., Grosso N., Cordova F., Pallavicini R., Mewe R. (2001) :
   The XMM-Newton View of Stellar Coronae: Coronal Structure in the Castor X-Ray Triplet.

   Astron. Astrophys., 365, L344.

Abbreviations

FIP	=	First Ionization Potential
XMM-Newton	=	X-Ray Multi Mirror Mission (ESA Cornerstone)

2.6 X-Ray Spectroscopy with XMM-Newton and Chandra

Institute / Laboratory	**:**	Paul Scherrer Institute, Laboratory for Astrophysics
In cooperation with	*:*	SRON, Utrecht, The Netherlands University of Colorado, Boulder, USA PMOD/WRC, Davos
Principal Investigator	**:**	M. Güdel (PSI)
Co-investigators	**:**	M. Audard (PSI) K. W. Smith (PSI/ETH Zürich) R. Mewe (SRON/Utrecht) A. J. Raassen (SRON/Utrecht) K. van der Hucht (SRON/Utrecht) S. L. Skinner (Univ. of Colorado) W. Schmutz (PMOD/WRC)
Field of research	**:**	Astrophysics

Method

Research based on existing instruments :

XMM-Newton, Chandra, coordinated with ground-based instruments (VLA, VLBA).
Theory

Purpose of research

XMM-Newton and Chandra provide for the first time high-resolution X-Ray spectroscopy of a large number of cosmic sources. X-Ray spectra give unique access to the temperature statification of sources, their density, and their composition.

We are systematically studying the coronal composition from X-Ray spectroscopy of about three dozens of stars, obtained either within the guaranteed time section of XMM-Newton, or within the guest observer programs of XMM-Newton and Chandra. X-Ray spectroscopy of hot stars provides a new window to the composition and dynamics of stellar winds.

Time-line from to

Planning	=>	1996 - 2000
Measurement phase	=>	2000 - 2003
Data evaluation	=>	2000 - 2005

Actual status

Using X-Ray lines from various chemical elements, we study systematic effects in the elemental composition of stellar atmospheres. We have uncovered a so-called "Inverse First-Ionization Potential Effect" in magnetically active stars, a trend in the coronal composition that is inverse to what is seen in the (inactive) Sun or other inactive stars. Detailed studies of high-resolution spectra are pivotal for testing our understanding of the atomic physics relevant for the transitions in a coronal environment. A spectroscopic study of the high-signal-to-noise spectrum of Capella illustrates the incompleteness of the presently used spectral codes, but also shows that a quite restricted number of spectral lines is sufficient to derive reliable parameters.

Investigations of hot stars that shed winds show that the conventional picture of homogeneous mass loss with relatively mild heating in shocks does not apply in a number of sources. Very hard spectra point to the presence of extremely hot material. The origin of this plasma is uncertain. An extended observing campaign of the hot-star binary gamma Velorum for the first time shows a combination of a collisionally dominated spectrum with a photoionization component. The latter, represented by various recombination continua, is probably due to photoionization of a wind cavity by the hard emission emitted from the energetic shock forming in the collision zone between the two winds.

Three most relevant publications

1. Audard M., Behar E., Güdel M., Raassen A.J.J., Porquet D., Mewe R., Foley C.R., Bromage G.E. (2001) :
   The XMM-Newton View of Stellar Coronae : High-Resolution X-Ray Spectroscopy of Capella.

   Astron. Astrophys., 365, L329.

2. Brinkman A.C., Behar E., Güdel M., Audard M., den Boggende AJ.F., Branduardi Raymont G., Cottam J., Erd C., den Herder J.W., Jansen F., Kaastra J.S., Kahn S.M., Mewe R., Paerels F.B.S., Peterson J.R, Rasmussen A.P., Sakelliou I., de Vries C. (2001) :
   First Light Measurements with the XMM-Newton Reflection Grating Spectrometers : Evidence for an Inverse First Ionisation Potential Effect and Anomalous Ne Abundance in the Coronae of HR 1099.

   Astron. Astrophys., 365, L324.

3. Skinner S.L., Güdel M., Schmutz W., Stevens I.R. (2001) :
   Detection of a Companion and Rich Emission-Line Spectrum in the Wolf-Rayet Binary gamma^2 Velorum.

   Astrophys. J., 558, L113.

Abbreviations

FIP	=	First Ionization Potential
XMM-Newton	=	X-Ray Multi Mirror Mission (ESA Cornerstone)

2.7 Radio to X-Ray Variability of the Quasar 3C 273

Institute / Laboratory	**:**	Geneva Observatory and INTEGRAL Science Data Centre	
In cooperation with	*:*	Several Institutes mainly in Europe	
Principal Investigator	**:**	T. Courvoisier	
Co-investigators	**:**	R. Walter S. Paltani M. Tuerler	P. Favre S. Deluit J. Zurita
Field of research	**:**	Astrophysics	

Method

Satellite

Purpose of research

The bright quasar 3C 273 is the object of repeated multi-wavelength observations from the radio domain to gamma rays. These observations have provided spectral energy distributions that span more than 15 decades of the electromagnetic spectrum. Over 20 years of data are now available, providing one of the largest sets of data on an Active Galactic Nucleus. These data provide strong constraints on the models for the physical origin of the radiation of quasars. Since many different physical processes are involved in the QSO phenomenon, the multi wavelength data we obtain allows to some extent to establish the relationships that exist between the emission components.

We have successfully written an INTEGRAL proposal. The corresponding observations will start in December 2002, and bring important reults on the high energy emission of this object.

Actual status

A large data base covering more than 15 orders of photon energy and 20 years of observations is being organised in Geneva. These data will be collectively published.

Three most relevant publications

1. The quasar 3C 273 T. J.-L. Courvoisier :
   The Astronomy and Astrophysics Review 9,1, 1998.

2. 30 years of multi-wavelength observations of 3C 273 Tuerler M. et al. :
   Astronomy and Astrophysics Suppl. 134, 89, 1999.

3. Modelling 20 years of synchrotron flaring in the jet of 3C 273 Tuerler M., Courvoisier T.J. L., and Paltani S. :
   2000, A\&A 361, 850.

2.8 Variability of Active Galactic Nuclei in the Ultraviolet Domain

Institute / Laboratory	**:**	Geneva Observatory and INTEGRAL Science Data Centre
Principal Investigator	**:**	T. Courvoisier
Co-investigators	**:**	S. Paltani M. Tuerler P. Favre
Field of research	**:**	Astrophysics

Method

Satellite

Purpose of research

We are using a compilation of all low dispersion IUE data on Active Galactic Nuclei to study the variability of these objects in a statistical way. Having access to all the IUE data (spanning from 1978 to 1995) provides a large number of objects in each of the classes of AGN and allows us to deduce the variability characteristics of the subclasses and a comparison of these. It is found that all classes vary in a similar way. Only the distribution of the number of objects as a function of the variability shows some difference between the classes. This result is rather unexpected. The variability characteristics of the objects are poorly correlated with other properties of the objects (like luminosity, redshift etc).

We are discussing the variability of a large sample of objects in terms of a model based on the superposition of single events. This leads to a physical parametrisation of the variability that is now being confronted to several physical processes that have been suggested as the possible cause of the events.

The results obtained illustrate the importance that a well organised and accessible archive of space data can have.

Actual status

We published the compilation of all the data in 1992, since then we have been using the data to describe the variability of AGN and to use these descriptions to test models of these sources.

The properties of the continuum variability and in particular its dependence on the luminosity of the objects has been studied.

The properties of the line variations have also been published.

This project is moving towards the analysis of the X-Ray variability of AGN.

Three most relevant publications

1. Courvoisier T.J.-L. and Paltani S. :
   1992, ESA SP 1153 A and B.

2. Tuerler M. and Courvoisier T.J.-L. :
   1998, A+A 329, 863.

3. Thèse de M. Tuerler :
   Université de Genève, mars 2000.

(Favre P. and Courvoisier T.J.-L. in preparation)

2.9 High Energy Emission of Seyfert Galaxies

Institute / Laboratory	**:**	Geneva Observatory and INTEGRAL Science Data Centre
Principal Investigator	**:**	T. Courvoisier
Co-investigators	**:**	S. Deluit
Field of research	**:**	Astrophysics

Method

Satellite

Purpose of research

We are using the emission above 15 keV, where absorption effects are minimised in order to investigate the differences in the emission properties of Seyfert 1 and 2 galaxies. This is in contrast to studies at lower energies in which the difference between the 2 classes of objects seem to be clearly due to absorption effects.

We have computed average Spectra of subclasses of Seyfert Galaxies and compare them.

We find that the emission between Seyfert 1 and 2 Galaxies seem to be genuine also in their intrinsic emission, if comfirmed this would speak against the unified model for these classes of objects which predicts that absorption ought to be the only difference.

Actual status

The data are obtained from the archive of SAX data. The average Spectra have been computed and the analysis papers are submitted or in preparation.

One most relevant publication

1. Deluit and Courvoisier, submitted.

2.10 ISO and HST Observations of Active Galactic Nuclei

Institute / Laboratory	**:**	Geneva Observatory and INTEGRAL Science Data Centre
Principal Investigator	**:**	T. Courvoisier
Co-investigators	**:**	M. Polletta
Field of research	**:**	Astrophysics

Method

Satellite

Purpose of research

We have observed narrow line Seyfert galaxies and quasars with ISO in the far infrared domain. Both programs aim at understanding the difference between those AGN that are radio loud and those for which the radio emission is very weak. Both categories of AGN have very similar properties in the other spectral domains and the origin of the difference is unclear. It is thought that radio emission is related to the presence of a jet, this would mean that the question we ask is equivalent to asking why some AGN have jets and not the others.

A second part of the work has dealt with HST observation of the nearby galaxy M51.

Actual status

This work has been finished with the defense and publication of the PhD thesis of M. Polletta.

Three most relevant publications

1. Polletta M. and Courvoisier T.J.-L. :
   ISOPHOT observations of narrow line Seyfert 1 galaxies.
   1999, A\&A 350, 765.

2. Polletta M. and Courvoisier T.J.-L. :
   The Far-Infrared emission of Radio Loud and Radio Quiet Quasars.

3. Wilkes B.J. and Hooper E.J. :
   Polletta, PhD. Thesis, Geneva University.
   2000, A\&A 362, 75.

2.11 INTEGRAL Science Data Centre (ISDC)

Institute / Laboratory	**:**	Geneva Observatory and INTEGRAL Science Data Centre
In cooperation with	*:*	Several institutes in Europe, Russia and the US
Principal Investigator	**:**	T. Courvoisier
Co-investigators	**:**	R. Walter and members of the international consortium
Field of research	**:**	Astrophysics

Method

Satellite

Purpose of research

The Geneva Observatory was active in the elaboration of the gamma ray mission INTEGRAL concept that was accepted as a medium mission by ESA in June 1993.

INTEGRAL will be an imaging and spectroscopy gamma ray astronomy satellite. Launch is foreseen in 2002.

INTEGRAL will be open to the scientific community at large. It is, therefore, essential to provide the community with the tools necessary to reduce and interpret the data from the instruments. The ISDC has been awarded the task of developing and operating a centre that will provide the users with an adequate level of support to use the mission data. The ISDC will also perform a standard set of analysis on the data and archive the data and the results of this analysis. In addition the ISDC will look at the data in near real time to detect transient sources and other unexpected results.

Research on several topics of high energy astrophysics is taking place at the ISDC. This comprises high mass binaries, low mass binaries, gamma ray bursts and the several projects dealing with AGN mentionned in these pages.

The ISDC is a centre attached to the Geneva Observatory.

Actual status

The ISDC was accepted by ESA in 1995.

Major development work took place between 1996 and 2002. The ISDC was found ready for its task during the Ground Segment Readiness Review of the mission.

Both garanteed time and open time will be available for ISDC researchers.

The satellite is ready for launch in October 2002.

One most relevant publication

1. The Astronomical community and the INTEGRAL mission in "2nd INTEGRAL workshop : the transparent Universe".

   ESA Sp-382, pp 581.

2.12 Planck Data Processing

Institute / Laboratory	**:**	INTEGRAL Science Data Centre
In cooperation with	*:*	The two consortia that propose instruments on the Planck mission.
Principal Investigator	**:**	T. Courvoisier M. Tuerler
Field of research	**:**	Astrophysics

Method

Satellite

Purpose of research

It is proposed that Switzerland contributes to the first steps of the Planck data processing. The ISDC is gathering an important experience in this domain that can be used in the context of other missions. This will provide access to the Swiss astronomers to the Planck data and thus allow us to participate fully in the exploration of the structures revealed by the cosmic microwave background.

Actual status

Parts of the Planck data analysis that are to be provided by the ISDC are being defined.

2.13 Plasma and SupraThermal Ion Composition (PLASTIC) on STEREO

Institute / Laboratory	**:**	Physikalisches Institute, University of Bern
In cooperation with	*:*	University of New Hampshire, USA Max-Planck-Institut für extraterrestrische Physik, Garching, Germany NASA/Goddard Space Flight Center, Maryland, USA University of Kiel, Germany
Principal Investigator	**:**	P. Bochsler (UBe lead Co-I)
Co-investigators	**:**	L. Blush M. Wiesmann P. Wurz B. Luethi J. Fischer

Method

Development and construction of own instruments :

We are developing the entrance system/energy analyzer for the PLASTIC instrument to be flown on the NASA STEREO mission.
Others : space craft

Purpose of research

We have been selected by NASA to serve as a major hardware Co-Institution for the upcoming STEREO (Solar TErrestrial Relations Observatory) missions. STEREO will consist of two spacecraft, each equipped with identical instrumentation. One spacecraft will lead the Earth on its motion around the Sun, the other will lag it. Both spacecraft will form an extending baseline (at a rate of about ± 20 degrees per year). This will allow for stereoscopic observations of the Sun, the corona, and interplanetary space.

We are collaborating with the University of New Hampshire, the other major hardware institution, to build the PLAsma and SupraThermal Ion Composition (PLASTIC) sensor. PLASTIC will measure the composition of the solar wind and of suprathermal ions in the energy-per-charge range 0.3 keV/e to 100 keV/e. Measurements of the composition of the solar wind will enable us to probe the 3-d structure of the solar corona and to identify different solar wind parcels in complicated structures such as coronal mass ejections that pass the STEREO spacecraft.

We will contribute to PLASTIC the entrance system/energy analyzer, important detector components, as well as our calibration facilities and engineering and scientific support.

Time-line frome to

Planning	=	ongoing
Construction	=	May 2002 - Sept. 2004
Measurement phase	=	January 2006 - 2009
Data evaluation	=	2006 - 2010

Actual status

We have finalized the design of the entrance system and performed detailed tests on the detector components. Detailed tests of the entrance system are foreseen for fall 2002 and later and of the integrated instruments in spring 2004.

2.14 COLLISA - Collection of Interstellar Atoms

Institute / Laboratory	**:**	Physikalisches Institute, University of Bern
In cooperation with	*:*	Space Research Institut (IKI) of the Russian Academy of Sciences, Moscow
Principal Investigators	**:**	P. Bochsler, Bern G. Zastenker, Moscow
Co-investigators	**:**	F. Bühler, Bern Yu. Agafonov, Moscow
Field of research	**:**	Interstellar medium

Method

Research based on existing instruments :
Collection and detection of the isotopes 3He and 4He in the interstellar neutral gas.

Development and construction of own instruments :
The collectors were developed in 1994 and 1995 by IKI, with the advice and support of the Physikalisches Institut.
Others : Mir Space Station

Purpose of research

The isotopic composition of the neutral helium in the interstellar medium was determined directly by exposing, on space station Mir, a set of specially prepared metal foils to trap the infalling interstellar flux, then returning the foils to Earth for mass-spectrometric analysis of the collected sample of interstellar material. The 3He/4He isotopic ratio of the local interstellar medium (LISM) has been determined successfully. The result agrees with the only determination made so far by a different method. The improved value enables more refined conclusions on the chemical evolution of the galaxy, including ongoing nucleosynthesis in stars.

Time-line from to

Planning	=>	1992 - 1993
Construction	=>	1994 - 1995
Measurement phase	=>	1995 - 1996
Data evaluation	=>	1996 - 2002

Actual status

After a short planning phase and a very short construction phase, two collectors (foil cameras), provided with preconditioned metal foils, were mounted on the Spektr module of Mir and launched in Mai 1995. In summer of 1995 and in spring of 1996, two sets of detector foils were exposed to the infall of neutral atoms of interstellar origin. They have been analyzed since 1996 for trapped helium. Both isotopes, 3He and 4He, have been detected and their isotopic ratio in the local interstellarmedium (LISM) has been determined by this new and direct method.

Even more sensitive analytical methods are now investigated in the hope to improve this result and hopefully to detect also the isotopes 20Ne and 22Ne of interstellar origin.

Three most relevant publications

1. F. Bühler, M. L. Bassi, P. Bochsler, O. Eugster, E. Salerno, G. N. Zastenker, Yu. N. Agafonov, L. G. Gevorkov, N. A. Eismont, A. V. Prudkoglyad, V. V. Khrapchenkov, and N. I. Shvets :
   First detection of 4He in a sample of interstellar neutral gas collected onboard Mir station.

   Astrophysics and Space Science, 274, 19-24, 2000.

2. E. Salerno, F. Bühler, P. Bochsler, H. Busemann, O. Eugster, G. N. Zastenker, Yu. N. Agafonov, and N. A. Eismont :
   Direct measurement of 3He/4He in the LISM with the COLLISA experiment.

   in : Solar and Galactic Composition.

   Ed. R. F. Wimmer-Schweingruber, AIP CP 598, pp. 275-280, 2001.

3. G. N. Zastenker, Yu. N. Agafonov, N. A. Eismont, A. V. Prudkoglyad, V. V. Khrapchenkov, L. G. Gevorkov, S. A. Burguchev, A. V. Kochetkov, E. Salerno, F. Bühler, P. Bochsler, J. Fischer, M. Bassi, H. Busemann, and O. Eugster :
   Method and results of the direct measurement of abundance and isotopic composition of the interstellar neutral helium.

   Cosmic research, v. 40, No. 4, pp. 347-356, 2002.
   Also in Kosmicheskie Issledovaniya (in Russian), v. 40, No. 4, pp. 374-384, 2002.

2.15 Imaging of Mars Analogue Materials with the Mars Express Lander (Beagle 2) Camera System

Institute / Laboratory	**:**	Naturhistorisches Museum Bern (NMBE)
In coorporation with	*:*	Micro-Cameras & Space Exploration SA, Neuchâtel, (Space-X) Space Research Centre, Physics and Astronomy, Department, University of Leicester, UK
Principal Investigator	**:**	B. Hofmann, NMBE
Co-Investigators	**:**	J.-L. Josset (Space-X), M. Josset (NMBE)

Method

Digital imaging of rock specimens representing Mars analogue materials using a camera and geometry identical to the video camera system onboard Beagle 2.

Images are taken in the standard distance for stereo imaging (60 cm) and at 8 cm using a close-up lens (incorporated in the filter wheel on Beagle 2).

Purpose of research

Imaging of rocks during the Viking and more recently Pathfinder missions on Mars has shown that the interpretation of close-up views of rocks is intrinsically difficult. The aim of this research is to provide experience and constraints of such image interpretation. A standard routine to obtain a best possible interpretation will be formulated with the aim to obtain a routine geological interpretation of each imaged rock (e.g. volcanic, impact breccia, detrital sediment). Images of rock structures caused by the former activity of microbial life will aid the search for similar structures in rocks visible on Mars. This project aims to apply experience gained during the investigation of fossil microbial structures in terrestrial rocks during the Mars Express mission (2003-2004).

Actual status

During 2001 preparations were made in order to start routine imaging in 2002. Hard ware was set up and tested and a collection of >30 rock samples representing suitable Mars analogue materials was assembled (including terrestrial rocks, microbial fabrics, and a Mars meteorite).

2.16 Prototype Synchrotron Radiation Detector

Institute / Laboratory	**:**	Laboratory for High Energy Physics ETH-Zurich	
In cooperation with	*:*	RWTH Aachen (Germany) MIT Cambridge (USA) Academia Sinica Taipei (Taiwan) CSIST Lung-Tan (Taiwan) KNU Taegu (Korea)	
Principal Investigator	**:**	G. Viertel	
Co-investigators	**:**	C. Camps V. Commichau G. Fluegge K. Hangarter M. Capell V. Koutsenko A. Lebedev S.C.C. Ting D. Baetzner A. Tiwari H. Anderhub	A. Biland O. Grimm H. Hofer M. Kraeber W. Lustermann D. Ren B. Zimmermann S.C. Lee Z. L. Ren G. N. Kim M. W. Lee
Field of research	**:**	Astrophysics	

Method

Development and construction of own instruments :

Detector to measure low energy X-Rays and charged particles.
Others : NASA Space Shuttle

Purpose of research

The Prototyp Synchrotron Radiation Detector (PSRD) is a particle physics experiment designed to provide crucial data for the design of the Synchrotron Radiation Detector (SRD) that will be a part of the upgraded Alpha Magnetic Spectrometer (AMS). AMS is scheduled to operate on the International Space Station (ISS) during a multi-year mission.

The SRD will detect the synchrotron radiation that is emitted by very high-energy electrons and positrons in the earth magnetic field and so extends the energy range accessible to AMS to several TeV. The SRD is designed to be sensitive to photons in an energy range from 2.5 keV to 100 keV and will suppress against backgrounds by good timing capabilities.

To determine the necessary timing precision, the knowledge of the diffuse photon and charged particle background rate is necessary. Since available data is only very sparse and incomplete, the main goal of the PSRD is to determine these backgrounds. It is a small size detector that will fly as a secondary payload on the Space Shuttle flight STS-108 late in 2001.

A detector principle similar to the one envisaged for the SRD is employed : inorganic YAP scintillating crystals (Yttrium-Aluminum Perovskite doped with Cerium) are coupled directly to photo multiplier tubes that are read out by fast electronics. Using YAP crystals of two different thicknesses, the sensitive energy range of the PSRD extends from 2 keV to several MeV.

The PSRD has in addition two silicon macro strip detectors (strip pitch 194 micrometer), oriented orthogonal to each other, that are read out via the same analogue pipeline chips (originally designed for the CMS detector at CERN) that are foreseen for the SRD. This will allow a first test of these electronics in a space environment. A charged particle trigger consisting of two plastic scintillators allows, together with the rough tracking capability of the macro strip detectors, the determination of the response of the YAP crystals to high-energy charged particles.

Furthermore, four sets of solar cells are used as a solar light monitor. A new type of flexible solar cell, developed by the solid state laboratory of ETH Zurich, is used. It is based on $Cu(In,Ga)Se_2$ (CIGS) deposited on polymer sheets. It has a high conversion efficiency and a very good power-to-weight ratio and so is of considerable interest for space applications. Their performance in space will be measured for the first time.

Time-line from to

Planning	=>	1998 - 1999
Construction	=>	2000
Measurement phase	=>	December 5, 2001 - December 17, 2001
Data evaluation	=>	2002

Actual status

The construction of the PSRD was completed and tested in March 2001. Besides the functional tests, the detector had to pass a thermal-vacuum test, an electromagnetic compatibility test and a vibration test. In April the experiment was sent to the Goddard Space Flight Center (Greenbelt, USA) for the final tests and safety checks. As part of the multiple payload project MACH-1, the PSRD was installed on a shuttle cross bay bridge and shipped to KSC (September 2001)

The space shuttle ENDEAVOUR launched for the 12 days flight mission at KSC on December 5, 2001. Two hours and 53 minutes after launch, PSRD was activated and a few minutes later confirmation of running was received through the data down link. The initially allocated data taking time of 26 hours was extended during the mission by the NASA control center to more than 110 hours. After the successful mission, the experiment was shipped back from GSFC to ETH Zurich. The recorded data volume of 45 Gbyte is now being processed.

Three most relevant publications

1. H. Hofer et al. :
   Charge determination of high-energy electrons and nuclei by synchrotron radiation with AMS Nucl.

   Instr. and Methods in Physics Research A 416 (1998) 59-63.

2. H. Anderhub et al. :
   The Prototype Synchrotron Radiation Detector (PSRD), to be published in Nucl.

   Instr, and Methods in Physics Research A.

3. G. Viertel et al. :
   The ALPHA Magnetic Spectrometer Nucl.

   Instr. and Methods in Physics Research A 419 (1998) 295-299.

Abbreviations

AMS	=	ALPHA Magnetic Spectrometer
CERN	=	European Organization for Nuclear Research
GSFC	=	Goddard Space Flight Center
PSRD	=	Prototype Synchrotron Radiation Detector
SRD	=	Synchrotron Radiation Detector
STS	=	Space Transportation System
YAP	=	Yttrium Aluminum Perovskite

III Earth Observation Earth Resources

3.1 ENVISAT ASAR Expert Support Laboratory : ScanSAR Interferometry

Institute / Laboratory	**:**	Remote Sensing Laboratories (RSL), Department of Geography, University of Zurich-Irchel, Winterthurerstrasse 190, CH-8057 Zürich
In cooperation with	*:*	European Space Agency POLIMI SARMAP POLIBA
Principal Investigator	**:**	Prof. Dr. D. Nüesch
Co-investigators	**:**	Dr. D. Small Dr. E. Meier A. Schubert
Field of research	**:**	Earth resources, Earth Observation

Method

Research based on existing instruments :

ENVISAT ASAR

Purpose of research

In this project, RSL acts as a component of a research and development project team aiming to make interferometric measurements possible between normal synthetic aperture radar (SAR) acquisitions and those acquired in a ScanSAR mode (e.g. ENVISAT ASAR wide swath or alternating polarization). RSL's contribution focuses on the generation and assessment of synthetic interferograms based on a DEM and parametric information describing two SAR SLC datasets. The synthetic interferograms then allow both DEM-flattening of ASAR interferograms and local spectral shift filtering during interferogram formation itself.

Monitoring of changes to the Earth's surface via differential InSAR is made much more practicable via this technique, as large areas may be acquired in wide swath mode systematically; then immediately following an event (e.g. Earthquake) a high resolution image mode acquisition can be made and before/after differences measured.

Time-line from to

Planning	=>	1998 - 2000
Construction	=>	1999 - 2002
Measurement phase	=>	2002 - 2003
Data evaluation	=>	2002 - 2003

Actual status

Interfaces were constructed to the ENVISAT data formats and shared for use among other group members. Refined software for synthetic interferogram generation was developed and delivered.

In a later project stage, the calculation of auxiliary geometry parameters was requested and added. Tests of the software were successfully conducted using "simulated" ENVISAT ASAR data based data acquired by the ERS satellites covering San Francisco, Los Angeles, and Bern, Switzerland.

Further refinements are ongoing, and new tests will be necessary once the first raw wide swath data become available following ENVISAT's launch.

One most relevant publication

1. Small D., Meier E., Nüesch D. (2002) :
   Phase Noise Countermeasures for Synthetic Interferogram Generation.

   Proc. of IGARSS 2002, Toronto, Canada, in print.

Abbreviations

AP	=	ENVISAT ASAR Alternating Polarisation Mode
ASAR	=	Advanced Synthetic Aperture Radar
ESA	=	European Space Agency
ESL	=	Expert Support Laboratory
GEC	=	Geocoded Ellipsoid Corrected
IM	=	ENVISAT ASAR Image Mode
PRI	=	Precision Image
RSL	=	Remote Sensing Laboratories
SLC	=	Single Look Complex
WS	=	ENVISAT ASAR Wide Swath Mode

3.2 Investigation of the Potential of Imaging Spectrometry as an Earth Observation Method for Environmental Analysis

Institute / Laboratory	**:**	Remote Sensing Laboratories (RSL), Department of Geography, University of Zurich-Irchel, Winterthurerstrasse 190, CH-8057 Zürich
Principal Investigator	**:**	Prof. Dr. K.I. Itten
Co-investigators	**:**	Dr. M. Schaepman Dr. D. Schläpfer
Field of research	**:**	Earth resources, Remote Sensing

Method

Research based on existing instruments :

HyMap, DAIS, MODIS, MISR
Simulation, Theory, Aircraft, Satellite
Others : Ground based instruments

Purpose of research

Within this project the potential of imaging spectroscopy for the investigation of different natural systems is investigated. In the ongoing phase, special emphasis is being put on the analysis of vegetation, aerosols, and the development of a relational database system for the management of a spectral database.

The primary goal of a spectral database for imaging spectroscopy data is the link between spatial and spectral data.

The analysis of these metadata requires a systematic collection of reference spectra, which can be accessed using relational database. Input and output of spectra is feasible either via web-based interface or command line scripts. In addition to that, on-line analysis tools allow for further investigation and comparison of these Spectra.

Time-line from to

Planning	=>	10/2000 - 10/2003
Construction	=>	n/a
Measurement phase	=>	Yearly
Data evaluation	=>	Yearly

Actual status

As for the database part, conceptual work has resulted in a database scheme, which describes the spectral 'aspect of reality' by means of entities and attributes. The underlying relational database system represents a well-known and reliable basis for data processing, whereas users can query from and feed data to the database interactively. Heterogeneous data from various spectroscopic sources, such as BRDF measurements, spectral radiometer data, and eventually image data, can now be homogenized and retrieved by using a common denominator. The identification of an appropriate data model as well as suitable technology could be completed and led to the implementation of a prototype that demonstrates all functionalitites.

The potential of the database is demonstrated using aerosol retrival algorithms with imaging spectrometer data.

We also focus on the retrieval of spatially distributed biogeophysical and biogeochemical parameters relevant for vegetation. Special emphasis is put on the combined retrieval potential of spectro-directional measurements.

Three most relevant publications

1. Berger M., Moreno J., Müller A., Beisl U., Richter R., Schaepman M., Strub G., Stoll M. P., Nerry F., Leroy M., Rast M., Wursteisen P., and Attema E. :
   The DASIEX campaigns in Support of a Future Land Surface Processes Mission.

   ESA Bulletin 105, February 2001, pp. 101-111.

2. Strub G., Keller J., Schaepman M., Beisl U., and Itten K. :
   Comparison of modeled and measured diurnal directional reflectance data of an alfalfa canopy.

   Proc. ISPRS Commission VII, Workshop on spectral Signatures, Aussois, France, pp. 285-290, 2001.

3. Bojinski S., Schaepman M., Schläpfer D., and Itten K. : SPECCHIO :
   A Web-accessible spectral Database for the Administration of Heterogeneous Campaign Data.

   Proc. EARSeL, 2nd Intl. Workshop onImaging Spectroscopy, Enschede, The Netherlands, CD ROM, 2000.

Abbreviation

BRDF = Bidirectional Reflectance Distribution Function

3.3 Polarimetric Synthetic Aperture Radar Interferometry (POL-InSAR) in L-band for the Extraction of geo- and biophysical parameters

Institute / Laboratory	**:**	Remote Sensing Laboratories (RSL), Department of Geography, University of Zurich-Irchel, Winterthurerstrasse 190, CH-8057 Zürich
In cooperation with	*:*	Swiss Federal Research Institute WSL
Principal Investigator	**:**	Prof. Dr. D. Nüesch
Co-investigators	**:**	Dr. E. Meier O. Stebler
Field of research	**:**	Earth resources, Earth Observation

Method

Research based on existing instruments :

- spaceborne :	mission	-> Space Radar Laboratory (SRL, NASA/JPL)
	sensor	-> Shuttle Imaging Radar System C (SIR-C, NASA/JPL)
	platform	-> Space Shuttle (NASA)
- airborne :	sensor	-> Experimental SAR (ESAR/DLR)

Purpose of research

The purpose of this project is to extract geo- and biophysical parameters from space- and airborne POL-InSAR (polarimetric synthetic aperture radar interferometry) L-band (1.3GHz) data. The POL-InSAR method requires full polarimetric scattering matrix data in an interferometric acquisition configuration. POL-InSAR improves the performance of conventional scalar SAR interferometry by exploiting the wave polarisation, allowing a more sophisticated physical interpretation of SAR interferograms. SAR interferometry enables the extraction of topographic heights. If interferometric scattering matrix data are available, complex interferograms can be decomposed into independent interferograms of singularpolarisations that can be related to certain scattering mechanisms (coherent singularvector-target decomposition).

Further, it is the goal of this project to understand these L-band scattering mechanisms and to describe the physical properties of the scattering media, especially for vegetation covers, characterised by a random volume over a multi-polarising ground (crown-branches-trunk-ground). The inversion problem of POL-InSAR measurements has to be solved and geo- and biophysical parameters such as topographic heights beneath vegetation covers, vegetation heights/extinction and general geometric properties of vegetation volumes have to be retrieved. Since the spaceborne as well as the airborne data are acquired in a (multi-temporal) repeat-pass mode, different baselines (normal distances between flight tracks) are available, allowing for a more accurate estimation of the required POL-InSAR parameters.

In parallel, different scattering scenarios are being modelled in order to improve the evaluation of the POL-InSAR measurements. Field campaigns were carried out during the project phase to collect appropriate ground reference data.

Time-line from to

permanent activity => since 1999

Actual status

In a first step, the study has concentrated on the analysis of spaceborne POL-InSAR measurements acquired by the Space Shuttle/SIR-C sensor during the SRL2-mission in 1994. During that time, the system was flown in a unique multi-baseline POL-InSAR configuration. We used this data set to evaluate the potential of the POL-InSAR technique and to establish the corresponding algorithmic framework. A consistent and comprehensive model was built up to study the polarimetric response of natural targets (so called 'distributed targets'). Under the hypothesis that L-band wave propagation through a random vegetation volume is polarisation independent, the model assumes a random volumetric structure over a multi-polarizing ground scatterer. It was possible to locate the individual scattering mechanisms within a forest canopy vertically and to derive corresponding vegetation heights (differential POL-InSAR heights).

Currently, the studies focus on the analysis of the multi-baseline Pol-InSAR E-SAR data. This sensor was flown in an identical configuration as the spaceborne case. The higher spatial resolution helps to derive more detailed information about the polarimetric backscattering response of vegetation covers. Forward and inverse modeling of the multi-baseline L-band Pol-InSAR data are currently realised.

Three most relevant publications

1. Stebler O., Meier E., Nüesch D. (2001) :
   Multi-baseline airborne Pol-InSAR measurements for the estimation of scattering processes within vegetation media.

   Proc. IGARSS'2001, Sydney, Australia.

2. Stebler O., Meier E., Nüesch D. (2001) :
   Multi-baseline airborne Pol-InSAR measurements for the analysis and inversion of scattering processes within vegetation media

   Proceedings of the 3rd International Symposium on Retrieval of Bio- and Geophysical Parameters from SAR Data for Land Applications.

   11-14 September, Sheffield, UK, ESA SP-475, pp. 301-306.

3. Stebler O., Meier E., Nüesch D. (2002) :
   Multi-baseline polarimetric SAR interferometry - first experimental spaceborne and airborne results.

   ISPRS Journal of Photogrammetry and Remote Sensing (P&RS), accepted for publication.

Abbreviations

SAR	=	Synthetic Aperture Radar
InSAR	=	Interferometric SAR
POL-InSAR	=	Polarimetric InSAR

3.4 APEX- Airborne Prism Experiment

Institute / Laboratory	**:**	Remote Sensing Laboratories (RSL) Department of Geography, University of Zurich-Irchel, Winterthurerstrasse 190, CH-8057 Zürich
In cooperation with	*:*	European Space Agency / PRODEX European Space Agency / EOEP VITO (Belgium)
Principal Investigator	**:**	Prof. Dr. K.I. Itten
Co-investigators	**:**	Dr. M. Schaepman Dr. W. Debruyn
Field of research	**:**	Earth resources, Remote Sensing

Method

Development and construction of own instruments :

Airborne Imaging Spectrometer (APEX) as simulator for spaceborne instruments.
Aircraft

Purpose of research

Based on the present demand for airborne and spaceborne imaging spectroscopy data in remote sensing, the European Space Agency (ESA) has initiated a project to build a new generation airborne hyperspectral imager named APEX. APEX is an acronym used for Airborne PRISM Experiment. APEX is a pushbroom imager with 300 spectral channels in the 400-2500 nm wavelength region, and with 1000 pixels across track. It will be flown in an aircraft at operating altitudes between 4 and 10 km having a spatial resolution of 2-5 meters.

The mission objectives of APEX are mainly being a simulator, calibrator, and validator for spaceborne multispectral and hyperspectral instrument (such as SPECTRA). APEX further on shall foster the application development for hyperspectral imaging in Europe and worldwide. The project shall be an European answer to the scientific success of American hyperspectral instruments. Its specifications are state-of-the-art in resolution and overall radiometric performance.

Time-line from to

Planning	=>	1997 - 2000
Construction	=>	2002 - 2004
Measurement phase	=>	2005 - 2010
Data evaluation	=>	2005 - 2010

Actual status

RSL is responsible for the scientific management of the project, for industrial consulting concerning the specialities of imaging spectrometer instrument, and for the construction of the Processing and Archiving Facility (PAF). The latter will be an universal, database driven system supporting the processing and distribution of all APEX data acquisitions. Sophisticated information technology tools are used for a versatile processing system, which will be persistent throughout the operational phase of the instrument.

ESA EOEP has taken the lead within APEX by providing the SWIR detector technology, the calibration home base, and the technical management.

The Phase C/D will be starting in July 2002.

Three most relevant publications

1. Schaepman M., Schläpfer D., and Müller A. :
   Performance Requirements for Airborne Imaging Spectrometers.

   Proc. SPIE, Imaging Spectrometry VII, Vol. 4480, 2001, in print.

2. Börner A., Wiest L., Keller P., Reulke R., Richter R., Schaepman M., and Schläpfer D. :
   SENSOR : A tool for the simulation of hyperspectral remote sensing systems.

   ISPRS J. Phot. and Remote Sens. 55 (299-312), 2001.

3. Schläpfer D., Schaepman M., and Strobl P. :
   Impact of spatial resampling methods on the radiometric accuracy of airborne imaging spectrometer data.

   Fifth International Airborne Remote Sensing Conference and Exhibition. September 17 20, 2001, San Francisco, USA, accepted for print.

Abbreviations

APEX	=	Airborne PRISM Experiment
LSPIM	=	Land Surface Processes and Interactions Mission
PRISM	=	Process Research by Imaging Spectrometry Measurement
RSL	=	Remote Sensing Laboratories

3.5 Terrain-Geocoding and Image Simulation

Institute / Laboratory	**:**	Remote Sensing Laboratories (RSL), Department of Geography, University of Zurich-Irchel, Winterthurerstrasse 190, CH-8057 Zürich
In cooperation with	*:*	European Space Agency
Principal Investigator	**:**	Prof. Dr. D. Nüesch
Co-investigators	**:**	Dr. E. Meier, Dr. D. Small
Field of research	**:**	Earth Observation

Method

Research based on existing instruments :

Envisat, ERS-1/2, RADARSAT-1

Purpose of research

The project aims to demonstrate terrain-geocoding of multimode RADARSAT & ENVISAT imagery, improve radiometric calibration, and improve automation in terrain geocoding by developing image simulation techniques. Automated geocoding methods whereby no manual tiepoint selection is necessary for refinement of the SAR geometry, is possible in regions like the Swiss Alps, where correlation between an image simulation calculated through combination of a DEM and a rough geometry (platform position and pixel spacings) provides offsets and offset trends that in turn provide the refined geometry for a precision terrain geocoding.

Changes in terrain-geocoding processing algorithm are required when swath length becomes greatly extended (compared to the ERS case); optimal approaches for these cases need to be developed and assessed.

Time-line from to

Planning	=>	1994 - 1995
Construction	=>	1996 - 2003
Measurement phase	=>	1996 - 2002
Data evaluation	=>	2001 - 2003

Actual status

The terrain geocoding of single-beam scenes has been tested on many scenes, and is operational. Integration of illuminated area (image simulator) has also been used on many scenes (also other sensors) and is in use for radiometric calibration, and experimentally for refinement of image geometry. Image simulation is being used for quantitative investigation of the effects of nominal incidence angle on the relationship between radar and map geometries. Automated refinement of the geometry using image simulation (esp. In mountainous areas) has being tested on multiple products, including an extended medium resolution simulated ENVISAT data set.

First experiments with swaths of extended length have been conducted, and refinements to the software are ongoing. Quantitative evaluation of results will be conducted in the course of RSL's calibration & validation activities for the ENVISAT ASAR.

Three most relevant publications

1. Small D., Meier E., Nüesch D. (2001) :
   Efficient Geolocation and Image Simulation for Extended SAR Strip Maps.

   Proc. IGARSS'2001, Sydney, Australia, July, 2001.

2. Small D., Biegger S., Nüesch D. (2000) :
   Automated Tiepoint Retrieval through heteromorphic Image Simulation for Spaceborne SAR Sensors.

   Proc. of ERS-ENVISAT Symposium 2000, Gothenburg, Sweden, Oct. 16-20, 2000.

3. Small D., Biegger S., Nuesch D. (2000) :
   The Topology of SAR Imagery in Rough Topography.

   Proc. of EUSAR'2000, Munich, Germany, May 23-25, 2000, pp. 501-504.

Abbreviations

ESA	=	European Space Agency
IGARSS	=	International Geoscience and Remote Sensing Symposium
RSL	=	Remote Sensing Laboratories
SAR	=	Synthetic Aperture Radar

3.6 Product Development for Mapping and Monitoring of Land Cover Dynamics in Tropical Areas

Institute / Laboratory	**:**	Remote Sensing Laboratories (RSL), Department of Geography, University of Zurich-Irchel, Winterthurerstrasse 190, CH-8057 Zürich
In cooperation with	*:*	Sarmap S.A., CH-6989 Purasca geoconcept, CH-8037 Zürich National Resource Management Service (NRMS), Sri Lanka European Space Agency (ESA)
Principal Investigator	**:**	Prof. Dr. K.I. Itten
Co-investigators	**:**	Prof. Dr. D. Nüesch Dr. U. Frei, R. Fischer P. Schmid
Field of research	**:**	Earth resources, Remote Sensing

Method

Research based on existing instruments :

ERS SAR, Radarsat

Purpose of research

Multitemporal radar images were classified for mapping the areal extent of irrigated paddy fields. These measurements, together with ancillary data, allow for an early rice yield prediction, what in turn allows the government to take appropriate measures to guarantee price stability.

The project was carried out within the European Space Agency's Data User Programme (DUP), that intends to stimulate end user markets for data products generated from spaceborne Earth observation data, in particular data gathered by ERS- and ENVISAT instruments.

Time-line from to

Measurement phase	=>	1997 - 1999
Data evaluation	=>	1997 - 2000

Actual status

For a Sri Lankan test site, some prototype maps were generated, and the suitability of ERS data was assessed. The developed algorithms were verified using a second test site in Thailand. In parallel, the experimental software was upgraded for operational use.

In view of the possibilities offered by ENVISAT, data products derived from the ASAR instrument were simulated. The research part of the project has been terminated, while the results are being exploited by Sarmap S.A. on an operational basis.

Two most relevant publications

1. Holecz F., Dwyer E., Monaco S., Schmid B., Frei U., Fischer R., 2000 :
   An Operational Rice Field Mapping Tool using Spaceborne SAR Data.

   ERS-ENVISAT Symposium, Goeteborg, Schweden, 9 p.

2. Itten K.I., Frei U., Fischer R., Nuesch D., Holecz F., Schmid B., 2000 :
   Product Development for Mapping and Monitoring of Land Cover Dynamics in Tropical Areas, Final Report for the 3rd project phase (April 1999 - June 2000).

   ESA contract no. 12239/97/I-HGE, CCN 99002, 62 p.

Abbreviations

DUP	=	Data User Programme
ERS	=	European Remote Sensing Satellite
ESA	=	European Space Agency
NRMS	=	National Resource Management Service (Sri Lanka)
RSL	=	Remote Sensing Laboratories

3.7 Study of the Synergy of Hyperspectral-Multispectral Data - Scaling of Spectrally derived Land-Surface Parameters

Institute / Laboratory	**:**	Remote Sensing Laboratories (RSL), Department of Geography, University of Zurich-Irchel, Winterthurerstrasse 190, CH-8057 Zürich
In cooperation with	*:*	European Space Agency
Principal Investigator	**:**	Prof. Dr. K.I.Itten
Co-investigators	**:**	Dr. T.W. Kellenberger
Field of research	**:**	Earth resources, Remote Sensing

Method

Research based on existing instruments :

HyMap, SPOT VEGETATION, NOAA/AVHRR, IRS-1C WIFS, Landsat ETM+
Aircraft, Satellite

Purpose of research

In the framework of ESA's new strategy for Earth Observation in the post-2000 time frame, four research/demonstration missions, focusing on advancing in understanding of the different Earth system processes have been proposed. One of the missions is dedicated to the study of land-surface processes and their interactions with the atmosphere. This Land-Surface Processes and Interaction Mission (LSPIM) focuses on the measurement of surface characteristics such as albedo, reflectance, bidirectional reflectance distribution function (BRDF) and surface temperature which are linked to the processes driving bio/geophysical and biochemical variables. Even though this mission was not selected in fall 1999 as first core mission, the ESA Programme Board stressed the importance of the LSPIM mission.

The primary goal of the LSPIM mission is the provision of bio-geophysical processes and land atmosphere interactions at the local scale and advance the understanding of these processes and interactions on global scale. The HyMuS study (Hyperspectral – Multispectral Synergy – scaling of spectrally derived lans-surface parameters) focusses on the upscaling aspect of LSPIM.

The objective of the study was to investigate the effects of scaling, aggregating or lumping on optical remote sensing data and derived biophysical / biochemical parameters, serving as input in land-surface process models at local up to global scale. The different land-surface processes vary from local scale (homogeneous plots) over regional scale (uniform land cover plots) up to global scale. The variation of the land-surface processes are frequently non-linear over scales with respect to the degree of spatial and temporal averaging of input data that can be performed for a given level of error when modelling the processes.

Time-line from to

Planning	=>	1/1999 - 12/2000
Construction	=>	n/a
Measurement phase	=>	n/a
Data evaluation	=>	3/1999 - 10/2000

Actual status

The first part of the study is based on a hyperspectral data set of the HYMAP sensor with 5m spatial ground resolution. The data was taken in 1998 over a rural region in Switzerland. Three different case parameters which serve as input into canopy models, describing primary production, have been selected : The normalized difference vegetation index NDVI, the MERIS global vegetation index (MGVI), and the normalized difference water index NDWI.

Seven different cases have been performed to analyse the effects of upscaling from 5m to 1km spatial resolution and to establish a link of the upscaled data to NOAA/AVHRR and SPOT VEGETATION data. From these investigations requirements for the upscaling of land surface parameters have been derived which can be applied to similarly structured regions.

In the second part of the study, the focus was on upscaling data sets with large coverage but less spectral resolution. Based on a Landsat ETM+ scene of Eastern Switzerland, the effects of landsurface heterogeneity in the upscaling approach was investigated. Establishing a spectral, spatial and informational link from spatially high resolved data (ETM+, SPOT HRVIR, IRSA) to global data sets (SPOT VEGETATION, NOAA/AVHRR) was of high priority. The study demonstrates the scaleability of NDVI, MGVI and NDWI from local scale up to global scale.

Three most relevant publications

1. Kellenberger T., Dickerhof C., Schläpfer D. (2000) :
   Study of the synergy of hyperspectral-multispectral data-scaling of Spectrally derived land-surface parameters.

   Final report of ESA-Contract 13397/98 NL/GD RSL - Remote Sensing Laboratories, University of Zürich, Switzerland.

2. Kellenberger T. (2001) :
   Upscaling of spectrally derived land-surface parameters.

   International Symposium on Physical Measurements & Signatures in Remote Sensing, Aussois 2001, pp. 111-116.

3. Kellenberger T., Eckert S. (2000) :
   Study of the synergy of hyperspectral-multispectral data - scaling of spectrally derived and-surface parameters, Part II.

   Final report of ESA-Contract 13397/98/NL/GD CCN2; RSL - Remote Sensing Laboratories, University of Zürich, Switzerland.

Abbreviations

AVHRR	=	Advanced Very-High Resolution Radiometer (Sensor of NOAA)
ESA	=	European Space Agency
HRVIR	=	High Resolution Visible and Infrared Sensor of the SPOT-4
HYMAP	=	Hyperspectral scanner from HyVista Corporation of Australia
IRS-1C	=	Indian Remote Sensing Satellite
Landsat	=	ETM+ Landsat Enhanced Thematic Mapper Plus (multispectral Scanner)
LSPIM	=	Land Surface Processes and Interactions Mission
MGVI	=	Meris Global Vegetation Index
NDVI	=	Normalized Difference Vegetation Index
NDWI	=	Normalized Difference Water Index
PRISM	=	Processes Research for Imaging Spectrometry Mission
SPOT	=	Système pour l'observation de la Terre
VEGETATION	=	Multispectral scanner on board SPOT-4 (1km resolution)

3.8 EO Application to Hazard Mapping

Institute / Laboratory	**:**	Gamma Remote Sensing AG
In cooperation with	*:*	Institute of Geodesy and Photogrammetry of the ETH Zürich
Principal Investigator	**:**	A. Wiesmann
Co-investigators	**:**	M. Honikel (ETH), U. Wegmüller, T. Strozzi, C. Werner
Field of research	**:**	Earth Observation

Method

Others : EO data processing and interpretation.

Purpose of research

Evaluate potential and develop applications of SAR data for the mapping of natural hazards (forest storm damage, flooding, avalanches, landslides).

The main methods used are change detection techniques applied to multi-temporal and interferometric SAR.

The research also includes signal processing and modeling aspects. In additions methods to combine the potential of optical and SAR EO data for mapping applications, in particular the mapping of natural hazards, are evaluated.

Time-line from to

Planning	=>	1998 - 2005
Measurement phase	=>	1991 - 2005
Data evaluation	=>	1998 - 2005

Actual status

The related KTI project Combined Remote Sensing Natural Monitoring, CIRSTEN, in cooperation between the Institute of Geodesy and Photogrammetry of the ETH Zürich and GAMMA to combine the potential of optical and SAR EO data for mapping applications, in particular the mapping of natural hazards, with GAMMA's main focus on SAR based applications will be finalized in 2002.

The related ESA GSTP Study on Multi-Sensor and Interferometric Retrieval Techniques study (done in cooperation with Joanneum Research, Graz, and the University of Innsbruck) is a two years project (2000-2002) in which GAMMA investigates the potential of remote sensing, and in particular SAR, to map natural hazard events, including forest storm damage, flooding, and avalanches.

In 2002 UNOSAT, a long term ESA Earth Observation Market Development project, was started to better develop the use of EO based information in the context of disaster management and humanitarian aid projects. UNOSAT consortium members are UNOPS, UNITAR, Spot-Image, Gamma-RS and Digitech.

The related ESA DUP Project ALPS focuses on the detection and mapping of creeping slopes using differential SAR interferometry. The main application area is the alpine zone above the tree-line.

So far the hazard types investigated included :

- forest storm damage (Lothar)
- avalanche mapping
- flood mapping
- land slide mapping

Three most relevant publications

1. A. Wiesmann, L. Demargne, F. Ribbes, M. Honikel, H. Yésou, and U. Wegmüller :
   " Forest storm damage assessment with ERS Tandem data "

   Proceedings of ERS-ENVISAT Symposium, Gothenburg, Sweden, 16-20 Oct. 2000.

2. A. Wiesmann, U. Wegmüller, M. Honikel, T. Strozzi T., and C. Werner :
   " Hazard mapping with multi-temporal SAR and InSAR "

   Proc. 3rd Int. Symp. on Retrieval of Bio- and Geophysical Parameters from SAR data for land applications, Sheffield, UK, 11-14 Sep. 2001, ESA SP-475, pp. 133-138, 2002.

3. U. Wegmüller, A. Wiesmann, M. Honikel, T. Strozzi T., and C. Werner :
   " Potential roles for space-borne SAR in disaster management and humanitarian relief "

   Proc. 3rd Int. Symp. on Retrieval of Bio- and Geophysical Parameters from SAR data for land applications, Sheffield, UK, 11-14 Sep. 2001, ESA SP-475, pp. 307-311, 2002.

Abbreviations

EO	=	Earth Observation
SAR	=	Synthetic Aperture Radar
ESA	=	European Space Agency
DUP	=	Data User Program

3.9 EO Application to Hazard Mapping

Institute / Laboratory	**:**	Gamma Remote Sensing AG
In cooperation with	*:*	CNR-ISMAR, Venice, Italy Deutsche Steinkohle (DSK) Deutsche Montan Technologie (DMT)
Principal Investigator	**:**	T. Strozzi
Co-investigators	**:**	L. Tosi (CNR-ISMAR) V. Spreckels (DSK) N. Benecke (DMT) U. Wegmüller C. Werner A. Wiesmann
Field of research	**:**	Earth Observation

Method

Others : EO data processing and interpretation.

Purpose of research

Land surface deformation mapping with differential SAR interferometry.

Evaluate potential and develop applications for different types of land surface deformations (subsidence caused by ground-water extraction and natural compaction, mining induced subsidence, glacier motion, land slides, seismic deformation, volcanic deformation).

Time-line from to

Planning	=>	1997 - 2005
Measurement phase	=>	1991 - 2005
Data evaluation	=>	1997 - 2005

Actual status

In the frame of projects supported by the ESA Data User Programme (DUP) and Earth Observation Market Development Programme (EOMD) GAMMA developed and demonstrated SAR interferometric deformation mapping services. The applications included subsidence caused by ground-water extraction and natural compaction, as well as subsidence related to exploration of the underground resources coal, oil, and gas. The work was supported by contacts to authorities as well as the mining and oil industry. Between Nov. 2001 and Nov. 2003 a land subsidence monitoring service in the lagoon of Venice for regional and administrative authorities, will be developed in cooperation with CNR-ISMAR, Venice, Italy as project partner.

The interferometric techniques necessary for land slide monitoring are being developed and applied to the Swiss and Italian Alps. First promising results indicate a good potential.

Three most relevant publications

1. U. Wegmüller, T. Strozzi, and L. Tosi :
   "Differential SAR interferometry for land subsidence monitoring : methodology and examples"

   Proceedings of SISOLS 2000, Ravenna, Italy, 25 -29 September 2000.

3. T. Strozzi, U. Wegmüller, L. Tosi, G. Bitelli, and V. Spreckels :
   "*Land subsidence monitoring with differential SAR interferometry*"

   Photogrammetric Engineering and Remote Sensing (PE&RS), Vol. 67, No. 11, pp. 1261 1270, Nov. 2001.

4. V. Spreckels, J. Musiedlak, U. Wegmüller, T. Strozzi, and C. Wichlacz :
   "Detection of underground coal mining-induced surface deformation by differential InSAR data"

   ISPRS WG I/2, I/5, IV/7 Workshop on High resolution mapping from space, Hannover, Germany, 19-21 Sep. 2001.

Abbreviations

EO	=	Earth Observation
SAR	=	Synthetic Aperture Radar
ESA	=	European Space Agency
DUP	=	Data User Programm
EOMD	=	Earth Observation Market Development Program

3.10 EO Application to Environmental Monitoring

Institute / Laboratory	**:**	Gamma Remote Sensing AG
In cooperation with	*:*	VTT-Automation, Finland European Forest Institute (EFI), Stora Enso, Finland Univ. Jena, Germany
Principal Investigator	**:**	U. Wegmüller
Co-investigators	**:**	C. Schmullius, (Univ. Jena) T. Häme (VTT) A. Wiesmann T. Strozzi C. Werner
Field of research	**:**	Earth Observation

Method

Others : EO data processing and interpretation.

Purpose of research

Evaluate potential and develop applications of EO data in the context of environmental monitoring, with one main focus on forest and forest change mapping and the development of carbon monitoring services related to the implementation of the Kyoto protocol.

Another focus is on the use of EO data based products as input to carbon cycle and green-house gas models.

Time-line from to

Planning	=>	1997 - 2005
Measurement phase	=>	1991 - 2005
Data evaluation	=>	1997 - 2005

Actual status

In the frame of ESA's programme TESEO (Treaty enforcement services using Earth Observation) a project for the development of carbon monitoring services related to the implementation of the Kyoto Treaty, was successfully proposed by a team lead by VTT-Automation, Finland, with the European Forest Institute (EFI), Stora Enso, Finland, and GAMMA as partners.

A project duration of 16 months is planned. GAMMA's responsibilities are to review the potential of existing and near future SAR techniques and sensors and to propose, implement, and demonstrate Kyoto related services. GAMMA participates in the EC Framework 5 project

SIBERIA II (2002-2005), which concentrates on research related to the use of EO data based products as input to carbon cycle and green-house gas models.

Three most relevant publications

1. T. Strozzi, P. B. G. Dammert, U. Wegmüller, J-M. Martinez, A. Beaudoin, J. Askne, and M. Hallikainen :
   Landuse mapping with ERS SAR interferometry, IEEE Trans. Geosci.

   Remote Sensing, Vol. 38, No. 2, pp. 766-775, 2000.

2. A. Wiesmann, L. Demargne, F. Ribbes, M. Honikel, H. Yésou, and U. Wegmüller :
   " Forest storm damage assessment with ERS Tandem data "

   Proceedings of ERS-ENVISAT Symposium, Gothenburg, Sweden, 16-20 Oct. 2000.

3. A. Wiesmann, U. Wegmüller, T. Strozzi, and C. Werner :
   " The use of JERS SAR within the boreal forest mapping project SIBERIA "

   Proceedings of IGARSS 2000, Honolulu, USA, 24-28 July 2000.

Abbreviations

EO	=	Earth Observation
SAR	=	Synthetic Aperture Radar
ESA	=	European Space Agency

3.11 SAR and SAR Interferometric Algorithms and Software Research and Development

Institute / Laboratory	**:**	Gamma Remote Sensing AG
Principal Investigator	**:**	C. Werner
Co-investigators	**:**	U. Wegmüller T. Strozzi
Field of research	**:**	Earth Observation

Method

Others : EO data processing and interpretation.

Purpose of research

SAR and SAR interferometric algorithms and software research and development as technology push to the development of EO based applications.

The activity strongly interacts with GAMMA's EO application development projects. Another objective is to keep GAMMA's high level commercial software package up-to-date.

Time-line from to

Planning => 1999 - 2003

Actual status

Recent *SAR and SAR interferometric algorithms and software* research and development included :

- the combination (stacking) of multiple interferograms to significantly reduce deformation estimation errors
- the investigation and development of alternative methods for surface deformation mapping such as intensity and coherence tracking
- phase unwrapping algorithm development using triangular network and minimum cost flow methods

In 2001, research and development of a new technique for the interferometric interpretation of the SAR image phase of point targets was started.

In 2003 adaptations to the ASAR sensor on ENVISAT, will be completed including the development of tools to explore the additional functionality of this new sensor.

Three most relevant publications

1. C. Werner, U. Wegmüller, T. Strozzi, and A. Wiesmann :
   " Gamma SAR and Interferometric Processing Software "

   Proceedings of ERS-ENVISAT Symposium, Gothenburg, Sweden, 16-20 Oct. 2000

2. C. Werner, T. Strozzi, A. Wiesmann, U. Wegmüller, T. Murry, H. Pritchard, and A. Luckman :
   " Complementary measurement of geophysical deformation using repeat-pass SAR "

   Proceedings of IGARSS 2001, Sidney, Australia, 9-13 July 2001.

3. U. Wegmüller, C. Werner, T. Strozzi, A. Wiesmann :
   "Automated and precise image registration procedures "

   Proceedings of MultiTemp2001 Workshop, Trento, Italy, 13-14 Sep. 2001 (published by World Scientific).

Abbreviations

EO	=	Earth Observation
SAR	=	Synthetic Aperture Radar
ESA	=	European Space Agency

3.12 CIRSTEN - Combined Remote Sensing Natural Disaster Monitoring

Institute Laboratory	**:**	Institute for Geodesy and Photogrammetry, ETH, Zurich
In cooperation with	*:*	Gamma Remote Sensing, Bern
Principal Investigator	**:**	Marc Honikel
Co-investigators	**:**	Urs Wegmueller Andreas Wiesmann
Field of research	**:**	Natural disasters

Purpose of research

Recent natural disasters like landslides, flooding or forest fires have shown the need for natural risk management in Europe, as they endanger directly public health and cause severe damages on the national economy.

In order to improve the efficiency of existing hazard management practices, we proposed a natural hazard and disaster monitoring service for sensitive areas. The project addresses the localisation and mapping of natural hazards using SAR and optical data from earth observation satellites, including the retrieval of both thematic and geometric information. Remote sensing data offer a regular information for prevention and damage assessment of natural disasters and provide large scale environmental monitoring and updating capabilities.

The results are stored as information layers in a geographic information system, which enables a user friendly access and compatibility with pre-existing databases. The final product is a fast, inexpensive and ready to use service for the prevention and management of natural hazards.

Time-line from to

Planning	=>	1999 - 1999
Construction	=>	2000 - 2000
Measurement phase	=>	2000 - 2002
Data evaluation	=>	2000 - 2002

Actual status

Different disasters in Switzerland have been studied : Storm Lothar, flooding of the river Aare, and occurence of avalanches. The data and the developed techniques have been successfully applied and proved their unique capability to map large scale disasters.

Two weeks after the incident, the results of our Lothar study for forest damage monitoring delivered by far the first type of that information for Switzerland, long before any official campaigns were undertaken. Independent evaluation from the French satellite carrier SPOT Image proved the correctness of our results in France. Similarly, flooding and avalanche incidents have been successfully examined in cooperation with Swiss authorities. In addition,

the combined use of stereo-optical and SAR interferometric data for digital elevation model (DEM) generation has been studied and appropriate data fusion tools have been developed. In this way, DEMs with an error of less than 5m could be derived in Switzerland. We conclude that disaster monitoring benefits from the properties and availability of both optical and SAR remote sensing data sets.

In detail :

- The SAR change detection ability and the opportunity to retrieve cloud and sun independent information
- The resolution and content of multispectral optical data
- The robust performance of DEM generation from optical data and the amount of measured points with SAR
- The thematic information included in both data
- The complementarity between the data

Three most relevant publications

1. Honikel M. (2000) :
   High quality spaceborne InSAR DEM generation for height database update, ISPRS WG II/2, Workshop on Three dimensional Mapping from InSAR and Lidar, Banff, Canada.

   July 2001, Proc. on CD.

2. Wiesmann A., Wegmueller U., Honikel M., et al. (2001) :
   Hazard mapping with multi-temporal SAR and InSAR nt. Symposium on the retrieval of Bio- and Geophysical paramters from SAR data, Sheffield, UK.

   September 2001, Proc. on CD.

3. Honikel M., Wegmueller U., Wiesmann A. (2001) :
   Das Projekt CIRSTEN. Kartierung von Naturkatastrophen mit optischen und SAR Fernerkundungsdaten DGPF Jahrestagung Geodaten schaffen Verbindungen, Konstanz, Germany.

   September 2001, Proc. on CD.

Abbreviations

DEM	=	digital elevation model
SAR	=	synthetic aperture Radar
SPOT	=	systeme pour l'observation de la terre

3.13 SPECTRA - Surface Processes and Ecosystem Changes Through Response Analysis

Institute / Laboratory	**:**	Remote Sensing Laboratories (RSL), Department of Geography, University of Zurich-Irchel, Winterthurerstrasse 190, CH-8057 Zürich
In cooperation with	*:*	ESA/ESTEC
Principal Investigator	**:**	Dr. M. Rast ESA / ESTEC
Co-investigators	**:**	SPECTRA Scientific Preparatory Group
Field of research	**:**	Earth resources, Remote Sensing

Method

Simulation, Satellite

Purpose of research

The response of vegetation to climate variability is a major scientific question. Analyses of the global carbon cycle and of terrestrial ecosystems demonstrate strong links with the observed climatic trends. The monitoring of the carbon stock in terrestrial environments, as well as the improved understanding of the surface-atmosphere interactions controlling their exchanges of matter, energy and momentum, is of immediate interest for an improved assessment of the various components of the global carbon cycle. Studies of the Earth System processes at the global scale rely on models that require an advanced understanding and proper characterisation of processes at smaller scales.

The objective of this mission is to improve the description of those processes by means of better constraints on and parameterisations of the associated models. With SPECTRA a mission is proposed that shall focus on providing the critical information needed to improve biome specific parameterizations of canopy functioning models, for a range of scales from tens of meters to tens of kilometers, and help improve the description of carbon, energy, and water cycles in global models of Earth system processes. It will therefore aim at systematically observing a series of well identified globally distributed sites representing a large range of biomes and ecosystems. A combination of model up-scaling efforts and observations from a panoply of coarse spatial resolution sensors will link this local description of processes to global modeling of the Earth System. Therefore, the mission must improve the consistency of the biome and ecosystem specific model parameterization when global models are assimilating remote sensing data provided by the series of coarse resolution sensors.

The SPECTRA mission would be characterised by a single satellite - single instrument solution composed of :

- a platform anticipated to fly in a near-polar orbit, providing access to all land areas with the required spatial and temporal characteristics

- a sensor providing the required radiometric, spectral and directional performance in the visible to the thermal infrared domains

Time-line from to

Planning	=>	1998 - 2001
Construction	=>	2002 - 2008
Measurement phase	=>	2008 - 2012

Actual status

The SPECTRA mission has been selected at the *'Earth Explorers Granada 2001 User Consultation Meeting '* for industrial feasibility studies from 2002-2003.

Three most relevant publications

1. ESA (M. Rast) (ed.) :
   SPECTRA - Surface Processes and Ecosystem Changes Through Response Analysis.

   ESA-Publication SP-1257(5), September 2001.

2. M. Menenti, M. Rast, F. Baret, W. Mauser, J. Miller, M. Schaepman, D. Schimel, and M. Verstraete :
   Understanding vegetation response to climate variability from space : the concept of the SPECTRA Mission.

   Global Change Open Science Conference, Amsterdam July 10th - 13th 2001, in print.

3. M. Menenti, M. Rast, F. Baret, W. Mauser, J. Miller, M. Schaepman, D. Schimel and M. Verstraete :
   Understanding vegetation response to climate variability from space : the scientific objectives, the approach and the concept of the SPECTRA Mission.

   4th International Scientific Conference on the Global Energy and Water Cycle, Paris, September 10th - 14th 2001, in print.

Abbreviation

SPECTRA	=	Surface Processes and Ecosystem Changes Through Response Analysis

3.14 Airborne Millimeterwave Stratospheric Observing System (AMSOS)

Institute / Laboratory	**:**	Institute of Applied Physics, University of Bern, Sidlerstrasse 5, 3012 Bern, Switzerland
Principal Investigator	**:**	Dr. Dietrich G. Feist
Co-investigators	**:**	Prof. Dr. Niklaus Kämpfer
Field of research	**:**	Atmosphere

Method

Research based on existing instruments :

Retrieval of vertical profiles of stratospheric water vapor from atmospheric microwave spectra. The instrument has been constructed at our institute and is used on a campaign basis about once per year.

Purpose of research

Water vapor is one of the most important trace gases is the middle atmosphere. It is involved in a large number of chemical as well as dynamical processes throughout the stratosphere and mesosphere. Water vapor molecules in the atmosphere emit microwave radiation at several distinct frequencies that can be detected with a microwave radiometer from the shape of the detected lines, the vertical distribution of the water vapor molecules can be derived. This method allows remote sensing of stratospheric water vapor profiles above the instrument in a range of roughly 15-60 km altitude.

Our instrument can be used onboard an aircraft as well as on the ground from a high-altitude site. Operation from an aircraft allows measurements over a large geographical while ground-based operation allows continuous observations over extended periods of time. The observed water vapor profiles show patterns and changes in stratospheric circulation that could be related to global change.

Time-line from to

Planning	=>	fall of 1997 to spring 1998 (last major refurbishment)
Construction	=>	first half of 1998
Measurement phase	=>	yearly campaigns or continuous operation since August 1998
Data evaluation	=>	from end of campaign to approx. 6 months after a campaign

Actual status

The instrument is currently being upgraded with a more sensitive receiver, new quasi-optics and new software. Therefore, it is currently not in ground-based operation on the International Scientific Station Jungfraujoch as it has been during the previous two winters.

The last flight campaign took place in September 2002 and covered almost all latitudes on the northen hemisphere. A similiar flight campaign is planned for summer/fall of 2003.

Two most relevant publications

1. A. Siegenthaler, O. Lezeaux, D. G. Feist, N. Kämpfer :
   First water vapor measurements at 183 GHz from the high alpine station Jungfraujoch,

   IEEE Trans. Geosci. Remote Sens., Vol. 39, No. 9, pages 2084-2086, 2001.

2. R. Peter :
   Stratospheric and mesospheric latitudinal water vapor distributions obtained by an airborne millimeter-wave spectrometer.

   J. Geophys. Res., Vol. 103, No. D13, pages 16275, 16290, 1998.

3.15 Cloudmap (till January 2001)
Cloudmap2 (from February 2001)

Institute / Laboratory	**:**	Institute of Geodesy and Photogrammetry, ETHZ	
In cooperation with	*:*	UCL (UK) DLR (D) FUB (D) KNMI (NL)	MeteoSwiss (CH) SMHI (S) RAL (UK)
Principal Investigator	**:**	J.P. Muller (UCL)	
Field of research	**:**	Atmosphere	

Method

Research based on existing instruments :

ERS-2 ATSR2, MOMS, EOS-Terra MISR, Meteosat-6/-7
Aircraft, Satellite
Others : ground-based optical imagers

Purpose of research

The EU-FP4 project Cloudmap aimed to develop algorithms for new cloud-top products (heights, type, optical thickness, effective droplet size), especially for cirrus and contrail clouds from existing and new sensors, using three different techniques (brightness temperature with CO2 slicing method, stereoscopy and Oxygen A-band). These cloud-top products have been validated using airborne sensor underflights, multi-resolution contemporaneous observations from space sensors and ground-based remote-sensing instruments.

Cloudmap ended in January 2001 and is now continued by the EU-FP5 project Cloudmap2. Cloudmap2 aims to produce and exploit value-added remote sensing data products on macroscopic (e.g.cloud-top height) and microscopic (e.g. cloud droplet radius) properties and water vapour distributions in order to characterise sub-grid scale processes within Numerical Weather Prediction Models (NWP) through validation and data assimilation.

Current and near-future Earth Observation (EO) data, provided by ESA, EUMETSAT and NASA will be used to derive geophysical value-added data products over Europe and the North Atlantic region, whenever possible in near real-time. Ground-based active (cloud radar, ceilometer) and passive (stereo imager system, IR camera) remote-sensing instruments will be used to validate the EO-derived products as well as to be merged with the satellite-based results for a full 3D representation of the clouds. Numerical simulation experiments based on state-of-the-art radiative transfer methods will be used to quantify the effect of broken clouds on the Earth's radiation budget and lead to a better representation of clouds within NWP models. The role of ETH in Cloudmap and Cloudmap2 is to estimate cloud-top height (CTH) and wind (CTW) from stereo images from satellites and cloud-bottom height (CBH) and wind (CBW) from stereo images acquired by their own ground-based stereo imager system, with stereo-photogrammetric techniques. The cloud-top and -bottom results will then be combined and visualized in 3D. For the CTH estimation, both unrectified and rectified images are used. A general sensor model needs to be developed for the orientation of unrectified images from CCD linear array sensors with along stereo viewing. The model will be applied to different sensors and will take into account any additional parameters about the sensor interior and external orientation.

Time-line from to

Planning	=>	02-2000 - 03-2000
Measurement phase	=>	selected cases
Data evaluation	=>	02-2000 - 02-2003

Actual status

A sensor model for CCD linear array sensors with along-track stereo viewing has been developed. This model can provide direct or indirect georeferencing. If the sensor internal and external orientation are known from pre-flight calibration, GPS/INS observations or ephemeris data, the direct georeferencing algorithm estimates the object coordinates of homologous points, measured in at least 2 images, through a least squares forward intersection, without using any ground control points (GCPs).

On the other hand, the indirect georeferencing algorithm models the sensor external orientation, if it is unknown or not accurate enough, with piecewise second-order polynomial functions depending on time. Using GCPs and, additionally, tie points (TPs), the functions parameters of each piece and the ground coordinates of the TPs are estimated in a least squares adjustment.

The model has been developed for sensors whose optical system consists of one or more lenses; in case of multi-lens sensors, relative orientation parameters have been introduced between the lenses. The model was successfully tested on different CCD linear sensors carried on helicopter (Three-Line Sensor by Starlabo) and satellite (MOMS-02 by DLR) and will be applied on the unrectified images (level1B1) by MISR, which consists of 9 lenses and is carried on the EOS-AM1 spacecraft. First tests have been carried out.

The CTH estimation obtained applying the sensor model on the unrectifed images will be compared to the estimation from rectified images (level1B2) of the same sensor. In order to estimate CTH from rectified images, the along- and cross-track parallaxes of stereo pairs are automatically retrieved with the cloud-adapted multi-photo matching algorithm based on least-squares matching, developed at our Institute. The algorithm was applied on MISR and ATSR2 rectified images.

For a non-moving object, the cross-track parallax is zero (assuming minimal rectification errors) and the CTH can be calculated from the along-track parallax. For a moving object like clouds, the motion within the time delay of acquisition between the two views can contribute significantly to the along-track parallax, depending on the cloud motion direction. A new method was developped in order to correct this motion error with Meteosat-6 Rapid Scan or Meteosat-7 images. Another approach for multi-line sensors like MISR is to use at least three non-symmetric views and estimate simultaneously CTH and CTW.

A ground-based sky imager system consisting of 3 digital cameras with wide-angle lenses has been established. The internal of the cameras has been precisely determinated with close-range calibration, while for the external orientation “sky” ground control points (stars, aircraft) have been used. The CBH can be estimated from the stereo-images using photogrammetric methods and the cloud-adapted least-squares multi-photo matching.

The estimated CTH and CBH will be visualized in 3D models. Commercial softwares and other tools available at our institute have been investigated and tested. For animation, particle systems will be used, while for static visualization volume rendering will be applied.

Three most relevant publications

1. Seiz G. and Baltsavias E. (2001) :
   Comparison of satellite-based cloud-top height and wind from MISR, ATSR2 and Meteosat-6 Rapid Scans.

   EUMETSAT Users' Conference, 1-5 October 2001, Antalya.

2. Poli D. (2002) :
   General model for airborne and spaceborne linear array sensors.

   ISPRS Commission I Symposium, 9-15 November 2002, Denver, CO.

3. Seiz G. and Baltsavias E. (2001) :
   Cloud mapping using ground-based imagers.

   11th AMS Symposium on Meteorological Observations and Instrumentation, Albuquerque, 15 - 18 January 2001.

IV Solar Physics

4.1 Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI)

Institute / Laboratory	**:**	Institute of Astronomy, ETH Zurich
In cooperation with	:	University of California, Berkeley, USA Goddard Space Filght Center, Greenbelt, USA Paul Scherrer-Institut, Villigen, CH
Principal Investigator	**:**	R. P. Lin
Co-investigators	**:**	A. O. Benz (ETHZ) B.R. Dennis (Goddard SFC) A. Zehnder (PSI)
Field of research	**:**	Solar physics

Method

Development and construction of own instruments :

At ETH Zurich a data center has started to operate. Science data analysis software, user interface, data archive and internet connections have been produced.
Satellite

Purpose of research

The energy release of flares is a nonthermal process that accelerates electrons and ions to relativistic velocities. They can best be studied by emissions in hard X-Rays, Gamma-Ray lines and radio waves. An Small Explorer class satellite has been built by NASA with a strong Swiss envolvement.

The HESSI Experimental Data Center (HEDC) has been developed as a collaboration between three institutes at ETH Zurich (Astronomy, Computer Systems and Information Systems) to cope with the flow of RHESSI data and distribute them in Europe. Images and light curves are reconstructed at HEDC from single photon energy and time data. The data products demand considerable computing time. They are stored and can be browsed through the Internet. This greatly facilitates the overview on existing data and the selection for further analysis.The user also can have more products computed on-line and store them in the archive that is automatically growing in information on interesting events. A workshop on RHESSI Data Analysis will be held at ETH from April 18 to 20, 2002.

Time-line from to

Planning	=>	1998 - 1999
Construction	=>	2000 - 2003
Measurement phase	=>	2001 - 2003
Data evaluation	=>	2001 - 2005

Actual status

RHESSI was launched on February 5, 2002. The data are coming in every few hours through Internet and are stored in HEDC. First data products are currently being produced. The satellite is not yet in full operation as the roll angle is not known and cannot be easily determined as there is more Earth shine than expected and more errounous peaks in the light curve mimicking stars. There is no principal error in the system, but the fine tuning will take more time than expected. A temporary system will operate starting in early April 2002.

RHESSI data are complemented by radio observations by the ETH spectrometer PHOENIX-2 in Bleien (Switzerland) as well as observations by the VLA in the summer of 2002.

Three most relevant publications

1. R.P.Lin et al. (1997) :
   The High Energy Solar Spectroscopic Imager (HESSI).

   Small-Class Explorer, Proposal in response to NASA AO-97-OSS-03.

2. A.O. Benz, P. Saint-Hilaire and N.R. Vilmer (2002) :
   Location of narrowband spikes in solar flares.

   Astronomy and Astrophysics 383, 678-684.

3. S. Krucker, A.O. Benz, L.W. Acton, T.S. Bastian (1997) :
   Yohkoh observations of the source regions of solar, narrowband, millisecond spike events.

   Astronomy and Astrophysics 317, 569-579.

Abbreviations

RHESSI	=	Reuven Ramaty High Energy Solar, Spectroscopic Imager
PHOENIX	=	Radio spectrometer of ETH Zurich in Bleien, near Graenichen, AG
VLA	=	Very Large Array, radio interferometer in New Mexico
HEDC	=	HESSI Experimental Data Center

4.2 Coronal Holes Versus quiet Sun

Institute / Laboratory	**:**	Institute of Astronomy, ETHZ, CH-8092 Zürich
In cooperation with	*:*	Max-Planck-Institut für Aeronomie, Katlenburg-Lindau, Germany
Principal Investigator	**:**	S.K. Solanki
Co-investigators	**:**	K.Stucki, J.O.Stenflo M.C.E. Huber
Field of research	**:**	Solar physics

Method

Research based on existing instruments :

Satellite : SOHO (SUMER,CDS)

Purpose of research

The aim of the project is to determine how the fast solar wind is accelerated in coronal holes. For this we have analysed UV spectral lines in high-resolution Spectra obtained with SUMER on SOHO, complemented by CDS data from SOHO.

With lines formed at different temperatures we have explored the thermal, dynamic and to some extent the magnetic structure of the upper solar atmosphere, i.e. the chromosphere, the transition zone and the corona, which has allowed us to identify the underlying physical processes.

Time-line from to

Measurement phase	=>	1996 - 1997
Data evaluation	=>	1997 - 2001

Actual status

This project was carried out as a PhD thesis work by Katja Stucki. It came to a conclusion with the successful completion of her dissertation and thesis defense in April 2001.

Three most relevant publications

1. Stucki K., Solanki S.K., Schühle U., Rüedi I. :
   On the relationship between shift and intensity of ultraviolet lines in coronal holes and the quiet Sun.

   Astron. & Astrophys. 362 (2000), L49-L52.

2. Stucki K., Solanki S.K., Schühle U., Rüedi I., Wilhelm K., Stenflo J.O., Brkovi'c A., Huber M.C.E. :
   Comparison of far-ultraviolet emission lines formed in coronal holes and the quiet Sun.

   Astron. & Astrophys. 363 (2000), 1145-1154.

3. Stucki K. :
   Solar coronal holes observed with SOHO.

   Göttingen (Cuvillier), ISBN 3-89873-260-6. PhD thesis, ETH No. 14140 (2001).

Abbreviations

SOHO	=	Solar and Heliospheric Observatory
SUMER	=	Solar Ultraviolet Measurements of Emitted Radiation
CDS	=	Coronal Diagnostic Spectrometer

4.3 Dynamics and Heating of the Solar Chromosphere and Corona

Institute / Laboratory	**:**	Institute of Astronomy, ETH Zürich
In cooperation with	:	Max-Planck-Institut für Aeronomie, Katlenburg-Lindau, Germany
Principal Investigator	**:**	Sami K. Solanki
Co-investigators	**:**	A. Brkovic Rüedi J.O.Stenflo M.C.E. Huber
Field of research	**:**	Solar physics

Method

Research based on existing instruments :

CDS, EIT, MDI and SUMER instruments onboard the SOHO satellite and SXT instrument onboard the YOHKOH satellite.
Satellite

Purpose of research

The project aims at a better understanding of the structure, dynamicsand energetics of the upper solar atmosphere. The project consists of 3 parts :

Part 1
Variability in the quiet solar atmosphere :

The study of solar variability provides clues for understanding how the solar chromosphere, transition-region and corona are heated, since heating events, be they due to magnetic reconnection or the dissipation of wave pulses, are expected to produce transient brightenings in the emission from the relevant atmospheric layers. The Coronal Diagnostic Spectrometer (CDS) onboard the SOHO satellite has been used to obtain movies of quiet Sun regions at disc centre. These movies were used to study brightness variations of solar features at three different temperatures sampled simultaneously in the chromospheric He~I 584.3 A, the transition region O~V 629.7 A and coronal Mg~IX 368.1 lines.

Part 2
Blinker analysis :

Blinkers are transient brightenings seen in the extreme ultraviolet. They are candidates for microflare activity at transition-region temperatures. Their thermal energy content is reported to be on the order of 10^25 ergs or 10^-6 times that of a 'standard' flare. The same data used for Part 1) were used for this work as well.

Part 3
Tests of solar loop models

The aim of this work is to test simple relations between fundamental properties (temperature, length, pressure and heating rate) of quasi-steady coronal loops, as well as to test the loop model of Landini & Monsignori Fossi. We use observations carried out using several instruments onboard SOHO (CDS, EIT and MDI) as well as the soft X-ray telescope (SXT) on YOHKOH.

Time-line from to

Measurement phase	=>	18. 11.1996 / 20.12.1996 / 14. 04.1997 / 01.05.1997
Data evaluation	=>	1997 - 2001

Actual status

This project was carried out as a PhD thesis work by Alen Brkovic.

It came to a conclusion with the successful completion of his dissertation and thesis defense in June 2001.

Three most relevant publications

1. Brkovìc A., Rüedi I., Solanki S.K., Fludra A., Harrison R.A., Huber M.C.E., Stenflo J.O., and Stucki K. :
   EUV brightness variations in the quiet Sun.

   Astron. & Astrophys. 353 (2000), 1083-1093.

2. Brkovìc, A., Solanki, S.K.; Rüedi, I. :
   Analysis of blinkers and EUV brightenings in the quiet Sun observed with CDS.

   Astron. & Astrophys. 373 (2001), 1056-1072.

3. Brkovìc, A. :
   Structure and Variability of the Upper Solar Atmosphere observed with SOHO.

   Göttingen (Cuvillier), ISBN 3-89873-158-8, PhD thesis, ETH No. 14214 (2001).

4.4 Spectroradiometric in-Orbit Intercalibration of the UV Investigations on SOHO

Institute / Laboratory	**:**	Institute of Astronomy, ETH Zentrum, CH-8092 Zürich
In cooperation with	*:*	Max-Planck-Institut für Aeronomie, Katlenburg-Lindau, Germany INTEC, HTA Bern, Morgartenstr.2c, CH-3000 Bern
Principal Investigator	**:**	S.K. Solanki
Co-investigators	**:**	A. Pauluhn J.O. Stenflo M.C.E. Huber
Field of research	**:**	Solar physics

Method

Research based on existing instruments :

Satellite : CDS and SUMER on SOHO

Evaluation and intercalibration of a large data set of quiet sun measurements from the two instruments on board of SOHO.

Purpose of research

The intercalibration programme of the two telescopes and spectrometers SUMER and CDS on SOHO was designed in order to continuously monitor and compare their performance.

For this purpose a special observing sequence was established which consists of simultaneous measurements of the two instruments of a common area on the solar surface that is devoid of active regions (quiet Sun). These measurements have been made in three wavelengths regularly once per month since SOHO's routine observations started in March 1996.

Additionally, the large data set provides a good basis for statistical investigations of the long term behaviour of the quiet Sun.

Time-line from to

Measurement phase	=>	Mar. 1996 - Dec. 1999
Data evaluation	=>	Apr. 1998 - Sep. 2000

Actual status

The quiet Sun radiance values of CDS and SUMER have been compared for the time period from March 1996 until the loss of spacecraft in June 1998.

The instruments show reasonably good agreement in all three wavelength bands under study.

The statistical analysis of the large data sets resulted in accurate fits of theoretical distribution functions.

Also, the period after SOHO's recovery has been investigated, including the last available measurements (Aug. 1999 to Dec. 1999) for the CDS-SUMER intercalibration programme INTERCAL_1. The project was concluded in 2001.

Three most relevant publications

1. Pauluhn A., Solanki S.K., Rüedi I., Landi E., Schühle U. :
   Statistics of quiet Sun extreme ultraviolet intensities.

   Astron. & Astrophys. 362 (2000), 737-745.

2. Pauluhn A., Rüedi I., Solanki S.K., Lang J., Schühle U., Wilhelm K., Thompson W.T., Hollandt J., Huber M.C.E. :
   Intercalibration of SUMER and CDS on SOHO. II. SUMER A and B detectors and CDS NIS.

   Appl. Opt. 40 (2001), 6292-6300.

3. Pauluhn A., Solanki S.K., Schühle U., Wilhelm K., Lang J., Thompson W.T., Rüedi I., Hollandt J., Huber M.C.E. :
   Comparison of quiet-Sun radiances measured by CDS and SUMER on SOHO.

   Space Sci. Rev. 97 (2001), 63-66.

Abbreviations

SOHO	=	Solar and Heliospheric Observatory
SUMER	=	Solar Ultraviolet Measurements of Emitted Radiation
CDS	=	Coronal Diagnostic Spectrometer

4.5 Reconstruction of Solar Irradiance Variations from the Surface Distribution of the Solar Magnetic Field

Institute / Laboratory	**:**	Institute of Astronomy, ETH Zentrum, CH-8092 Zürich
In cooperation with	*:*	Max-Planck-Institut für Aeronomie, Katlenburg-Lindau, Germany Physikalisch-Meteorologisches Observatorium Davos Institut für Astronomie, Universität Wien
Principal Investigator	**:**	S.K. Solanki
Co-investigators	**:**	M.Fligge T. Wenzler M. Haberreiter W. Schmutz J.O.Stenflo Y.C.Unruh
Fiel of research	**:**	Solar physics

Method

Research based on existing instruments :

MDI to extract the surface distribution of solar magnetic features as a function of time
VIRGO to compare the reconstructions to measured total and spectral irradiance variations.
Satellite

Purpose of research

There is an urgent need for detailed studies of the effect of man-made greenhouse gases on the Earth's atmosphere and climate. One of the unknown boundary conditions for models of the evolution of the Earth's climate is the future variation of the solar irradiance (i.e. the total solar brightness measured at the Earth).

Although it is qualitatively known that the solar irradiance variations are caused by the Sun's magnetic field, the quantitative connection between the two is virtually unexplored. Without this knowledge it may be impossible to predict solar irradiance variations.

Our aim is to put the connection between the structure and distribution of solar magnetic features and the solar brightness on a firm quantitative basis and to enhance our understanding of this connection.

Time-line from to

Data evaluation => 1998 - 2003

Actual status

We modelled solar irradiance variations based on variations of the surface distribution of the solar magnetic field. The irradiance reconstruction makes use of sunspot and facular contrasts calculated as a function of wavelength and limb angle on the Sun. The position and size of magnetic features on the solar disk are extracted from full-disk magnetograms obtained by the Michelson Doppler Interferometer (MDI) onboard the SOHO spacecraft.

In the summer of 2001 a collaborative "Polyproject" between 4 institutes (Physikalisch-Meteorologisches Observatorium Davos and the three ETH institutes for Astronomy, Climatology, and Atmospheric Physics) was started, with the aim of exploring the climatological response of the Earth's atmosphere to the highly variable UV radiation from the Sun.

In the context of this joint project we shifted the emphasis to the translation of solar magnetograms into solar irradiance, both in the visible, but in particular in the UV where the stratospheric ozone absorption bands are located. We used powerful radiative-transfer codes to model the Spectra from various magnetic regions on the Sun. The computed spectral variations will be used as input for general circulation models to simulated Earth's climatological response.

Three most relevant publications

1. Fligge M., Solanki S.K., Unruh Y.C. :
   Modelling irradiance variations from the surface distribution of the solar magnetic field.

   Astron. & Astrophys. 353 (2000), 380-388.

2. Fligge M., Solanki S.K., Unruh Y.C. :
   Modelling Short-term Spectral Irradiance Variations.

   Space Science Review 94 (2000), 139-144.

3. Fligge M., Solanki S.K. :
   The solar spectral irradiance since 1700.

   Geophys. Res. Lett. 27 14 (2000), 2157.

Abbreviations

SOHO	=	Solar and Heliospheric Observatory
VIRGO	=	Variability of solar Irradiance and Gravity Oscillations

4.6 Isotopic Composition of the Solar Wind

Institute / Laboratory	**:**	Physikalisches Institut, University of Bern
In cooperation with	*:*	University of Maryland University of Michigan University of New Hampshire University of Kiel, Germany
Principal Investigator	**:**	Peter Bochsler
Co-investigators	**:**	Peter Wurz Xuyu Wang
Field of research	**:**	Solar physics Origin of the solar system

Method

Research based on existing instruments :

Satellite : MTOF on SOHO, SWIMS on ACE, MASS on Wind
Others : space craft

Purpose of research

Because of the tiny variations in the isotopic composition of refractory elements in various solar-system bodies, we may confidently assume that the solar isotopic composition of refractory elements (such as Mg, Si) is the same as in meteorites and the Earth. Because the volatile elements did not condense completely in comets, meteorites, or terrestrial planets, the Sun is the only reliable and available source of the isotopic composition of these elements as they were contained in the presolar nebula.

Possible isotope-fractionating effects can be understood by comparing the isotopic composition of refractory elements measured in the solar wind and in meteorites. Once these effects have been understood, the corresponding corrections can be applied to the volatile solar wind elements to obtain their pure, presolar abundances.

Time-line from to

Measurement phase => ongoing
Data evaluation => ongoing

Actual status

We have recently published the isotopic composition of three important elements :

Ar (Weygand et al, 1999), Fe (Wurz, 1999; Ipavich et al.,2001), and O (Wimmer Schweingruber et al., 2001).

We plan to publish the composition of S and Cl.

Three most relevant publications

1. J. Weygand, F. M. Ipavich, P. Wurz, J. A. Paquette, and P. Bochsler :
   " Determination of the argon isotopic ratio of the solar wind using SOHO/CELIAS/MTOF "

   Proceedings of the SOHO-8 workshop :
   " Plasma Dynamics and Diagnostics in the Solar Transition Region and Corona "

   ESA SP 446, pp 701 - 705, (1999).

2. F. M. Ipavich, J. A. Paquette, P. Bochsler, S. E. Lasley, and P. Wurz :
   " Solar wind iron isotopic abundances : Results from SOHO/CELIAS/MTOF " in
   " Solar and Galactic Composition "

   R. F. Wimmer-Schweingruber, ed., AIP conference proceedings, Melville, New-York, USA, pp. 121-126, (2001).

3. R. F. Wimmer-Schweingruber, P. Bochsler, and G. Gloeckler :
   " The isotopic composition of oxygen in the fast solar wind : ACE/SWIMS "

   Geophys. Res. Lett., 28, 2763 - 2766, (2001).

4.7 Investigations of the History of the Heliosphere

Institute / Laboratory	**:**	Physikalisches Institut, University of Bern
Principal Investigator	**:**	Robert F. Wimmer-Schweingruber
Co-investigators	**:**	Peter Bochsler
Field of research	**:**	Heliosphere

Method

Simulation, Theory
Others : Data interpretation

Purpose of research

Solar wind implanted in surface layers of lunar regolith grains has often been analyzed to infer the history of the solar wind.

In somewhat deeper layers, and thus presumably at higher implantation energies, a mysterious population, dubbed "SEP" for ``solar energetic particle", accounts for the majority of the implanted gas - 4 to 5 orders of magnitude more than expected from the flux of solar energetic particles. Its isotopic composition is distinct from the solar system. While the heavy Ne isotopes are enriched relative to 20Ne, 15N is depleted relative to 14N - a behaviour that is hard to explain with acceleration of solar material. N is overabundant with respect to the noble gases (especially Ar).

Actual status

We have investigated a major component (the "SEP" population) of the noble gas inventory in lunar soils and meteorites that has remained ununderstood since its discovery three decades ago. We have put forth a new interpretation of the so-called "SEP" population that has the strength that it can explain the amounts, probable implantation energies, and composition of the "SEP" particles. We show that interstellar pick-up ions that are efficiently accelerated in the heliosphere when it passes through dense interstellar clouds can account for the properties of the "SEP" population. This interpretation implies that lunar soils serve as an archive for the galactic environment of the solar system, or, to state it more fashionably, as an archive for solar system "climate", or as a ``travel diary" for the galactic voyage of the solar system.

During its history since its formation 4.57 bilion years ago, the solar system must have passed through many different galactic environments. Encounters with dense interstellar clouds have left their imprints in lunar and asteroidal soils. The so-called "SEP" component, a strongly overabundant population of noble gases (when compared to expectations based on present-day fluxes) is compositionally distinct from implanted solar wind and was also implanted at higher energies, 5 keV < E/m < 0.1 MeV/nuc. This component cannot be explained by a more active Sun in the past.

During encounters with dense clouds, the flux of interstellar pick-up ions increases because of the greatly enhanced abundance of interstellar material in the heliosphere. The ensuing compression and enhanced turbulence strongly accelerates pick-up ions to the energies needed to explain the "SEP" component. Pick-up ions are very efficiently accelerated because of their already high initial energy. We have investigated the long-term expectation value for the amount of implanted interstellar pick-up ions in lunar soils and find that it is on the order of 300 times its present-day value. In situ measurements with SEPICA on the ACE spacecraft have shown that presently, interstellar Ne accounts for about 10% of suprathermal Ne (at somewhat higher energies than investigated in our work), hence we see that in the long term, the interstellar medium contributes the dominant part of the fluence of suprathermal particles implanted in lunar soils.

Three most relevant publications

1. Wimmer-Schweingruber R.F. and Bochsler P. :
   " Is there a record of interstellar pick-up ions in the lunar regolith ? " in
   " Acceleration and Transport of Energetic Particles Observed in the Heliosphere "

   R. A. Mewaldt et al., eds., AIP conference proceedings, Woodbury, New York, pp 270 273, (2000).

2. Wimmer-Schweingruber R.F. and Bochsler P. :
   " Particles in the Heliosphere: From Solar Wind to EnergeticParticles - Implications for Lunar Soils and the InterstellarMedium " in *" The Outer Heliosphere : The Next Frontiers "*

   K. Scherer et al., eds., Pergamon, Amsterdam, pp 507 -510, (2001).

3. Wimmer-Schweingruber R.F. and Bochsler P. :
   " Lunar Soils : A Long-Term Archive for the Galactic Environment of the Heliosphere ? " in
   "solar and Galactic Composition "

   R.F. Wimmer-Schweingruber, editor, AIP conference Proceedings, Woodbury, New York, pp 309, 404 (2001).

4.8 SOHO/CELIAS : Solar Wind and Suprathermal Particles

Abundances of Elements, Charge States and Isotopes and Kinetic Properties of Heavy Ions.

Institute / Laboratory	**:**	Physikalisches Institute, University of Bern
In cooperation with	*:*	Max-Planck-Institut für Extraterrestrische Physik, Garching, Germany University of Maryland, College Park, NH, USA University of New Hampshire, Durham, NH, USA
Principal Investigator	**:**	Prof. Peter Bochsler, Physikalisches Institut, University of Bern
Co-investigators	**:**	H. Balsiger K. Bamert P. Wurz
Field of research	**:**	Solar physics

Method

Research based on existing instruments :

CELIAS instrument on the SOHO spacecraft.
Satellite

Purpose of research

Investigation of the solar wind composition.

Abundances of approximately 20 elements and their isotopes are studied in detail for different solar wind conditions.

Diagnostics of coronal conditions with charge state distributions of heavy ions.

Study of the temporal evolution of transient events (e.g. Coronal Mass Ejections) in the main energy range of the solar wind and for suprathermal particles.

Time-line from to

Data evaluation => ongoing

Actual status

SOHO was launched on December 2nd, 1995.

The CELIAS instrument is stilloperating nicely.

Data analysis, interpretation, and modelling are in progress. In addition, post-launch calibration in the Mefisto calibration facility of the University of Bern using the flight spare instrument is under way.

Three most relevant publications

1. P. Wurz, P. Bochsler, J.A. Paquette, and F.M. Ipavich :
   " The Calcium Abundancein the Solar Wind "

   Astrophys. Jou, 583 (2003), 489-495.

2. J.M. Weygand, F.M. Ipavich, P. Wurz, J.A. Paquette, and P. Bochsler :
   " Determination of the 36Ar/38Ar isotopic abundance ratio of the solar wind using SOHO / CELIAS / MTOF "

   Geochim. Cosmochim. Acta 65(24), (2001) 4589-4596.

3. K. Bamert, R.F. Wimmer-Schweingruber, R. Kallenbach, M. Hilchenbach, B.Klecker, A. Bogdanov, and P. Wurz :
   " *Origin of the May 1998 SuprathermalParticles : Solar and Heliospheric Observatory / Charge, Element, and Isotope Analysis System/(Highly) Suprathermal Time of Flight results "*

   J. Geophys. Res.107(A8), (2002) 10.1029/2001JA900173.

Abbreviations

SOHO	=	Solar and Heliospheric Observatory
CELIAS	=	Charge, Element and Isotope Analysis System

4.9 VIRGO Investigation on SOHO

Institute / Laboratory	**:**	PMOD/WRC, Davos	
In cooperation with	*:*	Multi-national H/W institutes : IRMB, Brussels, IAC, Tenerife, SSD of ESA, Noordwjik	
Principal Investigator	**:**	Claus Fröhlich	
Co-investigators	**:**	Andersen B. Appourchaux T. Berthomieu G. Crommelynck D.A. Dewitte S. Domingo V. Gough D.O. Jiménez A. Joukoff A. Leifsen T.	Pap J.M. Provost J. Roca Cortés T. Rüedi I. Schmutz W. Sekii T. Toutain T Wachter R. Wehrli C. Solanki S.K.
Field of research	**:**	Solar physics	

Method

Research based on existing instruments :

Satellite : VIRGO on SoHO

Purpose of research

Solar irradiance variability and Helioseismology with two type of absolute radiometers, sunphotmeters and a luminosity oscillation imager.

Time-line from to

Measurement phase => since 1996
Data evaluation => since 1996

Actual status

Running Experiment on a running spacecraft.

Three most relevant publications

1. Toutain T., Appourchaux T., Fröhlich C., Kosovichev A., Nigam R. and Scherrer P. :
   1998 a, Asymmetry and frequencies of low-degree p-modes and the structure of the sun's core.

   Astrophys. J. 506, L147 - L152.

2. Fröhlich C. and Lean J. : 1998b, The sun's total irradiance :
   Cycles and trends in the past two decades and associated climate change uncertainties.

   Geophys. Res. Let. 25, 4377-4380.

3. Appourchaux T., Fröhlich C., Andersen B., Berthomieu G., Chaplin W., Elsworth Y., Finsterle W., Gough D., Hoeksema J., Isaak G., Kosovichev A., Provost J., Scherrer P., Sekii T., and Toutain T. :
   2000, Observational upper limits for low-l solar g modes.

   Astrophys. J., 538, 401-414.

Abbreviations

VIRGO	=	Variability of Irradiance and Gravity Oscillations
SOHO	=	Solar and Heliospheric Observatory

4.10 SOVIM Investigation on the International Space Station

Institute / Laboratory	**:**	PMOD/WRC, Davos	
In cooperation with	*:*	H/W institutes : IRMB, Brussels, SSD of ESA, Noordwjik	
Principal Investigator	**:**	Claus Fröhlich	
Co-investigators	**:**	Appourchaux T. Crommelynck D.A. Dewitte S. Domingo V. Fleck B. Joukoff A.	Lean J. Rüedi I. Schmidtke G. Schmutz W. Thuiller G. Wehrli C.
Field of research	**:**	Solar physics	

Method

Development and construction of own instruments :

2 type of radiometers (PMO6-V, DIARAD), SPM, TASS.
Satellite

Purpose of research

Solar irradiance variability and spectral redistribution with two type of absolute radiometers and sunphotmeters (continuation of VIRGO, but no helioseismology).

Time-line from to

Planning	=>	started in 1996 - 2002
Construction	=>	started in 1999 - 2003
Measurement phase	=>	launch foreseen in 2004

Actual status

Planing in due course, manufacturing started.

One most relevant publication

1. Thuiller G., Fröhlich C., and Schmidtke G. (1999) :
   Spectral and total solar irradiance measurements on board the international space station.
   Proceedings of the 2nd European Symposium on the Utilisation of the International Space Station.

   ESA Publications Division, ESA SP 433, Noordwijk, The Netherlands, 605 - 611.

Abbreviations

SOVIM	=	Solar Variability and Irradiance Monitoring
VIRGO	=	Variability of Irradiance and Gravity Oscillations
SOHO	=	Solar and Heliospheric Observatory

4.11 PREMOS - Investigation on the French Satellite PICARD

Institute / Laboratory	**:**	PMOD / WRC, Davos
In cooperation with	*:*	H/W institutes : Centre National d'Etudes Spatiales Service d'Aéronomie du CNRS (SA), IRMB (Brussels)
Principal Investigator	**:**	PICARD : Gérard Thuillier; PREMOS : Werner Schmutz
Co-investigators	**:**	PMOD/WRC : Rozanov E., Rüedi I., Wehrli C.
Field of research	**:**	Solar – Terrestrial Relation

Method

Satellite observations.

PICARD is a microsatellite built by CNES. It will carry three instruments :
- PREMOS (PREcision Monitor for Solar Oscillation) under the PMOD responsibility.
- SODISM (SOlar DIameter and Surface Mapper) under the SA responsibility.
- SOVAP (SOlar VAriability PICARD) under the IRMB responsibility.

PMOD is in charge of the development and construction of the PREMOS 4-channel filters radiometer, preparation of the PREMOS data processing, and scientific interpretation.

Purpose of research

PREMOS :

UV irradiance at two selected wavelengths (215 and 265 nm); important for the ozone equilibrium of the terrestrial atmosphere. PREMOS measurements will be used (together with the TSI measurements of PICRAD/SOVAP and the images of PICARD/SODISM) as input for GCM simulations in order to investigate the response of the Earth's atmosphere to solar irradiance variations.
Two other channels in the visible and IR will be used for helioseismology measurements in relation with SODISM.

PICARD aims :

Confirm diameter variations (and validate ground measurements and their accuracy). Establish relation diameter/global irradiance/differential rotation. Study their variabilities and, if their amplitude allows, detect g-modes. Oblateness measure and solar shape to higher orders for dynamo and convection study. Provide Space Weather information by measurement of full Sun images at 1" resolution.

Time-line from to

Phase A and B studies	=>	1999 - 2003
Construction	=>	2003 - 2004
Measurement phase	=>	launch foreseen in early 2007 at the end of the solar minimum period of solar activity cycle 23.
Operation in orbit	=>	2007 to 2010

Actual status

End of phase B study.

Abbreviations

PREMOS	=	PREcision Monitoring for Solar Oscillation
SODISM	=	SOlar DIameter and Surface Mapper
SOVAP	=	SOlar VAriability PICARD

V Magnetosphere

5.1 The Low-Energy Neutral Atom Mass Spectrometer for IMAGE

Institute / Laboratory	**:**	Physikalisches Institute, University of Bern
In cooperation with	*:*	Goddard Space Flight Center, NASA, Greenbelt, MD, USA (T.E. Moore, F. Herrero) Lockheed Martin Palo Alto Research Laboratory, CA, USA (S.A. Fuselier) University of New Hampshire, NH, USA (J. Quinn)
Principal Investigator	**:**	J. Burch, PI of IMAGE mission, Southwest Research Institute, TX, USA Lead Investigator for LENA : T.E. Moore, GSFC / NASA
Co-investigators	**:**	P. Wurz P. Bochsler M. Wieser
Field of research	**:**	Magnetosphere

Method

Research based on existing instruments :

LENA instrument on the IMAGE spacecraft.
Satellite

Purpose of research

Investigation of the global ion outflow from the high-latitude ionosphere, its relationship to auroral features, and its consequences on magnetospheric processes will be investigated by the IMAGE mission. The investigations are performed via remote particle imaging of low-energy atoms emitted from the plasma volume of interest (LENA instrument). 2D mass- and energy-resolved images on time scales of minutes are the standard data product.

The main research topic is magnetospheric / ionospheric research and its relationship to solar wind plasma conditions.

In addition, the LENA instruments allows to study the neutral solar wind and the inflow of interstellar neutral gas.

Actual status

The IMAGE spacecraft was successfully launched on March 25, 2000.

After reaching the final orbit, commissioning the spacecraft, and initial operations the first light image of LENA was recorded on May 5, 2000 demonstrating full functionality of the instrument. Since then LENA operated continuously.

Three most relevant publications

1. M.R. Collier, T.E. Moore, K.W. Ogilvie, D.J. Chornay, J.W. Keller, S. Boardsen, J.L. Burch, B. El Marji, M.-C. Fok, S.A. Fuselier, A.G. Ghielmetti, B.L. Giles, D.C. Hamilton, B.L. Peko, J.M. Quinn, T.M. Stephen, G.R. Wilson, and P. Wurz :

   " Observations of neutral Atoms from the Solar Wind "

   J. Geophys. Res. 106(A11), (2001), 24893-24906.

2. S.A. Fuselier, A.G. Ghielmetti, T.E. Moore, M.R. Collier, J.M. Quinn, G.R. Wilson, P. Wurz, S.B. Mende, H.U. Frey, C. Jamar, J.-C. Gerard, and J.L. Burch :

   " Ion Outflow Observed by IMAGE Implications for Source Regions and Heating Mechanisms "

   Geophys. Res. Lett. 28(6), (2001), 1163-1167.

3. T.E. Moore, D.J. Chornay, M.R. Collier, F.A. Herrero, J. Johnson, M.A. Johnson, J.W. Keller, J.F. Laudadio, J.F. Lobell, K.W. Ogilvie, P. Rozmarynowski, S.A. Fuselier, A.G. Ghielmetti, E. Hertzberg, D.C. Hamilton, R. Lundgren, P. Wilson, P. Walpole, T.M. Stephen, B.L. Peko, B. van Zyl, P. Wurz, J.M. Quinn, and G.R. Wilson :

   " The Low-Energy Neutral Atom Imager for IMAGE "

   Space Sci. Rev. 91 (2000), 155-195.

Abbreviations

LENA	=	Low Energy Neutral Atom
IMAGE	=	Imager for Magnetopause-to-Aurora Global Exploration

VI Life Science / Microgravity

6.1 Signal Transduction and Genetic Expression in T-Lymphocytes in Microgravity

Institute / Laboratory	**:**	Space Biology Group ETH Zürich
In cooperation with	*:*	University of Sassari, University of Rome (CNR)
Principal Investigator	**:**	Dr. Marianne Cogoli-Greuter
Co-investigators	**:**	Dr. Augusto Cogoli Prof. Proto Pippia Prof Rodolfo Negri
Field of research	**:**	Life Science Microgravity

Method

Rocket

Purpose of research

Several experiments performed since 1983 in different Spacelab flights, in sounding rockets, in hypo and hypergravity have revealed dramatic gravitational effects on the *in vitro* activation of human T lymphocytes by the mitogen concanavalin A (Con A).
The most striking observation is that the activation of free-floating lymphocytes is nearly nil in microgravity. The data indicate that a failure of the expression of the interleukin-2 receptor (measured as protein secreted in the supernatant) is responsible of the loss of activity. Recent experiments performed under simulated microgravity in the fast rotating clinostat clearly showed that the expression of both IL-2 and IL-2Rα is significantly inhibited in simulated 0 x *g*.

Sounding rockets have proven to be a useful tool to clarify other aspects of the T lymphocyte activation in microgravity. The most important findings of the research performed on sounding rockets are: (1) The reception of the first signal required for activation, namely the binding of Con A to alpha-glucosides of membrane proteins, followed by patching and capping are only slightly affected at microgravity (2) The structure of the cytoskeleton, i.e. the intermediate filament vimentin and to a lesser extent also of tubulin, is changed in microgravity within 30 sec. (3) Free floating non activated cells are able to display autonomous locomotion in random directions.

On MASER 9 we studied the expression of immediate genes in T lymphocytes activated with Con A within 5 minutes. The timeline of the expression of the immediate genes following mitogenic activation in T lymphocytes, shows, that several genes are expressed within few minutes. In the original proposal only a few genes were selected to be analysed. In the meantime the new technology of microarray was developed which allows the analyses of several 1000 genes. The gene expression in the 0 x *g* samples will be compared to the samples of the in-flight 1 x *g* centrifuge.

Time-line from to

Planning	=>	August 1994 - 2001
Construction	=>	1995 - 2002
Measurement phase	=>	March 16, 2002 (Flight of MASER 9)
Data evaluation	=>	March 2002 - End 2002

Actual status

The experiment was flown on March 16, 2002 on MASER 9. Due to hardware failure only 50% of the samples could be recovered. The samples have been analysed for early gene expression using the microarray technology. Several genes have been found to be either induced or suppressed within 5 minutes exposure to 0 x *g*.

Abbreviations

IL-2	=	Interleukin 2
IL-2Rα	=	Interleukin 2 receptor, α-subunit

6.2 Cell-cell Interaction of Monocytes and T-Lymphocytes in Microgravity

Institute / Laboratory	:	Space Biology Group, ETH Zürich
In cooperation with	:	University of Sassari
Principal Investigator	:	Dr. Marianne Cogoli-Greuter
Co-investigators	:	Dr. Augusto Cogoli Prof. Proto Pippia
Field of research	:	Life Science, Microgravity

Purpose of research

Cell-cell interaction between T cells and monocytes (accessory cells) is an important element of signal transduction in immune cells. Nearly total loss of T cell activation in microgravity was discovered in 1983 and was confirmed later by several experiments in space. Although aggregate formation of lymphocytes in suspension has been observed in microgravity, there is no direct evidence that interactions between monocytes and T lymphocytes are occurring normally in space. Therefore the motility of adherent monocytes and their interaction with T lymphocytes in suspension will be analysed. The work will be supported by ground-based experiments with a new instrument, the "random positioning machine" simulating microgravity.

The objectives of this project are :

- to investigate the interactions of monocytes and T lymphocytes in order to test the hypothesis that reduced cell-cell interactions might be one of the reasons for the observed depression of the in-vitro activation of human lymphocytes
- to study motility and changes of the cytoskeletal structures of monocytes

Time-line from to

Planning	=>	February 2000
Construction	=>	October 2001 - November 2002

Actual status

The experiment has been selected by ESA in 1999. In 2000 it was subjected for the definition phase for the second flight of BioPack on the R2 mission (scheduled for 2002). In 2001 this mission was cancelled. ESA informed me in January 2002 that the definition phase had been put on hold by ESA as they are now looking for alternate flight opportunity.

In the meantime the hardware, financed by Prodex, was constructed. It is possible to adapt this hardware, which now needs crew intervention, for an automatic experiment performance.

VII Planets

7.1 Isotopic Abundances of Noble Gases in Lunar Rocks and Soils

Institute / Laboratory	**:**	Physikalisches Institut, University of Bern
In cooperation with	*:*	US National Aeronautics and Space Administration
Principal Investigator	**:**	O. Eugster, University of Bern
Field of research	**:**	Planets

Method

Research based on existing instruments.

Purpose of research

The abundances and isotopic composition of He, Ne, Ar, Kr, and Xe are measured mass spectrometrically in lunar rocks and soils. These investigations are supplemented by determinations of the concentrations of selected elements using neutron activation or ICP mass spectrometry. The purpose of this work is the study of the detailed history of rocks and soils based on cosmic ray effects, and the determination of the times, durations, and burial depths during exposure to cosmic irradiation. The elemental and isotopic composition of the noble gases trapped during rock formation or by implantation of solar wind particles are measured.

Actual status

Several solar gas rich lunar soils and breccias have trapped $^{40}Ar/^{36}Ar$ ratios >10, although solar Ar is expected to yield a ratio of <0.01. Radiogenic ^{40}Ar produced in the lunar crust from ^{40}K decay was outgassed into the lunar atmosphere, ionized, accelerated in the electromagnetic field of the solar wind, and reimplanted into lunar surface material. The ^{40}Ar loss rate depends on the decreasing abundance of ^{40}K. In order to calibrate the time dependence of the $^{40}Ar/^{36}Ar$ ratio in lunar surface material, the period of reimplantation of lunar atmospheric ions and of solar wind Ar was determined using the ^{235}U-^{136}Xe dating method that relies on secondary cosmic-ray neutron induced fission of ^{235}U. We identified the trapped, fissiogenic, and cosmogenic noble gases in lunar breccia 14307 and lunar soils 70001-8, 70181, 74261, and 75081. Uranium and Th concentrations were determined in the 74261 soil for which we obtain the ^{235}U-^{136}Xe time of implantation of 3.25 Ga ago. On the basis of several cosmogenic noble gas signatures we calculate the duration of this near surface exposure of 393 Ma and an average shielding depth below the lunar surface of 73 g/cm2. A second, recent exposure to solar and cosmic-ray particles occurred after this soil was excavated from Shorty crater 17 Ma ago. Using a compilation of all lunar data with reliable trapped Ar isotopic ratios and pre-exposure times we infer a calibration curve of implantation times, based on the trapped $^{40}Ar/^{36}Ar$ ratio. A possible trend for the increase with time of the solar $^{3}He/^{4}He$ and $^{20}Ne/^{22}Ne$ ratios of about 12%/Ga and about 2%/Ga, respectively, is also discussed.

Two most relevant publications

1. Eugster O. (1999) :
   Chronology of dimict breccias and the age of South Ray crater at the Apollo 16 site.

   Meteorit. Planet. Sci. 34, 385-391.

2. Eugster O., Terribilini D. Polnau E., and Kramers J. (2001) :
   The antiquity indicator 40Ar/36Ar for lunar surface samples calibrated by ^{235}U-^{136}Xe dating.

   Meteorit. Planet. Sci. 36, 1097-1116.

7.2 ASPERA-3 / Mars Express : Remote Particle Sensing of Ion Populations in Mars' Extended Atmosphere

Institute / Laboratory	**:**	Physikalisches Institute, University of Bern
In cooperation with	*:*	Swedish Space Research Institute, Kiruna, Sweden, (R. Lundin, S. Barabash, H. Anderson) Max-Planck Institut für Aeronomie, Lindau, Germany (J. Woch) Instituto di Fisica dello Spazio Interplanetari, Rome, Italy, (S. Orsini)
Principal Investigator	**:**	R. Lundin, Swedish Space Research Institute, Kiruna, Sweden
Co-investigators	**:**	P. Wurz P. Bochsler M. Wieser
Field of research	**:**	Planets

Method

Development and construction of own instruments :

NPD sensor for the ASPERA-3 instrument on the Mars Express mission.

Purpose of research

The general scientific objective of the ASPERA-3 (Analyzer of Space Plasmas and Energetic Atoms) instrument is to study the solar wind - atmosphere interaction and characterize the plasma and neutral gas environment in the near-Mars space through energetic neutral atom (ENA) imaging.

The main scientific objectives of the ASPERA-3 instrument are to :

1) Determine the instantaneous global distributions of plasma and neutral gas near the planet,
2) Study the atmospheric escape induced by the highly variable solar wind and solar UV irradiation,
3) Investigate the modification of the atmosphere through the solar wind ion bombardment,
4) Investigate the energy deposition from the solar wind to the ionosphere.

The Neutral Particle Detector (NPD) provides measurements of the ENA flux, resolving velocity and mass (H and O) of the coming particles with a coarse angular resolution.

Time-line from to

Planning	=>	11 / 1998 - 03 / 2000
Construction	=>	03 / 1999 - 03 / 2001
Measurement phase	=>	01 / 2004 - 2006
Data evaluation	=>	01 / 2004

Actual status

All sensors of the ASPERA-3 instrument have been integrated and have been fully calibrated.

The ASPERA-3 DPU had to be refurbished, and final integration in the Mars Express spacecraft will be in December 2002. In February 2003 the Mars Express spacecraft will be shipped to Baikonur. Earliest launch of the spacecraft is 21 May 2003 and arrival at Mars will be six months later.

Three most relevant publications

1. S. Barabash, R. Lundin, H. Andersson, J. Gimholt, M. Holstrsm, O. Norberg, M. Yamauchi, K. Asamura, A.J. Coates, D.R. Linder, D.O. Kataria, C.C. Curtis, K.C. Hsieh, B.R. Sandel, A. Fedorov, A. Grigoriev, E. Budnik, M. Grande, M. Carter, D.H. Reading, H. Koskinen, E. Kallio, P. Riihela, T. Säles, J. Kozyra, N. Krupp, S. Livi, J. Woch, J. Luhmann, S. McKenna-Lawlor, S. Orsini, R. Cerulli-Irelli, A. Mura, A. Milillo, E. Roelof, D. Williams, J.-A. Sauvaud, J.-J. Thocaven, D. Winningham, R. Frahm, J. Scherer, J. Sharber, P. Wurz, and P. Bochsler :

   " The Analyzer of Space Plasmas and Energetic Atoms (ASPERA-3) for the Mars Express Mission "

   ESA-SP (2002), in press.

2. M. Wieser, P. Wurz, K. Brüning, and W. Heiland :

   " Scattering of Atoms and Molecules off a Magnesium Oxide Surface "

   Nucl. Instr. Meth. B 192 (2002), 370 380.

3. P. Wurz :
   " Detection of Energetic Neutral Particles " in "*The Outer Heliosphere : Beyond the Planets*"

   Eds. K. Scherer, H. Fichtner, and E. Marsch), Copernicus Gesellschaft e.V., Katlenburg Lindau, Germany, (2000), 251-288.

7.3 Composition of Crust, Exosphere, Surface Evolution, Formation and Evolution of Planet Mercury

Institute / Laboratory	**:**	Physikalisches Institute, University of Bern
In cooperation with	*:*	Instituto di Fisica dello Spazio Interplanetari, Rome, Italy (S. Orsini) Swedish Space Research Institute, Kiruna, Sweden (R. Lundin, S. Barabash, J. Gimholt) Max-Planck-Institut für Aeronomie, Lindau, Germany (A. Korth)
Principal Investigator	**:**	P. Wurz, Physikalisches Institut, University of Bern
Co-investigators	**:**	W. Benz and P. Bochsler
Field of research	**:**	Planets

Method

Development and construction of own instruments :

Two mass spectrometers, one for the measurement of the composition of the exosphere (MAIA), one for the measurement of the composition of the regolith (LMS).
Simulation, Satellite

Purpose of research

The European Space Agency (ESA) has defined a new Cornerstone Mission, named BepiColombo, for the detailed exploration of planet Mercury. Because of observational difficulties Mercury is a largely unknown planet and therefore a high scientific return is expected from such an exploratory mission. We intend to participate in the BepiColombo mission by developing two mass spectrometers.

One mass spectrometer should be placed on BepiColombo/MSE spacecraft to measure the composition of the surface in the vicinity of the landing site with a Laser Mass Spectrometer (LMS).

The second instrument, the Measurement Analyzer for Ions and Atoms (MAIA), should be placed on the BepiColombo/MPO spacecraft to measure the elemental, chemical, and isotopic composition of Mercury's exosphere with a sensitive gas mass spectrometer.

With these two instruments we would substantially contribute to three out of the six main scientific goals set for BepiColombo.

Time-line from to

Planning, Design	=>	04/2004
Construction	=>	12/2007
Measurement phase	=>	03/2012 - 03/2014
Data evaluation	=>	03/2012

Actual status

Currently, we perform detailed design studies for both sensors. For MAIA we already realized a prototype instrument to verify that the instrument design meets the scientific requirements. For LMS we will have a prototype instrument by summer 2002.

In addition, we created computer models to simulate the Mercury exosphere and the regolith to enhance our understanding of the planet but also to establish realistic scientific requirements for the performance of the instruments to be developed.

Three most relevant publications

1. P. Wurz and L. Blomberg :
   " Particle Populations in Mercury's Magnetosphere "

   Planet. Space Sci. (49)14-15, (2001), 1643-1653.

2. M. Mildner, P. Wurz, S. Scherer, M. Zipperle, K. Altwegg, P. Bochsler, W. Benz, and H. Balsiger :
   " Measurement of neutral atoms and ions in Mercury's exopshere "

   Planet. Space Sci. (49)14-15, (2001) 1655-1658.

3. P. Wurz and R. Schletti :
   " Optical signal coupling in micro-channelplate detectors with sub nano-second performance "

   Rev. Sci. Instr. 72(8) (2001) 3225-3229.

Abbreviations

LMS	=	Laser Mass Spectrometer
MAIA	=	Measurement Analyzer for Ions and Atoms
MPO	=	Mercury Planetary Orbiter
MSE	=	Mercury Surface Element

7.4 ASPERA-4 / Venus Express : Remote Particle Sensing of Ion Populations in Venus' Extended Atmosphere

Institute / Laboratory	**:**	Physikalisches Institute, University of BernIn
In cooperation with	*:*	Swedish Space Research Institute, Kiruna, Sweden (S. Barabash, R. Lundin, H. Anderson) Max-Planck Institut für Aeronomie, Lindau, Germany (J. Woch) Instituto di Fisica dello Spazio Interplanetari, Rome, Italy (S. Orsini)
Principal Investigator	**:**	S. Barabash, Swedish Space Research Institute, Kiruna, Sweden
Co-investigators	**:**	P. Wurz, P. Bochsler, M. Wieser
Field of research	**:**	Planets

Method

Development and construction of own instruments :

NPD sensor forthe ASPERA-4 instrument on the Venus Express mission.

Purpose of research

The general scientific objective of the ASPERA-4 instrument is to study the solar wind atmosphere interaction and characterize the plasma and neutral gas environment in the near-Venus space through energetic neutral atom (ENA) imaging. ASPERA-4 is an almost identical copy of the ASPERA-3 instrument an MarsExpress. The main scientific objectives of the ASPERA-4 instrument are to :

1) Determine the instantaneous global distributions of plasma and neutral gas near the planet.
2) Study the atmospheric escape induced by the highly variable solar wind and solar UV irradiation.
3) Investigate the modification of the atmosphere through the solar wind ion bombardment.
4) Investigate the energy deposition from the solar wind to the ionosphere. The Neutral Particle Detector (NPD) provides measurements of the ENA flux, resolving velocity and mass (H and O) of the coming particles with a coarse angular resolution.

Time-line from to

Planning	=>	01/2001 - 08/2002
Construction	=>	08/2002 - 12/2004
Measurement phase	=>	05/2006 - 11/2007
Data evaluation	=>	05/2006

Actual status

The flight models of the sensors for the ASPERA-4 instrument are currently manufactured and integrated at the Swedish Space Research Institute. The hardware contribution from the University of Bern has already been delivered to Swedish Space Research Institute. Launch of the Venus Express spacecraft is foreseen for 9 November 2005 and arrival at Venus will be 153 days later.

Three most relevant publications

1. S. Barabash, R. Lundin, H. Andersson, J. Gimholt, M. Holstrsm, O. Norberg, M.Yamauchi, K. Asamura, A.J. Coates, D.R. Linder, D.O. Kataria, C.C. Curtis, K.C.Hsieh, B.R. Sandel, A. Fedorov, A. Grigoriev, E. Budnik, M. Grande, M. Carter, D.H. Reading, H. Koskinen, E. Kallio, P. Riihela, T. Säles, J. Kozyra, N. Krupp, S. Livi, J. Woch, J. Luhmann, S. McKenna-Lawlor, S. Orsini, R. Cerulli-Irelli, A. Mura, A. Milillo, E. Roelof, D. Williams, J. A. Sauvaud, J.-J. Thocaven, D.Winningham, R. Frahm, J. Scherer, J. Sharber, P. Wurz, and P. Bochsler :
   " *The Analyzer of Space Plasmas and Energetic Atoms (ASPERA-3) for the Mars Express Mission* "

   ESA - SP-1240 (2002), in press.

2. M. Wieser, P. Wurz, K. Brüning, and W. Heiland :
   " Scattering of Atoms and Molecules off a Magnesium Oxide Surface "

   Nucl. Instr. Meth. B 192 (2002), 370-380.

3. P. Wurz :
   "Detection of Energetic Neutral Particles" in *"The Outer Heliosphere : Beyond the Planets"* (eds. K. Scherer, H. Fichtner, and E. Marsch)

   Copernicus Gesellschaft e.V., Katlenburg-Lindau, Germany, (2000), 251-288.

Comets

7.5 ROSINA /Rosetta

Institute / Laboratory	:	Physikalisches Institute, Space research and Planetology, University of Bern
In cooperation with	*:*	TUB, Braunschweig; MPAe, Lindau; CESR, Toulouse; IPSL, St. Maur-Paris; LMM, Palo Alto; University of Michigan, Ann Arbor; BIRA, Brussels; SwRI, San Antonio
Principal Investigator	**:**	Prof. Hans Balsiger
Co-investigators	**:**	Prof. K. Altwegg, P. Bochsler, E. Kopp, PD Dr. P. Wurz
Field of research	**:**	Comets

Method

Development and construction of own instruments :

Mass spectrometers for the volatile cometary material.
Satellite

Purpose of research

As part of the core payload of the Rosetta mission, the Rosetta Orbiter Spectrometer for Ion and Neutral Analysis (ROSINA) will answer outstanding questions concerning the main objectives of the mission. The primary measurement objective of the spectrometer is :

- To determine the elemental, isotopic and molecular composition of the atmospheres and ionospheres of comets as well as the temperature and bulk velocity of the gas and the homogenous and inhomogeneous reactions of gas and ions in the dusty cometary atmosphere and ionosphere.

In determining the composition of the atmospheres and ionospheres of comets, the following prime scientific objectives, also defined by the Rosetta Science Definition Team will be achieved :

- Determination of the global molecular, elemental, and isotopic composition and the physical, chemical and morphological character of the cometary nucleus.
- Determination of the processes by which the dusty cometary atmosphere and ionosphere are formed and to characterize their dynamics as a function of time, heliocentric and cometocentric position.
- Investigation of the origin of comets, the relationship between cometary and interstellar material and the implications for the origin of the solar system.

- Investigation of possible asteroid outgassing and establish what relationships exist between comets and asteroids. To accomplish these very demanding objectives, ROSINA must have unprecedented capabilities, including :

1) Very wide mass range from 1 amu (Hydrogen) to >300 amu (organic molecules).
2) Very high mass resolution (ability to resolve CO from N2 and 13C from 12CH).
3) Very wide dynamic range and high sensitivity to accommodate very large differences in ion and neutral gas concentrations and large changes in the ion and gas flux as the comet changes activity between aphelion and perihelion.
4) The ability to determine the outflowing cometary gas flow velocities. The necessity for the unusual high capabilities of this experiment stems from the fact that it is one of the key instruments which is able to give meaningful data during the whole mission and thus by monitoring and characterizing the different phases of comet activity from apogee through perigee will lead to a full understanding of cometary behavior. Correlated studies with optical observations, with, for example, the dust instruments, the magnetometer and the surface science package further augment the scientific return of the ROSINA instrument.

Time-line from to

Planning	=>	1993 - 1995
Construction	=>	1996 - 2002
Measurement phase	=>	2005 (Mars flyby) - 2013 (end of mission) (to be confirmed)
Data evaluation	=>	2005 - ?

Actual status

The ROSINA instrument consists of three sensors : DFMS, a Double Focusing Magnetic Sensor with a high resolution and a large dynamic range, RTOF, a Reflectron Time-Of Flight mass spectrometer, with an extended mass range and a high sensitivity and COPS, the Comet Pressure Sensor which measures the total density, the ambient gas temperature and the bulk gas velocity relative to the spacecraft.
In the last year we delivered the flight models of all sensors as well as the flight spare models. Although the calibration of the sensors will only be completed after launch with the models staying on ground it can be said that the performance of ROSINA as a whole achieves or surpasses the design goals as stated in the proposal to ESA in 1995. Currently, instrument and space probe are ready for launch. Due to the Ariane V failure the mission has to be redefined. The launch is expected within the next two years.

One most relevant publication

1. Rosetta Orbiter Spectrometer for Ion and Neutral Analysis ROSINA :

   H. Balsiger et al., ESA-SP 1165, in print.

Abbreviations

ROSINA	=	Rosetta Orbiter Spectrometer for Ion and Neutral Analysis
DFMS	=	Double Focusing Magnetic Sensor
RTOF	=	Reflectron Time-Of Flight mass spectrometer
COPS	=	Comet Pressure Sensor

VIII INTERNATIONAL SPACE SCIENCE INSTITUTE

8.1 *International Space Science Institute*

Institute / Laboratory	:	International Space Science Institute (ISSI)
Principal investigator	:	J. Geiss (Executive Director), G. Paschmann, R. von Steiger
Field of research	:	Interdisciplinary interpretation and in-depth studies of data from multi-instrument, multi-spacecraft programs in the fields of Solar System Science (Heliospheric and Solar-Terrestrial Physics, Solar Wind and Solar Processes, Planetary Science), Astrophysics and Cosmology, and Earth Science from Space.

Method

The International Space Science Institute (ISSI) is an Institute of Advanced Studies at which scientists from different countries can work together face to face to analyse, compare and interpret their data. The main tools in carrying out projects are *Workshops* and/or *Working Groups* on topics selected by the Directorate; with participation by invitation only. On the other hand, ISSI supports research projects of *International Teams*, proposed by the scientific community and selected through a peer-review system. ISSI also hosts *Senior* and *Junior Visiting Scientists*. In total, ISSI welcomes about 250 visitors annually, who spend some 360 work-weeks at ISSI.

Purpose of research

Further interdisciplinary studies and interpretation of the very complex experimental data which originate from multi-experiment satellites, already launched or due to be launched over the next several years by different space agencies. Therefore, space scientists are encouraged to pool their data and results and to work closely with theorists and modelers. Scientists working in related fields and with ground-based observations and the results of laboratory investigations are also invited to participate. The results of these activities are expected to help identifying the scientific requirements of future space science projects.

Actual status

All scientific activities result in some form of publication, e.g. in ISSI's hardcover book series *Space Sciences Series of ISSI (SSSI)*, published by Kluwer Academic Publishers, Dordrecht, NL (reprinted from Space Science Reviews), in *ISSI Scientific Report Series (SR)*, published by ESA's Publications Division, or individual papers in peer-reviewed international scientific journals. As of the end of 2001, 12 volumes of *SSSI*, and the first volume of *SR* have been published. Information about the complete collection can be found on ISSI's website http://www.issi.unibe.ch, in the section 'Publications'.

Eleven most relevant publications

In 2000 and 2001, the following volumes appeared :

1. Corotating Interaction Regions :
   A. Balogh, J.T. Gosling, J.R. Jokipii, R. Kallenbach, and H. Kunow.

   (eds.), SSSI Vol. 7.

2. Composition and Origin of Cometary Materials :
   K. Altwegg, P. Ehrenfreund, J. Geiss, and W.F. Huebner.

   (eds.), SSSI Vol. 8.

3. From Dust to Terrestrial Planets :
   W. Benz, R. Kallenbach, and G. Lugmair.

   (eds.), SSSI Vol. 9.

4. Cosmic Rays and Earth :
   J.W. Bieber, E. Eroshenko, P. Evenson, E.O. Flückiger, and R. Kallenbach.

   (eds.), SSSI Vol. 10.

5. Solar Variability and Climate :
   E. Friis-Christensen, C. Fröhlich, J.D. Haigh, M. Schüssler, and R. von Steiger.

   (eds.), SSSI Vol. 11.

6. Chronology and Evolution of Mars :
   R. Kallenbach, J. Geiss and W.K. Hartmann.

   (eds.), SSSI Vol. 12.

There are a number of upcoming publications, which result from ISSI activities in 2000 and 2001 :

7. The Astrophysics of Galactic Cosmic Rays :
   R. Diehl, E. Parizot, R. Kallenbach, and R. von Steiger (eds.), SSSI Vol. 13 : Two ISSI Workshops were held in October 1999 and May 2000, respectively. Their aim was to examine the cosmic ray phenomenon in the context of our evolving understanding of the Galaxy as an astrophysical system.

   The workshops brought together physicists working in the fields of cosmic-ray origin and propagation, structure evolution and composition of the Galaxy and the interstellar medium, and relevant areas of radio, optical, X-ray and γ-ray astronomy.

8. Matter in the Universe :
   Ph. Jetzer, K. Pretzl, and R. von Steige.

   (eds.), SSSI Vol. 14 : ISSI-Workshop in March 2001.
   The aim of the workshop was to gather active researchers from various fields (cosmology, astrophysics, nuclear and particle physics as well as space science) to assess the exciting new developments in the search for abundant and yet unknown forms of matter in the Universe.

9. Auroral Plasma Physics :
G. Paschmann, S. Haland, and R. Treumann.

(eds.), SSSI Vol. 15 : Three ISSI-Workshops held in October 1999, March and December 2000.
This book is expected to be state-of-the-art and comprehensive, but at the same time to contain enough tutorial material to serve as a textbook for students.

10. Magnetism of Mars :
D. Winterhalter, M. Acuña, and A. Zakhorov.

(eds.), SSSI Vol. 16 : ISSI-Workshop held in October 2001.
The aim of the Team Workshop was to distinguish the intrinsic magnetic field of Mars from the field carried in the solar wind. The MGS MAG team members and the Phobos investigators described the capabilities and limitations of their missions and in this way, they came to united conclusions.

11. Radiometric Inter-calibration of SOHO :
A. Pauluhn, M.C.E. Huber, and R. von Steiger.

(eds.), SR Vol. 2 : Results of an ISSI-Working Group in 2001.
The scientific aim of the ISSI meetings has been the summary of the radiometric (inter-)calibration of SOHO. All instrument groups contributed to this outcome.

It is impossible to list all the individual papers published in international scientific journals, which are related to ISSI activities. In ISSI's sixth business year, from 1st July 2000 until 30 June 2001, around 110 articles written or co-authored by ISSI staff and/or ISSI visitors were published. The respective information can be found in our Annual Report 6, which is available online (http://www.issi.unibe.ch).

Another main tool of the scientific programme of ISSI are the International Teams. Teams are composed of 2 to 15 scientists of different laboratories, nationalities and expertise meeting for extended periods at ISSI. Their raison d'être is the performance of a research project with eventual publication of the scientific outcome. Their activity is directed and organised by a team leader who is also the initiator of the proposal to ISSI. Though in close contact with the scientific staff of the Institute the teams are largely independent in the execution of their project. During its sixth business year (1 July 2000-30 June 2001) ISSI hosted 17 International Teams, with about 150 members.
Teams are set up in a proposal procedure. The proposals submitted to ISSI are reviewed by external referees before a decision is made to grant them support at ISSI. A large announcement of opportunity to the scientific community is planned for 2003. Details can be found on ISSI's website http://www.issi.unibe.ch, in the section 'Scientific Activities'.

Outlook.
ISSI's programme for 2002 foresees the following topics (among others) :

- *Solar System History from Isotopic Volatile Signatures*
- *Earth Gravity from Space – From Sensors to Earth Sciences*
- *Planetary Systems and Planets in Systems*
- *Calibration Techniques for In-Situ Plasma Instrumentation*

Another important matter will be the succession of Prof. Johannes Geiss as Executive Director of the Institute. Prof. Roger-Maurice Bonnet has accepted the respective invitation and will take over this function on January 1, 2003.