

# Space Research In Sweden





# **SPACE RESEARCH IN SWEDEN**

## **Report to COSPAR 2002**

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# Contents

## PART I

<b>National Organisation of Space Activities</b> .....	7
Swedish National Space Board.....	7
Research Societies.....	9
Swedish Space Industries.....	10
<b>International Co-operation</b> .....	12
<b>Esrange</b> .....	13
<b>Space-related Facilities and Installations</b> .....	15
<b>National Scientific Space Programme</b> .....	16
Swedish Satellite Programme.....	16
Other Satellite projects.....	20
Sounding Rockets.....	21
Ballons .....	22
Human Spaceflight.....	22
Earth Observations .....	23

## PART II

<b>Introduction</b> .....	27
<b>Remote Sensing</b> .....	28
<b>Atmospheric Research</b> .....	32
<b>Space Physics</b> .....	34
<b>Astronomy and Astroparticle Physics</b> .....	37
<b>Astrobiology</b> .....	42
<b>Human Spaceflight</b> .....	43
<b>Material Sciences in Microgravity</b> .....	45
<b>Space Technology</b> .....	47

# **PART I**

## **Overview of Swedish Space Activities related to Research**

# National Organisation of Space Activities

## Swedish National Space Board

(Swedish: Rymdstyrelsen)

The Swedish National Space Board (SNSB), under the Ministry of Industry, Employment and Communications, is the central governmental agency responsible for national and international space activities in Sweden. SNSB is primarily an R&D agency and acts as research council for the distribution of government funds (Ministry of Education and Science) for basic space research.

The responsibilities of SNSB include:

- initiation of research, development and other activities connected with the Swedish space and remote sensing programmes;
- co-ordination of Swedish activities within the fields of space technology, space research, and remote sensing;
- distribution of government appropriations for Swedish space activities;
- authorisation and supervision of space activities in accordance with space law;
- maintenance of contacts with international organisations and institutions operating within the field of space activities and remote sensing.

SNSB is responsible for the planning and the co-ordination of Sweden's participation in the programmes of the European Space Agency (ESA).

SNSB has two advisory committees for space research and remote sensing. The members of the Board and of the space research and remote sensing advisory committees are listed below. SNSB has 14 employees. Per Tegnér is Director General of SNSB.

## **Members of the Board (2002)**

*P Tegnér*, SNSB (Chairman)

*S Håkansson*, Swedish Agency for Innovation Systems “Vinnova”, Stockholm

*B Johansson*, former member of parliament, Tidaholm

*S Kullgren*, Nokia Mobile Phones, Kista

*M Larsson*, Department of Physics, AlbaNova, Stockholm University

*L-E Liljelund*, National Environmental Protection Agency, Stockholm

*M Mikes-Lindbäck*, ABB Corporate Research, Västerås

## **Space Research Advisory Committee (2002)**

*M Larsson*, Department of Physics, Stockholm University (Chairman)

*E Friis-Christensen*, Danish Space Research, Copenhagen, Denmark

*G Grimvall*, Theoretical Physics, Royal Institute of Technology, Stockholm

*D Hughes*, Dept. of Physics and Astronomy, University of Sheffield, UK

*I Isaksen*, Department of Geophysics, Oslo University, Norway

*A Johnsson*, Physics, NTNU, Trondheim, Norway

*T Pulkkinen*, Finnish Meteorological Institute, Helsinki, Finland

*H Zinnecker*, Astrophysics Institute, Potsdam, Germany

### **Secretariat:**

*L Nordh*

*P Magnusson*

*M Lannerö*

## **Remote Sensing Advisory Committee (2002)**

*L-E Liljelund*, National Environmental Protection Agency, Chairman

*A Engberg*, Lantmäteriet, National land survey

*B Håkansson*, Swedish Meteorological and Hydrological Institute

*E Liljas*, Swedish Meteorological and Hydrological Institute

*E Normark*, Holmen Skog AB

*H Olsson*, Swedish University of Agricultural Sciences

*L Ulander*, Swedish Defence Research Agency

### **Secretariat:**

*M Nilsson*

*G Boberg*

*E Bergstedt*

# Research Societies

## Association of Swedish Space Scientists

(Swedish: Svenska rymdforskarens samarbetsgrupp, SRS)

Active space scientists are members of this group, whose main task is to provide a forum for discussions on joint projects within the scientific programme.

Secretary: *Stefan Larsson*

E-mail: [stefan@astro.su.se](mailto:stefan@astro.su.se)

URL: <http://www.astro.su.se/srs/>

## Swedish Astrobiology Network (SWAN)

The SWAN network is a non-profit association of Swedish scientists, who share an interest in astrobiology.

Chairman: *Nils Holm*

E-mail: [nils.holm@geo.su.se](mailto:nils.holm@geo.su.se)

URL: <http://www.astrobiologi.nu>

# Swedish Space Industries

The technical implementation of the national programme is mainly contracted by SNSB to the state-owned **Swedish Space Corporation** (SSC; in Swedish: "Rymdbolaget"). The Odin satellite is an example. The company is responsible for developing many scientific instruments for ESA's microgravity research programmes. SSC is the prime contractor for the ESA technology demonstrator Smart-1, to be launched towards the moon in 2003. SSC is also active on the commercial market. The space base Esrange (see page 13) is managed by SSC.

The private part of Swedish space industry is dominated by **Saab Ericsson Space** and **Volvo Aero Corporation**. Both companies have extensive technical development and manufacture for both the commercial space market and for ESA.

There are many smaller Swedish companies with products for applications in space, as exemplified in Table I – page 10.

Industry	Address	Telephone, Fax, WWW	Fields of activity
ACR Electronics AB	Box 99 619 00 Trosa Sweden	Phone: 0156-191 77 Fax: 0156-191 88 <a href="http://home.swipnet.se/~w-12495">home.swipnet.se/~w-12495</a> technology	-Mechanical and electronic design and construction -Spacecraft structure, sensor -Microwave antennas
Aerotech Telub AB	732 81 Arboga Sweden	Phone: 0589-800 00 Fax: 0589-61 16 52 <a href="http://www.aerotechtelub.se">www.aerotechtelub.se</a>	Assembly, integration and testing of small satellites, ground equipment for testing satellites, antennas for satellites
FOI, Swedish Defence Research Agency	Box 11021 161 11 Bromma Sweden	Phone: 08-634 10 00 Fax: 08-25 34 81 <a href="http://www.foi.se">www.foi.se</a>	Aerodynamic R&D, wind tunnel tests
Kampsax AB	Ågatan 32 431 35 Mölndal	Phone: 031-7067250 Fax: 031-7760852 <a href="http://www.kampsax.se">www.kampsax.se</a>	Production and delivery of geographic data
Metria Miljöanalys	Box 355 101 27 Stockholm Sweden	Phone: 08-579 972 70 Fax: 08-579 972 80 <a href="http://www.lantmateriet.se">www.lantmateriet.se</a>	Delivery of data, systems and support for geographic information.
Omnisys Instruments AB	Gruvgatan 8 421 30 Västra Frölunda Sweden	Phone: 031-734 34 00 Fax: 031-734 34 29 <a href="http://www.omnisisys.se">www.omnisisys.se</a>	Scientific instruments for space reserach (RF/microwave area)
Polymer Kompositer AB	Aminogatan 34 431 53 Mölndal Sweden	Phone: 031-86 40 54 Fax: 031-86 45 14 <a href="http://www.polymerkompositer.se">www.polymerkompositer.se</a>	Metallized carbon fibre structures
Rymdbolaget, Swedish Space Corporation	Box 4207 171 04 Solna Sweden	Phone: 08-627 62 00 Fax:08-98 70 69 <a href="http://www.ssc.se">www.ssc.se</a>	-Launch of sounding rockets and balloons -Reception of data from remote sensing satellites -Performs TT&C operations on polar orbiting satellites -Telecommunication-services -Airborn Maritime Surveillance System -Small satellites, instruments for sounding rockets, balloons -Microgravity payloads

<b>Industry</b>	<b>Address</b>	<b>Telephone, Fax, WWW</b>	<b>Fields of activity</b>
Saab Ericsson Space	405 15 Göteborg Sweden	Phone: 031-735 00 00 Fax: 031-735 40 00 www.space.se	-Spacecraft systems -Computers and data handling -Sensor system mechanisms -Spacecraft structures -flight control systems for sounding rockets -Microgravity payloads -Small satellites -Microwave antennas -Microwave electronics and fibre optics
Spacemetric	Tingsvägen 19 191 61 Sollentuna Sweden	Phone: 08-594 770 80 Fax: 08-594 770 89 www.spacemetric.se	Platformindependent software for production of satellite images
Spectrogon AB	Box 2076 183 02 Täby Sweden	Phone: 08-768 09 80 Fax: 08-768 72 05 www.spectrogon.com	Optics for scientific instruments
SweDish Satellite Systems AB	Hälsingegatan 40 Box 6495 113 82 Stockholm Sweden	Phone: 08-587 950 00 Fax: 08-587 950 05 www.swe-dish.se	Production of portable uplinks
SwedPower AB	Box 527 162 16 Stockholm	Phone: 08-7396000 Fax: 08-7396226 http://www.swedpower.se	Development and application of remote sensing and geographical information system technologies.
TeleWide AB	Nålvägen 4 931 57 Skellefteå Sweden	Phone: 0910-173 40 Fax: 0910-173 48 www.telewide.se	Development of a groundbased multisatellite antenna
Volvo Aero	461 81 Trollhättan Sweden	Phone: 0520-940 00 Fax: 0520-340 10 www.aero.volvo.se	-Production of combustion chambers Corporation and nozzles for Viking (Ariane 4) -Development of nozzle and turbines for Vulcain (Ariane 5) -Technology programme in pump systems, nozzles and combustion
YoYo Technology AB	Regeringsgatan 82 111 39 Stockholm Sweden	Phone: 08-454 8650 Fax: 08-10 46 32	Equipment for in-flight and Earth-based resistance exercise

# International Co-operation

Sweden is one of the founding members of the European Space Agency, **ESA**. Sweden participates in the mandatory basic and scientific programmes as well as in the optional programmes on Earth observations, telecommunications, microgravity, launcher development, International Space Station, and technology (GSTP). The Swedish contribution to ESA accounts for about 70% of the SNSB budget.

Bilateral co-operation on space science and applications, primarily the SPOT-programme for remote sensing, is carried out between Sweden and **France** under agreements with Centre National d'Etudes Spatiales, CNES.

The VEGETATION Programme is developed jointly by **France, the European Commission, Belgium, Italy** and Sweden.

Sweden, **Canada, Finland and France** are co-operating on the scientific satellite project Odin, which was launched in February 2001.

Bilateral scientific co-operation between Sweden (SNSB) and the **USA (NASA)** is carried out under specific agreements.

Similar scientific co-operation is carried out with **Russia** based on a Memorandum of Understanding between SNSB and the Russian Space Agency.

Memoranda of Understanding have been concluded as basis for co-operation with SNSB's counterparts in **Austria, Canada, India** and the People's Republic of **China**. Sweden is also engaged in other bilateral co-operative projects carried out on ad hoc basis.

Sweden is a member of **Intelsat, Eutelsat, Inmarsat** and **Eumetsat**.

# Esrange



*Overview of the Esrange facilities. Illustration:SSC*

Esrange is a Swedish space range situated north of the Arctic Circle close to the town of Kiruna. The base is managed by the Swedish Space Corporation. Space research activities are carried out at Esrange as an ESA special project with Germany, France, Switzerland, Norway and Sweden. Due to the geographical location studies of the aurora and other high latitude phenomena are of particular interest. In recent years the problem of ozone depletion in the arctic stratosphere has attracted much activity to the base.

The land recovery possibility makes Esrange very suitable for all sounding rocket experiments needing recovery, for instance microgravity research. Payloads are normally recovered by helicopter within an hour from launch.

The range also has long experience of releasing scientific balloons and has during recent years developed into a site for European and international ozone research campaigns.

Esrange is also used in various satellite projects. A number of ground segments for the support of national and international spacecraft programmes are in operation.

A facility for the reception, recording, filing, processing and dissemination of Earth observation satellite data was established at Esrange in 1978. The station was originally used for spacecraft in the Landsat series and operated within the framework of the European Space Agency's Earthnet programme. The station has been extended to handle data from both remote sensing and scientific satellites and has several independent antennas and processing systems.

A satellite control station of universal design performs TT&C operations on orbiting satellites. Esrange operates and monitors satellites on behalf of customers or offers use of the station in a transparent mode, where remote customers are connected to the station for access to their satellites in real time.

The ground control station for the Sirius telecommunication satellites is also located at Esrange.

At Salmijärvi, in the vicinity of Esrange, ESA has established a ground station for ERS-1, ERS-2 and ENVISAT, which is operated by SSC.

A ground control station for the Japanese Earth Resource Satellite JERS in cooperation with NASDA was inaugurated in April 1992.

# Space-Related Facilities and Installations

The EISCAT Scientific Association, a collaboration between Finland, France, Germany, Japan, Norway, Sweden and the United Kingdom, has installed a multistatic incoherent scatter facility in the auroral zone, comprising a system of stations at Tromsø (Norway), Kiruna (Sweden) and Sodankylä (Finland).

The **Onsala Space Observatory** operates three radio telescopes principally for radioastronomical observations, two at Onsala Space Observatory and one at La Silla, Chile.

Sweden operates major ground facilities in support of Earth observation satellites including a new X-band receiving station at **Sturup** in southern Sweden. A joint Scandinavian Intelsat ground station is located at **Tanum** on the west coast of Sweden.

A human centrifuge for hypergravity research is situated at the Karolinska Institute in Solna, near Stockholm.

# National Scientific Space Programme

Part II of this report gives an overview of the Swedish space research groups. These cover a broad range of disciplines, such as astrophysics, space physics, atmospheric research, remote sensing, material sciences, and physiology. The research is supported by research grants from SNSB as well as other funding agencies.

A large part of the national research programmes utilises space instrumentations made possible through ESA programmes. Some disciplines have also benefited extensively from satellites, sounding rockets and balloons financed on a national basis or through bi/multilateral cooperation. Finally, some research groups have utilised third party space hardware.

## Swedish Satellite Programme

### Viking – Sweden's first scientific satellite

Viking was launched by the launch vehicle Ariane from Kourou in 1986. The mission ended in May 1987.

The scientific objective of the Viking satellite was to study the ionospheric and magnetospheric phenomena at high geomagnetic latitudes in the altitude region up to about two Earth radii. Simultaneous measurements were made of electric and magnetic fields, particle distributions, plasma composition and waves as well as imaging in the ultraviolet of the aurora beneath.

Viking was operated from Esrange, Kiruna, where the telemetry data from the satellite was received and processed on a real time basis. Viking has yielded scientific results that go far beyond expectations. Also from an industrial point of view Viking was a success.

### Freja – Sweden's second scientific satellite

Freja, a scientific satellite in collaboration with Germany, carried instruments for research of the aurora. It was launched on 6 October 1992 as a "piggy back" on a Chinese carrier, Long March 2 and was fully operational until 6 October 1996.

Freja continued the upper ionosphere and lower magnetosphere research programmes that started in 1986 with the launch of Viking.

The mission target was the auroral zone. Freja carried detectors for high-energy particles, magnetic and electric wave experiments as well as electric field sensors and a UV imager. Freja had an almost ten times higher downlink data rate than Viking. It used an S-band downlink with a maximum experiment data rate of 500 kbps.

Two reception stations collected the scientific data. In northern Sweden, data was received at Esrange Space Centre, Kiruna; the other station was the Prince Albert Satellite Station in Canada's Saskatchewan province. Prince Albert's location was ideal for receiving real-time data when Freja traversed the auroral oval.

Freja got its commands from Esrange only. It operated over Canada without a real-time command link, thanks to its stored command capability.

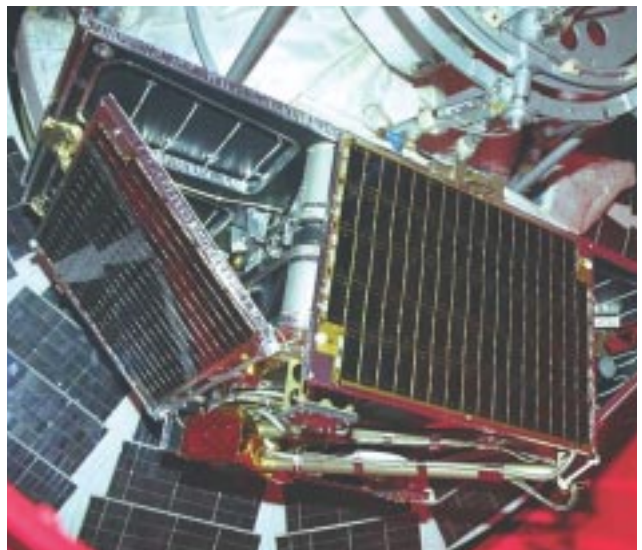
Freja was a scientific and technical success and has yielded a large amount of new scientific results.

## **Astrid 1**

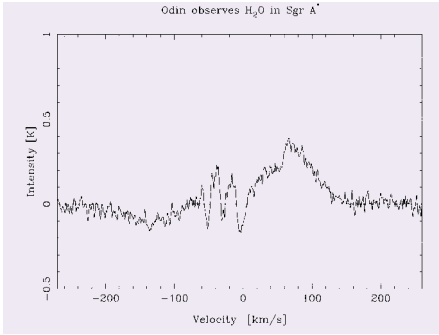
Astrid 1, the first Swedish microsatellite was launched in January 1995 with the aid of a Russian launch vehicle, COSMOS, from Plesetsk in Russia. Scientific data of high quality was obtained during one month and the spacecraft operated for 6 months. The total mass was approximately 20 kg and the payload consisted of instruments for measuring neutral particles and electrons in the magnetosphere and of UV photometers for imaging the aurora.

## **Astrid 2**

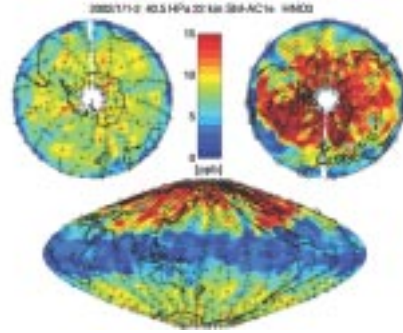
The second Swedish microsatellite, the 35-kg Astrid 2, was launched from Plesetsk into a 1000 km altitude polar orbit on 1998 December 10. A transmitter and receiver station was situated at the Swedish Space Corporation in Solna, and a receiver station in Antarctica. The satellite was operational until 1999 July 24 and yielded a large set of data on electric and magnetic phenomena occurring in the ionosphere and magnetosphere. The 10-kg payload consisted of an instrument for measurements of electric and magnetic fields (EMMA), a Langmuir probe for studies of fine temporal and spacial structures of the plasma (LINDA), an electron and ion spectrometer (MEDUSA), and a photometer for imaging of the aurora (PIA).



*The microsatellite Astrid 2 in launch configuration. Photo:SSC*



*This figure, a result from the Odin satellite, displays a complex spectrum of water vapour in the nucleus of our Galaxy.*



*This Odin result shows the distribution of nitric acid at an altitude of 22 km in January 2002. Nitric acid is a reservoir for nitrogen compounds, which can bind chlorine to the stratosphere and facilitate the formation of stratospheric clouds, which in turn can lead to the release of free chlorine.*

## Odin Orbital Observatory

The Odin satellite combines two scientific disciplines on a single spacecraft. One is astronomical studies of star formation and the early solar system. The second discipline is aeronomy and here Odin addresses the mechanisms behind the depletion of the ozone layer in the Earth's atmosphere and the effects of global warming. The Swedish Space Corporation (SSC), on behalf of the Swedish National Space Board (SNSB) and the space agencies of Canada (CSA), Finland (TEKES) and France (CNES), has developed the satellite and is responsible for its operation.

Odin is in operation since its launch with a Start-1 rocket from Svobodny in eastern Russia on 20 February 2001. The satellite was placed very precisely into a 620 km sun-synchronous, polar orbit with an ascending node near the terminator. The satellite is operated from a ground station at ESRANGE in northern Sweden.

The main instrument on Odin is an advanced radiometer which is used for both the astronomy and aeronomy missions. For the aeronomy mission the payload is complemented by a imaging grating spectrometer named OSIRIS (Optical Spectrograph and InfraRed Imaging System).

The radiometer consists of four tunable receivers operating in the frequency range 486-580 GHz and one fixed-tuned receiver at 119 GHz. The sub-mm receivers are tunable to cover a bandwidth of 17 GHz each. The frequency resolution is selectable between 0.1 and 1 MHz at instantaneous bandwidths of 0.1 and 1 GHz, respectively. All receivers have the same viewing direction and are fed by a 1.1 meter double-reflector (Gregorian) telescope. The resulting beam-size is on the order of 2 arc minutes for the high frequency receivers and 9 arc minutes for the 119 GHz receiver.

OSIRIS provides simultaneous observations with a UV/Visible spectrometer covering the spectral range 280-800 nm with a resolution of 1-2 nm and an IR imager with three channels, two at 1.7 microns and one at 1.53 microns, each having a passband of 10 nm.

Odin is 3-axis stabilised with an attitude control system suitable for both astronomy and aeronomy modes. It can stare at astronomical targets for hours with an accuracy better than 15 arc seconds or scan the limb of the Earth's atmosphere between 10 km and 120 km altitudes, 40 times per orbit, with a reconstructed accuracy of 1.2 arc minutes. The entire satellite is pointed towards the targets.

The basic data reduction and calibrations are made at Onsala/Chalmers for the radiometer and at Saskatoon (Canada) for OSIRIS. For astronomy this leads directly to data suitable for scientific analysis. For aeronomy the radiometer data go through additional refinement using algorithms developed under responsibility by the Global Environmental Measurements Group at Chalmers with support from the Observatory in Bordeaux and the Atmospheric Physics Group at Stockholm University. The corresponding production of so called Level 2 data is made under the responsibility of a group in Sodankylä, Finland.

At the time of writing Odin has been in operation during 18 months and has produced a lot of new data, which are now beginning to appear in the international scientific literature. The present plans assume a continued operation throughout 2003.

Odin data are being used to study the global distribution of species of key importance for understanding the physics and chemistry underlying ozone destruction and global warming. Among such species are ozone, various chlorine and nitric compounds, hydrogen compounds and aerosols. Odin has an unprecedented capability for measuring mesospheric water vapour and making very sensitive determinations of the abundance of e.g. chlorine monoxide.

Observations of water vapour, molecular oxygen and ammonia are among the main astronomy drivers of the mission. Odin has observed water vapour from comets and galactic molecular clouds, in some cases from both  $\text{H}_2\text{O}^{16}$  (557 GHz) and  $\text{H}_2\text{O}^{18}$  (548 GHz). Despite significant efforts molecular oxygen (119 GHz) has not yet been detected. The derived abundance limits are significantly lower than model predictions and in the order of 10 times lower than those obtained by SWAS. The ammonia line at 572 GHz has been detected in several galactic molecular clouds and star-forming regions.

## **Munin**

This 6-kg nano-satellite for space plasma measurements was developed by the Swedish Institute of Space Physics. It was launched as piggy back on a Delta II rocket on 2000 November 21 and was operated for 53 days.

## Other Satellite projects

The Swedish Institute of Space Physics in Kiruna participates with instruments/hardware in the Russian projects **Interball** (launched 1995 and 1996), the German project **Equator-S** (launched in 1997), and in the Japanese Mars mission **Nozomi** (Planet-B) (launched 1998). The Swedish Institute of Space Physics in Lund has a space weather programme utilising data from **SOHO** and other satellites.

The Institute of Space Physics in Kiruna and Uppsala and the Space Physics Group at the Alfvén Laboratory in Stockholm provided instruments to the ESA **Cluster II** satellites, which were launched on two Russian boosters in 2000. The Scandinavian data centre for Cluster II is situated at the Alfvén Laboratory.

The Institute of Space Physics in Uppsala participates in the joint NASA/ESA mission **Cassini/Huygens** (launched 1997) to the Saturn system and have provided hardware and software for a Langmuir Probe.

The institute of Space Physics in Uppsala and Kiruna, and the Space Physics Group at the Alfvén Laboratory in Stockholm, in close collaboration with Finnish and Norwegian groups, are responsible for part of the plasma instrument package on the **Rosetta** orbiter, to be launched in 2003. A research group at the Astronomical Observatory in Uppsala is scientifically involved in several instrument teams related to the Rosetta mission and have provided filters to the scientific camera onboard the orbiter.

The Stockholm Observatory and the Astronomical Observatories in Uppsala and Lund participate with several guest investigator programmes on the Hubble Space Telescope (**HST**) and other observatory satellites.

The Stockholm Observatory participates in the ESA satellite Infrared Space Observatory (**ISO**; 1995-1998) and has provided hardware to the infrared camera. The Observatory is also involved at CoI-level in the JEM-X experiment on the ESA satellite **Integral** (launch 2002), and they will contribute CsI crystals for the gamma-ray observatory **GLAST** (launch 2005). Researchers at the observatory are also actively involved in preparing for a future interferometric cluster of satellite telescopes, **Darwin**, for the detecting of exoplanets.

A research group at the Royal Institute of Technology is responsible for the anticoincidence shield for the Italian-led satellite experiment **PAMELA**, which will study the cosmic flux of antimatter.

A research group at the Astronomical Observatory in Lund has taken an active part in the Nordic Data Analysis Center in support of the ESA mission **Hipparcos** and is now applying the high precision astrometry to new branches of astronomy. The group has also been heavily involved in preparations for the ESA cornerstone project **GAIA**, an interferometric astrometry mission.

The Onsala Space Observatory takes an active part in the Russian interferometer project **RadioAstron** and in the Japanese interferometer mission **HALCA** (previously VSOP; launched in 1997). The Onsala group together with research groups at Chalmers University of Technology and the Stockholm Observatory are involved in the forth ESA cornerstone mission, **Herschel**. They will build a facility for testing mixer assemblies for the HIFI instrument, and provide mixers for the highest frequency band of HIFI. Staff at Stockholm Observatory are involved in development of software and interfaces for the instrument simulator for Herschel/Spire.

## Sounding Rockets

Sounding rocket launches have been carried out from **Esrangle** in northern Sweden since 1961, usually as international co-operative projects. Today most of the launches carry microgravity experiments for ESA's EMIR/ELIPS programmes. The German national microgravity programme is also an important customer. In addition, sounding rockets are used for studies of the upper atmosphere and ionosphere.

**TABLE OF SOUNDING ROCKET LAUNCHES 2000-2001**

<i>Mission</i>	<i>Launch date</i>	<i>Comments</i>
<i>Texus 37</i>	<i>2000 Mar 27</i>	<i>ESA microgravity experiments</i>
<i>Texus 38</i>	<i>2000 Apr 2</i>	<i>ESA microgravity experiments</i>
<i>Orion test</i>	<i>2001 Feb 19</i>	<i>Preparation for Maxus 4</i>
<i>Maxus 4</i>	<i>2001 Apr 29</i>	<i>ESA microgravity experiments</i>
<i>Texus 39</i>	<i>2001 May 8</i>	<i>DLR microgravity experiments</i>
<i>4 Superloki</i>	<i>2001 Dec 15–16</i>	<i>Meteorological data</i>
<i>Hygrosond 2</i>	<i>2001 Dec 16</i>	<i>Validation of Odin atmospheric data</i>

Within the Swedish national programme the sounding rocket **Hygrosond 2** was launched in 2001 to an altitude of 95 km. Concentrations of water vapour from 20 to 90 km were obtained with an instrument developed within a research pro-gramme in Atmospheric Physics at the Department of Meteorology, Stockholm University (MISU). The launch was part of a rocket/balloon campaign to validate observations from the Odin satellite.

# Balloons

The period 2000-2001 saw a continuation of international campaigns at ESRANGE for research on the upper polar atmosphere, in particular related to ozone depletion and other environmental questions. The Environmental and Space Research Institute (MRI), in collaboration with researchers at the Meteorological Institute at Stockholm University continued the Skerries programme with four additional balloon flights from ESRANGE during 2000 and 2001. The project addresses questions concerning the stratospheric climate by measurement of CFCs, water vapour, ozone, etc at high altitude. Balloons were also launched from ESRANGE in order to validate data from ESA's satellite Envisat and the Swedish led Odin satellite.



*An infrastructure for launch of large balloons has been established at ESRANGE. Photo: ESA*

Several balloon launches were carried out at ESRANGE within the French led international **Archeops** project, which studies the cosmic microwave background radiation with a 1.5-meter telescope.

A research group at the Royal Institute of Technology have provided instruments to the USA balloon project **Caprice** for measurement of antimatter in the cosmic particle flux.

# Human Spaceflight

Swedish researchers in physiology at the Karolinska Institute have active research programmes that examine astronauts before and after space flight, as well as programmes for studies during space flights. One group took part in the ESA Long Term Bed Rest in Toulouse during the autumn of 2001 (2nd part in spring 2002) for tests of a device to counter the effects of prolonged weightlessness.

A researcher at the Mid Sweden University had a crystal growth experiment in a GAS container on a Shuttle flight in 2001.



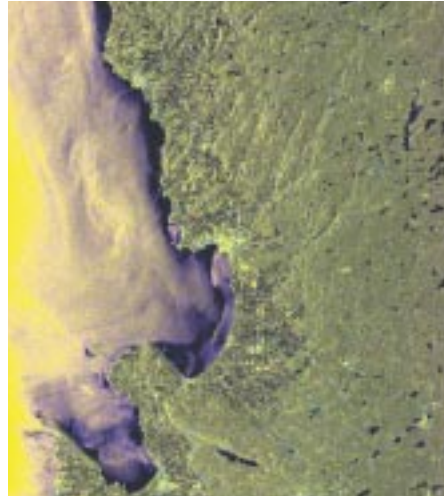
*ESA astronaut Christer Fuglesaug from Sweden during training for his first flight, which is planned for the Summer of 2003. Photo: Christer Fuglesaug.*

# Earth Observation

The Swedish National Space Board, SNSB, is responsible for funding of Swedish research and development activities within the area of Earth Observation. The funding includes financial support to research groups, to method and technique development and to users who intend to start or expand the use of remote sensing data.

## Research

SNSB supports a number of Swedish research groups that work with remote sensing. The research is carried out within areas such as forestry, global monitoring, climate change, meteorology, geodesy and atmospheric physics. At the moment global monitoring and activities linked to the European initiative GMES (Global Monitoring for Environment and Security) have high priority within the Swedish remote sensing programme.



*Part of Southwest Sweden. From ASAR, Envisat, April 8, 2002. Photo: ESA*

Sweden also has a large research programme called Remote Sensing for the Environment, supported by the Foundation for Strategic Environmental Research and managed by Metria (a division of the Swedish surveying authority, Lantmäteriet). The main goal of the programme is to develop methods where information from remote sensing satellites is used operationally. It is a unique programme where the major Swedish remote sensing organisations cooperate within eight research projects.

## Examples of Earth Observation in practical use

The Swedish National Board of Forestry is one of the big remote sensing users in Europe. The board uses SPOT and Landsat data in a GIS-based forest support system. They have produced a total land coverage for forestry control in Sweden and new data is added every year. The satellite images are used for change detection on each of the 100 local offices. This means that more than 500 people use the data, for example to check if felling is done according to what has been reported to the board.

Metria uses earth observation data to produce support for efficient and cost-effective planning and management of refugee camps. Detailed maps of camp infrastructure, thematic maps and digital elevation models are produced from high-resolution satellite images. Relief organisations can integrate the information directly into their decision-making and operational process.

Researchers at Uppsala University are developing an operation system for monitoring the water quality of Lakes Vättern and Vänern, Sweden's two largest lakes. The lakes are important water bodies for economic, ecological and aesthetic reasons, and for over 30 years Sweden has invested large sums of money to monitor their water quality by traditional means. Now it will be possible to estimate the concentrations of chlorophyll, dissolved organic matter and suspended particulate matter, using satellite sensors like MODIS and MERIS. These data will supplement the traditional monitoring efforts, and will allow temporal and spatial variations in water quality to be better understood.

## **ESA**

Sweden is a member state in the European Space Agency (ESA) and participates in ESA's Earth Observation programme. Earth Observation is a big part of the ESA activities and has always been of great importance to Sweden.

ERS-1 was the first European remote sensing satellite. It was launched in 1991 and the mission ended in March 2000. ERS-2 took over the operational services in 1996 and it still produces data. The most important instrument on board the satellites is a synthetic aperture radar (SAR) that provides sharp pictures even in the dark or through cloud cover. ERS-2 gathers climatic and environmental data from the surface of the earth and provides information on the propagation speed of ocean waves, the structure of the arctic ice as well as wind speed and direction.

In March this year ESA launched a new earth observation satellite to continue and extend ESA's ERS mission objectives and build a coherent European Earth observation programme. The satellite is called Envisat. It is an impressive satellite with its 25 metres and 8000 kilogram and it carries 10 different, very advanced instruments. Envisat is primarily concerned with monitoring the Earth's environment and climatic changes and will provide measurements of the atmosphere, ocean, land, and ice.

## **SPOT**

Sweden participates in the SPOT programme that is carried out in co-operation between France, Belgium and Sweden. SPOT consists of a series of earth observation satellites and the first satellite, SPOT 1, was launched in 1986. The fifth and last, SPOT 5, was successfully launched in May 2002. Important applications of SPOT imagery lie within the areas of mapping, telecom, forest management, agriculture, environmental monitoring, geology and planning.

On board SPOT 4 and SPOT 5 is also the Vegetation instrument, producing high frequency low resolution images. This is a sensor developed jointly by the European Commission, Belgium, France, Italy, and Sweden. The Vegetation system enables daily and global monitoring of the entire continental biosphere and crops. It was specially designed to track the vegetation, particularly in agricultural production, forestry and surveillance of the land environment worldwide. Free Vegetation products can be found at [www.vgt.vito.be](http://www.vgt.vito.be).

## Ground infrastructure

Earth observation satellite systems need to be supported by ground infrastructure. The Kiruna region in the far north of Sweden has an advantageous location north of the Arctic Circle that makes it eminent for tracking and control of satellites in polar orbits and reception of data from such satellites. Esrange, the Swedish Space Corporation's ground station outside Kiruna, is in all likelihood the world's busiest earth observation ground station. It supports many earth observation satellites in polar orbit, for example Landsat and SPOT. There is also a major facility for ERS-2 and Envisat at Salmijärvi, also outside Kiruna, that is owned by ESA and operated by staff from the Swedish Space Corporation. The Swedish Space Corporation also has an X-band ground station near Malmö in southern Sweden. This gives Sweden the capability of complete coverage of all of Europe from earth observation satellites in direct reception mode.

# **PART II**

## **Catalogue of Research Groups**

# Introduction

The following catalogue is intended to include all Swedish space research groups that during 2000-2001 have been actively involved in research utilizing equipment in space or preparing for space borne equipment. The catalogue is divided into disciplinary categories, and the research groups within each discipline are ordered by geography from the north of Sweden to the south.

In many cases the information appearing in the entries have been received from a member of the research group. In other cases the editors have synthesized the information from other sources, such as research applications or the web. Thus, the responsibility for the correctness and timeliness of the information varies from entry to entry.

# Remote Sensing

## **Water Resources Engineering, Luleå University of Technology**

*Water Resources Engineering, Luleå University of Technology, 971 87 Luleå, Sweden*

*Contact person: Angela Lundberg*

*Phone: +46-920-912 07, Fax: +46-920-916 97*

*E-mail: [angela.lundberg@sb.luth.se](mailto:angela.lundberg@sb.luth.se)*

*<http://www.luth.se>*

## **Department of Forest Resource Management and Geomatics, Swedish University of Agricultural Sciences in Umeå**

Research in remote sensing of forest ecosystems and mountain vegetation. Operational environmental monitoring of Swedish forests, using the combination of satellite images and national forest inventory field plots.

*Swedish University of Agricultural Sciences, 901 83 Umeå, Sweden*

*Contact persons: Håkan Olsson and Mats Nilsson*

*Phone: +46-90-786 5800, Fax: +46-90-778116*

*E-mail: [hakan.olsson@resgeom.slu.se](mailto:hakan.olsson@resgeom.slu.se), [mats.nilsson@resgeom.slu.se](mailto:mats.nilsson@resgeom.slu.se)*

*<http://www.resgeom.slu.se/default.cfm/>*

## **Centre for Image Analysis, Uppsala University**

*Centre for Image Analysis, Uppsala University, Lägerhyddvägen 17, 752 37 Uppsala, Sweden*

*Contact person: Ewert Bengtsson*

*Phone: +46-18-471 3467, Fax: +46-18-55 34 47*

*E-mail: [ewert@cb.uu.se](mailto:ewert@cb.uu.se)*

*<http://www.cb.uu.se>*

## **Limnology, Department of Evolutionary Biology, Uppsala University**

Remote sensing measurements of large European Lakes. Our work is focused on developing the algorithms and processing methods that will allow spatial variations in water quality parameters such as chlorophyll, dissolved organic matter and suspended particulate matter to be measured in large European lake using the latest generation of earth observing satellites (SeaWiFS, MODIS and MERIS). Presently our work is focused on Lakes Vänern, and Vättern in Sweden, and Lake Peipsi in Estonia. Funding has been obtained from the Swedish National Space Board and the European Union LIFE program.

*Department of Limnology, Uppsala University, Norbyvägen 20, 752 36 Uppsala, Sweden*

*Contact person: Don Pierson*

*Phone: +46-18-471 2699, Fax: +46-18-53 11 34*

*E-mail: don.pierson@ebc.uu.se*

*<http://www.ebc.uu.se/limno/research/AquaticOptics/optics.html>*

## **Remote Sensing Laboratory, Department of Physical Geography and Quaternary Geology, Stockholm University**

Development of methods for detecting and monitoring phytoplankton in the Baltic Sea and alike brakish water systems, using optical satellite data. Focus on time series of water quality parameters such as diffusive attenuation coefficient.

*Department of Physical Geography and Quaternary Geology, Stockholm University, 106 91 Stockholm, Sweden*

*Contact persons: Bengt Lundén and Bertil Håkansson*

*Phone: +46-8-16 47 71, Fax: +46-8-16 48 18*

*E-mail: lunden@natgeo.su.se, bertil.hakansson@natgeo.su.se*

*<http://www.natgeo.su.se/ink/home.html>*

## **Geoinformatics and Photogrammetry, Infrastructure and Planning, Royal Institute of Technology (KTH)**

*Infrastructure and Planning, KTH, 100 44 Stockholm, Sweden*

*Contact persons: L E Sjöberg, Anders Boberg*

*Phone: +46-8-790 7347, Fax: +46-8-790 7343*

*E-mail: abg@geomatics.kth.se*

*<http://www.kth.se>*

## **Department of Land and Water Resources Engineering, Royal Institute of Technology (KTH)**

*Land and Water Resources Engineering, KTH, 100 44 Stockholm, Sweden*

*Contact person: Sindre Langaas*

*Phone: +46-8- 790 8612, Fax: +46-8- 411 0775*

*E-mail: [langaas@kth.se](mailto:langaas@kth.se)*

*<http://www.kth.se>*

## **Swedish Meteorological and Hydrological Institute**

The research is focused on SAR and SSM/I sea ice applications in the Baltic Sea for operational products and in the Arctic Ocean for detecting climate variability. Also methods are developed to monitor and adapt new sensors to algae blooms in the Baltic Sea. The Numerical Weather Prediction group at SMHI is furthermore working with the utilisation of satellite data for weather forecasting models. At present this work is focused on satellite sounding information (ATOVS), on MODIS radance data and on ground-based GPS data.

*SMHI, Section for Research and Development, 601 76 Norrköping, Sweden*

*Contact persons: Sten Bergström, Nils Gustafsson, Bertil Håkansson*

*Phone: +46-11-495 80 00, Fax: +46-11-495 80 01*

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*[Nils.Gustavsson@smhi.se](mailto:Nils.Gustavsson@smhi.se),*

*<http://www.smhi.se>, <http://www.smhi.se/>*

## **Radar Remote Sensing Group, Radio and Space Science, Chalmers University of Technology**

The radar remote sensing group at Chalmers works with developing techniques for retrieve bio-geophysical parameters from synthetic aperture radar (SAR) images. In particular the focus is on understanding of the electromagnetic scattering and the properties of the imaging system.

*Radio and Space Science, Chalmers, 412 96 Göteborg, Sweden*

*Contact person: Gary Smith*

*Phone: +46-31-772 1844, Fax: +46-31-772 1884*

*E-mail: [smith@rss.chalmers.se](mailto:smith@rss.chalmers.se)*

*<http://www.rss.chalmers.se/rsg>*

## **Space Geodesy Group, Onsala Space Observatory, Chalmers University of Technology**

Using space geodetic systems, such as GPS, we study the dynamics of the earth, e.g. the crustal motions associated with the post-glacial rebound in northern Europe. We also use these systems for high precision navigational applications and to remotely sense the water vapour content of the atmosphere. These time series are now evaluated for the possible use in operational weather forecasting and the potential for climate research is also studied - the application of monitoring becomes more and more interesting as the time series become longer.

*Onsala Space Observatory, 439 92 Onsala, Sweden*

*Contact person: Gunnar Elgered*

*Phone: +46-31-772 5565, Fax: +46-31-772 5590*

*E-mail: kge@oso.chalmers.se*

*<http://www.oso.chalmers.se/Geo>*

## **Atomic Physics Division, Department of Physics, Lund Institute of Technology**

*Department of Physics, LTH, Box 118, 221 00 Lund, Sweden*

*Contact person: Hans Edner*

*Phone: +46-46-222 7658, Fax: +46-46-222 4250*

*E-mail: Hans.Edner@fysik.lth.se*

*<http://www-atom.fysik.lth.se>*

## **Department of Physical Geography, Lund University**

*Department of Physical Geography, Lund University, Box 118, 221 00 Lund, Sweden*

*Contact person: Lars Eklundh*

*Phone: +46-46-222 9655, Fax: +46-46-2224011*

*E-mail: lars.eklundh@natgeo.lu.se*

*<http://www.natgeo.lu.se>*

# Atmospheric Research

## **Atmospheric Physics Research Programme, Swedish Institute of Space Physics in Kiruna**

The programme studies the physical and chemical processes affecting the Arctic middle atmosphere, which includes the cold polar vortex of the dark stratospheric winter and the even colder, permanently daylit mesopause of summer.

*Swedish Institute of Space Physics, Box 812, 981 28 Kiruna, Sweden*

*Contact person: Sheila Kirkwood*

*Phone: +46-980-79083, Fax: +46-980-79091*

*E-mail: [sheila.kirkwood@irf.se](mailto:sheila.kirkwood@irf.se)*

*<http://www.irf.se/MRIatmos/>*

## **Department of Meteorology, Stockholm University**

Experimental and theoretical studies of the structure and composition of the middle atmosphere

*Department of Meteorology, Stockholm University, 106 91 Stockholm, Sweden*

*Contact person: Jacek Stegman, Erland Källén, Peter Lundberg, Kevin Noone*

*Phone: +46-8-16 24 08, Fax: +46-8-15 71 85*

*E-mail: [jacek@misu.su.se](mailto:jacek@misu.su.se)*

*<http://www.misu.su.se/atmphy.htm>*

## **Global Environmental Measurements Group, Radio and Space Science, Chalmers University of Technology**

The Global environmental measurements group works to provide and help interpret global datasets of relevance to environmental questions. Our current largest project is the Swedish built Odin satellite. We are responsible for the production of the geophysical data from the sub-mm receiver in collaboration with our French colleagues at the Obs. De Bordeaux. These data include the global height resolved distributions of ozone, chlorine monoxide, nitric acid and water vapour. We also work with assimilation of such data into atmospheric models and will in the coming year also utilise data from Envisat.

*Radio and Space Science, Chalmers, 412 96 Göteborg, Sweden*

*Contact person: Donal Murtagh*

*Phone: +46-31-772 5651, Fax: +46-31-772 1884*

*E-mail: donal@rss.chalmers.se*

*<http://www.rss.chalmers.se/gem>*

# Space Physics

## **Solar System Physics Research Programme, Swedish Institute of Space Physics in Kiruna**

The programme is devoted to comparative research on the evolution and dynamics of the solar system objects (planets, asteroids, meteoroids) and their interaction with the solar wind. In 2000-2001 the activities in the programme were concentrated around development of instruments for the ESA missions Mars Express, SMART-1, and Rosetta, but there is also participation in the Japanese Mars mission Nozomi and the Chinese magnetospheric mission Double Star. The programme also runs projects dedicated to simulations of plasma processes near the inner planets and ground based radar studies of meteors and dust. In 2000-2001 research on generation of energetic neutral atoms at Mercury and Mars as well as analysis of the meteor mass distributions were conducted.

*Swedish Institute of Space Physics, Box 812, 981 28 Kiruna, Sweden*

*Contact person: Stanislav Barabash*

*Phone: +46-980-791 22, Fax: +46-980-790 91*

*E-mail: stas@irf.se*

*<http://www.irf.se/rpg/>*

## **Sun-Earth Interaction Research Programme, Swedish Institute of Space Physics in Kiruna**

The programme focuses on understanding space plasma physics phenomena on the basis of measurements and modelling, and on predicting their effects on technological systems.

*Swedish Institute of Space Physics, Box 812, 981 28 Kiruna, Sweden*

*Contact person: Lars Eliasson*

*Phone: +46-980-790 87, Fax: +46-980-790 91*

*E-mail: lars.eliasson@irf.se*

*<http://www.irf.se/p2/>*

## **Space Plasma Physics Research Programme, Swedish Institute of Space Physics in Uppsala**

We explore the plasma universe. Data from our instruments on spacecraft are used to understand and model space plasma processes. Our main satellite projects are the four Cluster satellites (Earth orbit), Cassini (Jupiter and Titan) and Rosetta (comet P/Wirtanen).

*Swedish Institute of Space Physics, box 537, S-751 21 Uppsala, Sweden*

*Contact person: Mats André*

*Phone: +46-18-4715913, Fax: +46-18-4715905*

*E-mail: mats.andre@irfu.se*

*<http://www.space.irfu.se/>*

## **Solar Terrestrial Physics Research Programme, Swedish Institute of Space Physics in Uppsala**

Studies the coupled magnetosphere-ionosphere system and its interaction with the solar wind and the upper atmosphere by combining in situ, multi-satellite observations of small-scale processes at the various magnetospheric boundaries with global or at least meso-scale observations of the resulting effects in the magnetosphere and ionosphere.

*Swedish Institute of Space Physics, box 537, S-751 21 Uppsala, Sweden*

*Contact person: Hermann Opgenoorth*

*Phone: +46-18-471 5912, Fax: +46-18-471 5905*

*E-mail: opg@irfu.se*

*<http://kevo.irfu.se/stp-u.html>*

## **Physics in Space Research Programme, Swedish Institute of Space Physics in Uppsala**

The focus of the programme is on studying fundamental physical processes in space by using space as a physics laboratory.

*Swedish Institute of Space Physics, box 537, S-751 21 Uppsala, Sweden*

*Contact person: Bo Thidé*

*Phone: +46-18-471 5914, Fax: +46-18-471 5905*

*E-mail: bt@irfu.se*

*<http://www.wavegroup.irfu.se/>*

## **Division of Plasma Physics, Alfvén Laboratory, Royal Institute of Technology (KTH)**

Space Plasma Physics. The research aims at a better understanding of various plasma phenomena in the near-Earth space environment, in particular the auroral phenomenon, and also at understanding other planetary space environments. The research program is carried out with intense international collaboration. The research program is also characterized by a unique combination of space experiments, theoretical research including numerical simulations of plasma phenomena, and laboratory experiments.

*Division of Plasma Physics, Alfvén Laboratory, Royal Institute of Technology (KTH), S-100 44 Stockholm, Sweden*

*Contact person: Göran Marklund*

*Phone: +46-8-790 76 95, Fax: +46-8-24 54 31*

*E-mail: marklund@plasma.kth.se*

*<http://www.plasma.kth.se/space/>*

## **Division of Plasma Physics, Alfvén Laboratory, Royal Institute of Technology (KTH)**

Dusty plasmas in microgravity, space-relevant laboratory plasma experiments, plasma cloud skidding, and diagnostics in the VASIMR plasma rocket prototype engine.

*Division of Plasma Physics, Alfvén Laboratory, Royal Institute of Technology (KTH), S-100 44 Stockholm, Sweden*

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*E-mail: brenning@plasma.kth.se*

*<http://www.plasma.kth.se/lab/>*

## **Swedish Institute of Space Physics in Lund**

The group studies solar activity and the link with climate changes, it studies and forecasts the effects of space weather on technological systems, it runs the Regional Warning Center (RWC-Sweden) within International Space Environment Service (ISES) and it archives Space Weather Euro News (SWEN).

*Swedish Institute of Space Physics, Scheelevägen 17, SE-223 70 Lund, Sweden.*

*Contact person: Henrik Lundstedt*

*Phone: +46-46-286 21 20, Fax: +46-46-12 98 79*

*E-mail: henrik@lund.irf.se*

*<http://www.lund.irf.se/HeliosHome/irflund.html>*

# Astronomy & Astroparticle Physics

## **Extragalactic Group, Uppsala Astronomical Observatory**

Activities in 2000-2001: Images and spectra of globular clusters in the blue compact galaxy (BCG) ESO 338-IG04 were obtained with the WFPC2 and STIS at the HST. UV-spectra of the BCG Haro 11 were obtained with FUSE. The goal was to study gas flows, Ly continuum leakage and to search for molecular hydrogen.

*Astronomical Observatory, Box 515, S-751 20 Uppsala, Sweden*

*Contact person: Nils Bergvall*

*Phone: +46-18-471 59 75, Fax: +46-18-471 59 99*

*E-mail: [nils.bergvall@astro.uu.se](mailto:nils.bergvall@astro.uu.se)*

*<http://www.astro.uu.se/galaxies/>*

## **Stellar Atmospheres Group, Uppsala Astronomical Observatory**

Studies of Stellar Atmospheres; Boron in the Early Galaxy and the History of the Sun

*Astronomical Observatory, Box 515, S-751 20 Uppsala, Sweden*

*Contact person: Kjell Eriksson, Bengt Edvardsson, Bengt Gustafsson*

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*E-mail: [Kjell.Eriksson@astro.uu.se](mailto:Kjell.Eriksson@astro.uu.se)*

*<http://www.astro.uu.se/atmos/>*

## **Planetary System Group, Uppsala Astronomical Observatory**

Studies of Small Bodies in the Solar System

*Astronomical Observatory, Box 515, S-751 20 Uppsala, Sweden*

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*Phone: +46-18-471 59 71, Fax: +46-18-471 59 99*

*E-mail: [Hans.Rickman@astro.uu.se](mailto:Hans.Rickman@astro.uu.se)*

*<http://www.astro.uu.se/planet/>*

## **Astroparticle Physics, Royal Institute of Technology (KTH)**

The Satellite based PAMELA spectrometer will measure the flux of antimatter and search for signatures of dark matter elementary particles. The GLAST (Gamma-ray Large Area Space Telescope) instrument, to be launched around 2006 will investigate gamma-rays in the energy range 20 MeV to 300 GeV and locate new point sources and look for structures from dark matter particles.

*Department of Physics, Royal Institute of Technology (KTH), SCFAB, S-106 91 Stockholm, Sweden*

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*Phone: +46-8-553 781 78, Fax: +46-8-553 782 16*

*E-mail: carlson@particle.kth.se*

*<http://www.particle.kth.se/>*

## **Infrared Group, Stockholm Observatory**

The research group is actively participating in national and international space experiments with instruments for observations in the infrared and sub-mm spectral regions including ISO (now only data analyses), Odin (scheduling, data reduction and analyses), Herschel (instrument simulator and scientific planning), NGST (phase A study of the mid-IR instrument) and Darwin (study phase).

*Stockholm Observatory, SCFAB, S-106 91 Stockholm, Sweden*

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*Phone: +46-8-5537 8524, Fax: +46-8-5537 8510*

*E-mail: olofsson@astro.su.se*

*<http://www.astro.su.se/English/groups/infrared/ir.html>*

## **Late Stages of Stellar Evolution, Stockholm Observatory**

Research on Late Stages of Stellar Evolution

*Stockholm Observatory, SCFAB, S-106 91 Stockholm, Sweden*

*Contact person: Hans Olofsson, Claes Fransson*

*Phone: +46-8-5537 8516, Fax: +46-8-5537 8510*

*E-mail: hans@astro.su.se*

*<http://www.astro.su.se/English/groups/latestages>*

## **High Energy Astrophysics Division, Stockholm Observatory**

Theoretical and observational work associated with compact sources in various fields of high energy astrophysics. These sources normally contain accreting black holes and neutron stars resulting in diverse phenomena such as gamma-ray bursts, active galactic nuclei, and X-ray binaries. Members of instrument teams for the Integral and GLAST gamma-ray missions.

*Stockholm Observatory, SCFAB, S-106 91 Stockholm, Sweden*

*Contact persons: Roland Svensson, Stefan Larsson*

*Phone: +46-8-5537 8542, Fax: +46-8-5537 8510*

*E-mail: [svensson@astro.su.se](mailto:svensson@astro.su.se)*

*<http://www.astro.su.se/English/groups/head/index.html>*

### **Galaxy Group, Stockholm Observatory**

Galaxy evolution as viewed with the Hubble Space Telescope. UV to near IR data from the Hubble Space Telescope are used to investigate the resolved stellar populations and the star cluster content of blue compact and starburst galaxies in the relatively nearby universe. These fossil records are used to investigate the past and present star formation activity in these galaxies.

*Stockholm Observatory, SCFAB, S-106 91 Stockholm, Sweden*

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*E-mail: [ostlin@astro.su.se](mailto:ostlin@astro.su.se)*

*<http://www.astro.su.se/English/groups/galactic/galaxy.html>*

### **Observational Cosmology at Stockholm Observatory**

Supernovae

*Stockholm Observatory, SCFAB, S-106 91 Stockholm, Sweden*

*Contact person: Claes Fransson*

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*E-mail: [claes@astro.su.se](mailto:claes@astro.su.se)*

*<http://www.astro.su.se/~claes/obscosm.html>*

### **Elementary Particle Physics Group, Department of Physics, Stockholm University**

Cosmology

*Department of Physics, Stockholm University, SCFAB, S-106 91 Stockholm, Sweden*

*Contact person: Ariel Goobar*

*Phone: +46-8-5537 8659, Fax: +46-8-5537 8601*

*E-mail: [ariel@physto.se](mailto:ariel@physto.se)*

*<http://www.physto.se/fogr/partfys/english.html>*

## **Group for Advanced Receiver Development, Onsala Space Observatory**

Herschel HIFI Beam Measurement Range

*GARD, MC2, Chalmers University of Technology, S-412 96 Göteborg, Sweden*

*Contact person: Victor Belitsky*

*Phone: +46-31-7721893, Fax: +46-31-7721801*

*E-mail: belitsky@oso.chalmers.se*

*<http://gard04.mc2.chalmers.se/>*

## **Receiver Integration/Optimisation and Data Processing for the Odin Satellite, Onsala Space Observatory**

Activity before the Odin launch on 20 February 2001: Integration, testing, and optimisation of the quasi-optical mm/submm radiometer system was successfully performed at our Odin receiver laboratory at Chalmers, under the leadership of Magne Hagström. Development of efficient data processing, calibration and final data reduction software was done by Michael Olberg and Per Bergman. Optimisation of the Odin observing program was reached in a close interaction between Åke Hjalmarson and the Odin Astronomers in Canada, Finland, France, and Sweden.

Activity after the Odin launch: All mm/submm aeronomy and astronomy data is pipeline processed at the Odin Data Centre at Onsala, managed by Michael Olberg. Considerable efforts to understand and rectify data peculiarities, and attitude reconstruction have been implemented by Michael Olberg, Per Bergman, and our Odin research student Henrik Olofsson, with some leadership via Åke Hjalmarson.

*Centre for Astrophysics and Space Science at Chalmers University of Technology, Onsala Space Observatory, SE-439 92 Onsala, Sweden*

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*<http://www.oso.chalmers.se/Odin/odin.html>*

## **Odin Astronomy at Onsala Space Observatory**

Odin astronomers at Onsala Space Observatory are deeply involved in analysis of Odin's H<sub>2</sub>O and H<sub>2</sub>O<sup>18</sup> observations in interstellar molecular clouds and comets, and in the simultaneous searches for molecular oxygen and also in H<sub>2</sub>O searches in nearby galaxies. Searches for new interstellar molecules, at wavelengths not observable from ground because of severe atmospheric attenuation, is another area of interest.

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*<http://www.oso.chalmers.se/Odin/odin.html>*

### **Atomic Astrophysics, Lund Observatory**

We participate in various astrophysical programs on spectroscopy with the HST and FUSE aimed at e.g. abundance studies of chemically peculiar stars and radioactive dating of first generation stars. We also study atomic radiative processes in low-density astrophysical plasmas, in particular fluorescence and stimulated optical emission. We have an active program in laboratory spectroscopy for measurements of atomic parameters used in the astrophysical analyses.

*Lund Observatory, Box 43, SE-221 00 Lund, Sweden*

*Contact person: Sveneric Johansson*

*Phone: +46-46-22221583, Fax: +46-46-2224614*

*E-mail: [sveneric.johansson@astro.lu.se](mailto:sveneric.johansson@astro.lu.se)*

*<http://www.astro.lu.se/atomic/>*

### **Stellar Astrometry & Galactic Research at Lund Observatory**

Space astrometry techniques (Hipparcos and GAIA) are applied or planned for studies of individual stars, their space motions, and statistical characteristics. Main research areas are the determination of astrometric (non-spectroscopic) radial velocities, studies of stellar multiplicity, and the kinematics and formation histories of galactic stellar populations. The group participates very actively in the scientific development of the ESA GAIA mission.

*Lund Observatory, Box 43, SE-221 00 Lund, Sweden*

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*E-mail: [lennart@astro.lu.se](mailto:lennart@astro.lu.se)*

*<http://www.astro.lu.se/~lennart/Astrometry/>*

# Astrobiology

## **Department of Palaeozoology, Swedish Museum of Natural History**

Microanalysis of Microfossils on Earth – Preparation for Ancient Earth studies and for Sample return from Mars

*Department of Paleozoology, Swedish Museum of Natural History, Box 50007, 104 05 Stockholm, Sweden*

*Contact persons: Tomas Hode, Stefan Bengtson*

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*[http://www.nrm.se/pz/re\\_tomash.html.en](http://www.nrm.se/pz/re_tomash.html.en)*

## **Department of Geology and Geochemistry, Stockholm University**

Synthesis and characterisation of peptides encoded by self-assembled monolayers on nucleic acid bases absorbed on mineral surfaces: Relevance to pre-RNA information processing and the origins of life.

*Stockholm University, Department of Geology and Geochemistry, SE-106 91 Stockholm, Sweden (also Örebro University, Department of Natural Sciences, MTM Research Center, SE-701 82 Örebro, Sweden)*

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*E-mail: [nils.holm@geo.su.se](mailto:nils.holm@geo.su.se)*

# Human Spaceflight

## **Section for Environmental Physiology, Karolinska Institutet**

Pulmonary and Cardiovascular Effects of Gravity and Weightlessness

*Department of Physiology and Pharmacology, Karolinska Institutet, S-171 77 Stockholm, Sweden*

*Contact person: Dag Linnarsson*

*Phone: +46-8-7286890, Fax: +46-8-339702*

*E-mail: dag.linnarsson@fyfa.ki.se*

*<http://www.fyfa.ki.se/fyfaextern/Linnarsson/dlindex.html>*

## **Section for Exercise Physiology, Karolinska Institutet**

Exercise Prescriptions for Astronauts

*Section for Exercise Physiology, Department of Physiology and Pharmacology, Karolinska Institutet, S-171 77 Stockholm, Sweden*

*Contact person: Per Tesch*

*Phone: +46-8-7287553, Fax: +46-8-331904*

*E-mail: Per.Tesch@fyfa.ki.se*

*<http://www.fyfa.ki.se/>*

## **Department of Physics, Royal Institute of Technology (KTH)**

Dose Estimation by Simulation of the ISS Radiation Environment (DESIRE). Using the GEANT4 package supported by CERN the dose in space vehicles will be estimated. The GEANT4 results will be compared with other simulation packages and transport code calculations.

*Department of Physics, Royal Institute of Technology (KTH), SCFAB, 106 91 Stockholm, Sweden*

*Contact persons: Christer Fuglesang, Bengt Lund-Jensen*

*Phone: +46-8-55378179, Fax: +46-8-55378216*

*E-mail: christer.fuglesang1@jsc.nasa.gov*

*<http://www.particle.kth.se/>*

## **Swedish National Institute for Working Life – West**

Human factors engineering analysis in the design of the Cupola module for the International Space Station. Computer simulations and physical mock-up demonstrations of ergonomics.

*Swedish National Institute for Working Life – West, Box 8850, SE-402 72  
Göteborg, Sweden*

*Contact person: Anders Sundin*

*Phone: +46-31-501600, Fax: +46-31-501610*

*E-mail: anders.sundin@niwl.se*

*<http://www.niwl.se/>*

## **Architecture and Development Studies, Lund Institute of Technology**

The STAR Design studio (Space and Terrestrial Architectural Research Design) studies pre- industrial habitat in i.e. Tanzania and South-East Asia, and develops design concepts for future habitats in space in cooperation with NASA/Johnson Space Center, Houston TX. STAR Design focuses on architectural and design issues related to the daily life in space and covers space and artefacts.

*Department of Architecture and Development Studies, Lund Institute of  
Technology, Box 118, 221 00 Lund, Sweden*

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*E-mail: Maria.Nystrom@ark3.lth.se*

*<http://www.ark3.lth.se/>*

# Material Sciences in Microgravity

## **Department of Engineering, Physics and Mathematics, Mid Sweden University**

Crystal growth is done by zone melting and Bridgman techniques to understand the influence of convection on dopant distribution in grown material. Especially the coupling between weak convection and radial segregation is studied. Metal solidification experiments were performed in November 2001 on a Get Away Special on a NASA space shuttle.

*Mid Sweden University, 851 70 Sundsvall, Sweden*

*Contact person: Torbjörn Carlberg*

*Phone: +46-60-148751, Fax: +46-60-148802*

*E-mail: [torbjorn.carlberg@mh.se](mailto:torbjorn.carlberg@mh.se)*

*<http://www.mh.se>*

## **Institute for Surface Chemistry**

Foaming Mechanisms in Transient Foams under Microgravity

*Institute for Surface Chemistry (Ytkemiska Institutet AB), Box 5607, S-114 86, Stockholm, Sweden*

*Contact person: Bengt Kronberg*

*Phone: +46-8-790 99 17, Fax: +46-8-20 89 98*

*E-mail: [bengt.kronberg@surfchem.kth.se](mailto:bengt.kronberg@surfchem.kth.se)*

*<http://www.surfchem.kth.se/yki/web/research/ceis.html>*

## **Division for Casting of Metals, Royal Institute of Technology (KTH)**

Solidification of Metals and Formation of Metallic Foams under Microgravity

*Division of Casting of Metals, Brinellvägen 68, S-100 44 Stockholm, Sweden*

*Contact persons: Jonas Fjellstedt, Hasse Fredriksson*

*Phone: +46-8-790 79 89, Fax: +46-8-21 65 57*

*E-mail: [jonasf@matpr.kth.se](mailto:jonasf@matpr.kth.se)*

*<http://www.matpr.kth.se/>*

## **Division of Metallurgy, Royal Institute of Technology (KTH)**

Thermophysical Properties of Silicate Melts

*Division of Metallurgy, Royal Institute of Technology, 100 44 Stockholm, Sweden*

*Contact person: Seshadri Seetharaman*

*Phone: +46-8-790 83 55, Fax: +46-8-790 09 39*

*E-mail: seeth@metallurgi.kth.se*

*<http://www.metallurgi.kth.se>*

## **Department of Physics and Measurement Technology, Linköping University**

"Sublimation epitaxial growth of SiC in microgravity" is a research project on growth from the vapor phase where the microgravity relevance of the sublimation epitaxy technique is expected mainly in microscopic phenomena. The objectives of the on-going study are to obtain information by experiments and simulation on the basic transport mechanism and dynamics of sublimation growth of 4H-SiC homoepitaxial layers to reveal the influence of gravity on impurity incorporation and subsequent point defect formation.

*Department of Physics and Measurement Technology, Linköping University,  
S-581 83 Linköping, Sweden*

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*E-mail: roy@ifm.liu.se*

*<http://www.ifm.liu.se/Matephys>*

# Space Technology

## **Space Technology, Swedish Institute of Space Physics**

Satellite instruments and subsystems, nanosatellites, space environment impact, flight control software.

*Swedish Institute of Space Physics, Box 812, 981 28 Kiruna, Sweden*

*Contact person: Rickard Lundin*

*Phone: +46-980-790 63, Fax: +46-980-790 91*

*E-mail: rickard.lundin@irf.se*

*<http://www.irf.se/technology/>*

## **The Ångström Space Technology Center, Uppsala University**

Micro System Technology for space applications. The technical research is focused on high performance nano satellites and future planetary exploration probes.

*Uppsala University, Department of Material Science, ÅSTC, Box 534, SE-751 21 Uppsala, Sweden*

*Contact persons: Jan-Åke Schweitz, Lars Stenmark*

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*Fax: +46-18-471 3572*

*E-mail: jan-ake.schweitz@angstrom.uu.se*

*<http://www.astc.material.uu.se>*

## **Department of Microelectronics, Chalmers University of Technology**

Superconducting THz Mixers for the Herschel Payload Based on NbN Hot-Electron Devices. Using Extremely Low Noise Microwave IF Amplifiers Based on In-House HEMT Transistors.

*Department of Microelectronics, Chalmers University of Technology, SE-412 96 Göteborg, Sweden*

*Contact persons: Harald Merkel, Erik Kollberg*

*Phone: +46-31-7721848, +46-31-7721841, Fax: +46-31-164513*

*E-mail: harald@ep.chalmers.se*

*[http://www.nt.chalmers.se/mmw/home/home\\_e.htm](http://www.nt.chalmers.se/mmw/home/home_e.htm)*

*The Swedish National Space Board, SNSB, is a central governmental agency under the Ministry of Industry, Employment and Communication. SNSB is responsible for national and international activities relating to space and remote sensing, primarily research and development.*

*SNSB has three main tasks:*

- to distribute government grants for space research, technology development and remote sensing activities*
- to initiate research and development in Space and Remote Sensing areas*
- to act as Swedish contact for international co-operation*

*Basic research is financed via the Ministry of Education and Science. SNSB functions as a research council for Swedish research using equipment in space or at high altitudes in the atmosphere.*

*The Swedish space programme is carried out by means of extensive international cooperation, in particular through Sweden's membership of the European Space Agency, ESA.*



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