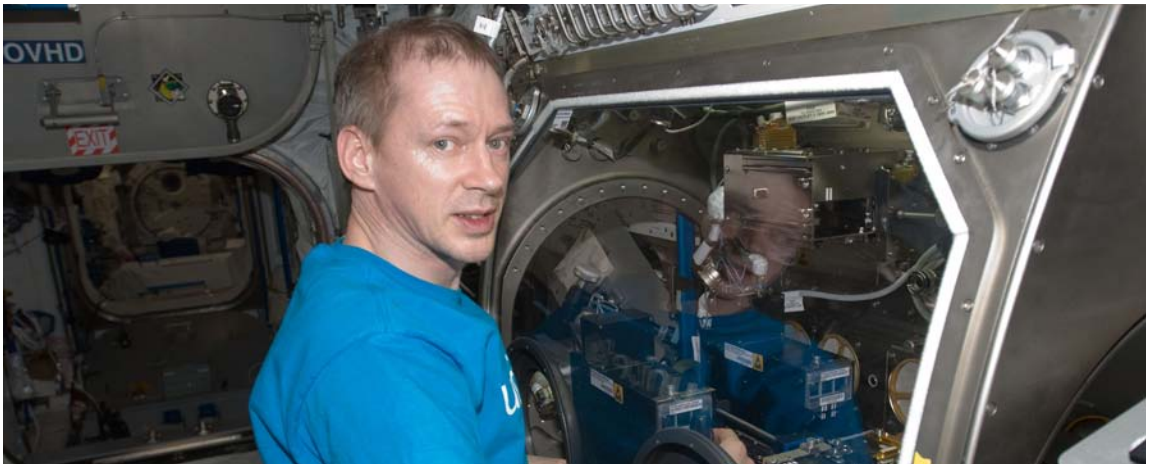
esa

→ SPACE FOR LIFE

human spaceflight science newsletter

March 2010



Frank de Winne onboard the ISS in front of the Microgravity Science Glovebox (MSG). Courtesy of NASA

In this issue:

- Frank de Winne on ISS
- SEEDS in EXPOSE–E
- Parabolic Flight no. 51
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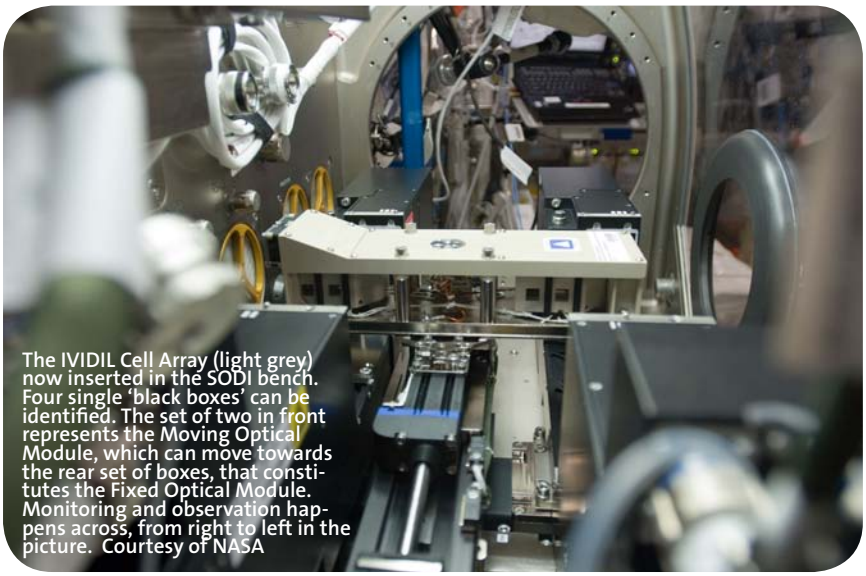
ISS EXPERIMENTAL ACTIVITIES PERFORMED DURING FRANK DE WINNE's STAY ON ISS

During his stay onboard the ISS, between his arrival 29 May and departure 01 December 2009 ESA astronaut Frank de Winne in the end had a full experimental programme. Upload restrictions did at one point threaten the scientific programme, but work-arounds gave in the end almost 100% of the science that had been expected. This article gives a short account of each experiment Frank de Winne performed, with special focus on the last activated experiment, the SODI-IVIDIL experiment.

After its uploading onboard the 17A (STS-128) mission in August 2009, the Selectable Optical Diagnostics Instrument (SODI) was installed as planned on 23 September, with a functional check-out on 1 October. Five days later the first SODI related experiment, IVIDIL was run for the first time. The eagerly awaited downloaded initial data on the optical performance of the instruments revealed nominal function. Once started, some of the experiment ran continuously for 24 hours and 5 days a week.
In the IVIDIL experiments three key parameters are investigated:
1) The so-called thermo-diffusion in fluids, which means obtaining an even temperature diffusion over time, after an initial temperature gradient between each end of the volume. This is a very slow process when left to itself,
2) The g-jitter, investigated for what it in reality means for fluid sciences in Space, as this has never been substantiated, but always been assumed to be a significant problem, and
3) vibration as a way of homogenizing multi-component liquids in microgravity has been investigated, where natural convective mixing is absent.

SODI has been planned to serve three experiments, as the 'Selectable' in the name of the instrument indicates certain flexibility. The three experiments are:
- **IVIDIL** (Influence of Vibration on Diffusion in Liquids)
- **DSC** (Diffusion Soret Coefficient) and
- **COLLOID**

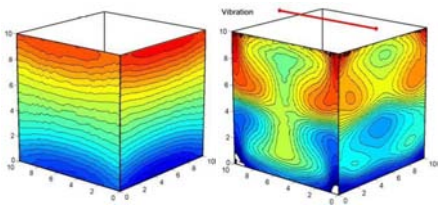
DSC is the next one up, presently being performed, with COLLOID following.
The sample container – named 'cell array' - is placed in the middle and in the direction front to back of the MSG, see picture next page. The monitoring part closest to the front – named 'moving optical module' - can move on rails, when commanded by the user - to go to a new position. For IVIDIL, however, this will not be necessary (this function is foreseen for the next SODI experiment, DSC).
The IVIDIL experiment has two test cells only, and each of the optical modules, the moving and the fixed one, monitor



The IVIDIL Cell Array (light grey) now inserted in the SODI bench. Four single 'black boxes' can be identified. The set of two in front represents the Moving Optical Module, which can move towards the rear set of boxes, that constitutes the Fixed Optical Module. Monitoring and observation happens across, from right to left in the picture. Courtesy of NASA

each a cell. The cell array is mounted on the so-called vibration mechanism, and vibrations with different frequency and amplitude can be induced. Laser beams sent from right to left through relevant mirror arrangements are the basis for monitoring in an interferometer mode, allowing to 'see' movements in fluids that are not visible to the human eye[1]. For a comprehensive description of interferometer images, please see also Newsletter no. 1, 2009, p. 8-9.

IVIDIL has been performed by Frank de Winne and Bob Thirsk a number of times during their stay. The experiment has been a great success on many accounts, not the least confirming the conclusions from a



number of numerical simulations performed on the ground before the flight. The main topic of the IVIDIL experiment was the influence of vibration on diffusion processes – so looking at FLUIDS - more specifically investigating the effect of vibration with different frequency and amplitude on a mixture of water and isopropanol for the aspect of mixing aspects of initial concentration and temperature gradients, and the time it takes. In addition, the decade long discussion of the impact of g-jitter could be investigated profoundly with this setup.

Between 8 October and 3 December around 30 experimental runs have been performed, and most have been highly successful.

The experiments have, as said, been preceded by numerical simulations on Earth, i.e. computer modelling based on assumptions of how fluid would be influenced by vibration in a gravity free environment as on the ISS.

G-jitter.

Over decades it has been discussed which influence the so-called g-jitter would have on such experiments as these, where fluid physics is investigated. It now can be concluded that the g-jitter in the form it is experienced on the ISS is much less disturbing for the experiment than hitherto assumed. The fluid compartment studied has been exposed to a broad spectrum of vibration frequencies and amplitudes, leading to a very important database regarding what has an effect and what not. It has even been studied to which extent vibration could even generate fluid flows.

Additional experiments performed during Frank de Winne's stay.

3D SPACE

This was the first neurosciences experiment in Columbus. So far it has been performed by NASA astronauts Greg Chamitoff, Mike Barrat, and Tim Kopra, and JAXA astronaut Koichi Wakata, in addition to Frank de Winne, and Canadian astronaut Robert Thirsk. Thus 6 test subjects, which is an almost complete data set for this kind of experiments.
The experiment seeks to identify differences in perception of dimensions and depth (3D) between the normal gravity on Earth and the 0-gravity onboard the ISS. Such differences could have consequences for onboard crew activities.
The 3D SPACE experiment setup was described in Newsletter February 2009

CARD

This short-name covers the original experiment title: "A model for investigating mechanisms of heart disease with new portable equipment"
The experiment has been carried out by Koichi Wakata on 20-21 May 2009. Before Wakata ESA astronaut Thomas Reiter, and after Wakata, three NASA astronauts performed it, in addition to Frank de Winne.

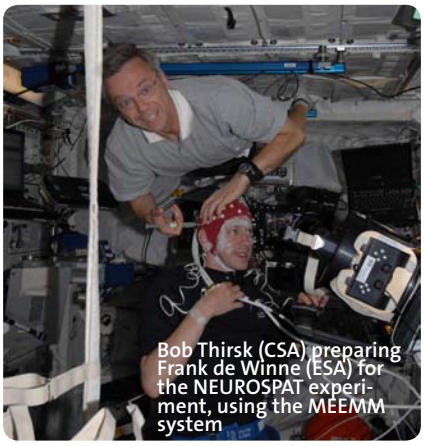
The experiment tests two hypotheses that are based on a more than two decades long research in understanding the reaction of the cardiovascular system to exposure to microgravity. Not that it per se represents any imminent danger, as the cardiovascular reflexes have been shown to return to normal after flight, but rather because, according to present physiological understanding of causal relation between stimulus and response in the cardiovascular system, the responses that can be observed in Space in the areas of adjustment of blood pressure, resistance in the circulation, tissue fluid filling and urine excretion, etc. do not fit completely with theories. Thus, the new theories for how the observable reactions could be brought about

1. The colour images show the concentration map (in false colour) of the IVIDIL sample (a binary mixture of water and isopropyl alcohol) when subjected to temperature. The sample undergoes a phase separation, induced by the so-called Soret effect, with alcohol migrating towards the cold side. When no vibration is applied (left picture) the sample reaches a steady state linear concentration distribution, just slightly perturbed by border effects. When strong, controlled vibration is applied to the cell in the direction indicated by the red arrow (right image) the steady state concentration distribution is heavily distorted by the presence of soluto-vibrational convection.

will be tested.
As this experiment in a way encompasses all the observations made in Space based cardiovascular physiology, we will devote space in a future Newsletter to a more thorough explanation of these intriguing findings.

EPM/NEUROSPAT

This is the second neurosciences experiment performed in Columbus, which fully makes use of EPM assets. Subjects may be tested on different flight days, as long as testing occurs


Bob Thirsk (CSA) preparing Frank de Winne (ESA) for the NEUROSPAT experiment, using the MEEMM system

in the period of FD5 to FD15, which is after the space adaptation period and still early in the mission.
The experiment involves recording of the electroencephalographic activity of the brain (EEG dynamics) and event related potentials (ERP) during performance of a visual-orientation perception and visuo-motor tracking task that we and astronauts may encounter on a daily basis.
The stimulus set will also contain task-irrelevant novel visual stimuli to allow assessment of electrophysiological correlates of novelty processing.
Novel conditions of microgravity accompanied by a multitude of stressors may place an increased load on the cognitive capacity of the human brain, which therefore is an additional aspect of investigation.

The first use of the MEEMM system, was very successful. Ensuring that all of the 64 electrodes connect well to the skin of the skull traditionally creates problems, which aspect has therefore also been a design-driver for the head cap assembly. Actually, very good EEG signals were obtained in these experiments, which is a significant relief, as it is one of the most critical problems in multielectrode EEG measurements.

Science data, the large stored digital EEG files, were returned with 17A (STS-128).
The experiment is supposed to be continued under a future ESA-Russia cooperative agreement, providing Russian cosmonauts as test subjects from beginning of Increment 23 and onwards.
The NEUROSPAT experimental setup was described and explained in Newsletter September 2009

SOLO

The SOLO experiment is demanding for the crew in the manner that a certain diet has to be followed fairly accurately for as long as 5 days. One period is a diet with low salt intake and another with a normal salt intake. And in addition the same amount of calories should be taken in every day. This sets some restrictions on the freedom to eat what


NASA astronaut Greg Chamitoff preparing the SOLO experiment. Courtesy of NASA

you feel like for those periods.
The food items to be used have been packed specifically for the experiment and in addition material for giving blood samples and urine samples are packed in specific pouches.
Blood samples are taken for analysis of a number of parameters related to fluid volume balance in the body, factors influencing bone metabolism, such as blood pH, as also explained in the February 2009 Newsletter. Urine samples are given in order to calculate the total salt excretion over each 24 period, such that an overall bookkeeping of the salt excretion dynamics can be analysed.

The first urine and blood samples were returned to Earth onboard the 2J/A (STS-127) flight.
In the meantime, astronauts Greg Chamitoff (picture), Mike Fincke, Mike Barrat and Frank de Winne have successfully completed the experiment

For more in-depth scientific reasoning for this experiment, please consult the Newsletter February 2009.

MOP

Title of this experiment is: "Vestibular adaptation to G-transitions" with the short name "MOP". The group of scientists behind this investigation has earlier performed experiments on Earth in relation to long duration centrifugation (1 1/2 hours at 3 G). Such scenarios made test subjects sick in a similar manner as seen in many astronauts who develop what we call the Space Adaptation Syndrome or SAS, in response to the exposure to low gravity. Based on an assumed mismatch between the different sensory inputs to the part of the brain where these are being integrated to form an adequate perception and body response, the positive G seems to create similar problems; thus the word 'g-transition' in the title, as the 'transition' is assumed to be the problem. In order to collect subject experience during g-transition periods from astronauts, questionnaires are filled in at different points in time. These have [initially] been filled in successfully with 15A (STS-119) and 2J/A (STS-127) crews

MUSCLE

Low Back Pain (LBP) is well known on Earth, but is also known in Space flight. The curvature of the spine is adjusted to optimally carry the load of the body in normal gravity. That load disappears in Space and so seems the curvature to undergo adjustment. Low Back pain on Earth is mostly related to loading factors of the spine, but also in Space low back pain develops, which must have different causes. A questionnaire for flight crews to fill in is the basis for trying to reveal details in development of low back pain in astronauts, with the objective of understanding underlying reasons for that sort of back pain in a load-free environment.

YEAST-B

During the last Soyuz direct exchange, the YEAST-B experiment has been successfully performed in BIOLAB. This experiment aimed at studying the growth of yeast in liquid cultures and on solid substrates,


Preparation of sample containers for YEAST-experiment

focusing the research on flocculation phenomena.
Flocculation is the phenomenon of cells clumping together, by means of forming so-called adhesines, a family or glycoproteines forming long chains that interact with similar structures on neighbouring cells. The phenomenon is important to examine in a gravity free environment, not the least in order to investigate if the process proceeds differently in that circumstance. Flocculation is part of many industrial and fluid treatment processes as well as it is an aspect of potential contamination of surfaces onboard the space station. The process is known to be very sensitive to a host of factors, and might as well actually change appearance due to lack of gravity. Flocculation can take place in a fluid or on a solid surface where appropriate cells grow. Such growths are often named bio-films – when the cell colony covers larger surfaces - and have been a source of concern since the start of permanent manned presence in Space. Such bio-films have a tendency to form in warm and humid areas.

YEAST experiment performance on ISS.

The experiment used two configurations, one in a liquid culture and one with solid substrate. The 26 experiment containers were processed between 2 and 7 October, with only 2 of 26 cultivation chambers failing. As a part of the sample processing and fixation, automated filtration and fixation of the cultivation chamber was successfully commanded from BIOLAB. After termination of the processing the experiment containers were stored at +4 degrees C in the Thermal Control Unit of BIOLAB, and returned with 18S.

Further equipment and experimental activities during Frank de Winne's stay

- The other external payload, SOLAR will stay onboard on an extended stay until 2013.
- STS-128 also brought onboard ESA's Material Science Laboratory (MSL), together with NASA's Material Science Research Rack (MSRR-1) in which MSL has been physically located. Frank de Winne with his fellow crew members performed the installation and check-out, and the first six experiment cartridges were processed as well.
- Portable Pulmonary Function System (Portable PFS) was uploaded with HTV-1, making it possible to begin new investigations (cardio-pulmonary physiology). This equipment supported the Thermolab experiment.
- A combined education/science experiment, in the form of a simple Fluid Physics experiment, FOAM-S, has been successfully performed after upload on HTV-1.
- Implementation of WEAR (SDTO) was tested, a virtual reality system with a transparent display in front of the eyes of the astronaut, providing a more efficient way to follow experiment procedures in a hands-free mode.
- Check-out and test of the European FLYWHEEL Exercise Device was performed
- Finally, the Protein Crystallisation and Diagnostics Facility PCDF experiments were completed and the facility was returned to Earth.
- ESA's EuTEF external payload was returned with STS-128 early September

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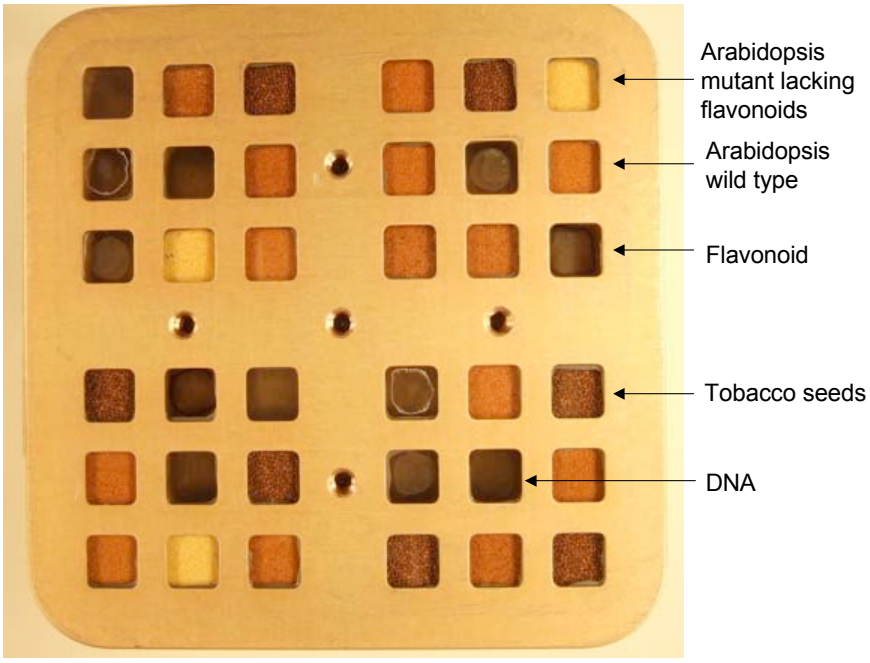
SEEDS IN EXPOSE–E – DO THEY CARRY THE SOLUTION TO RADIATION PROTECTION?

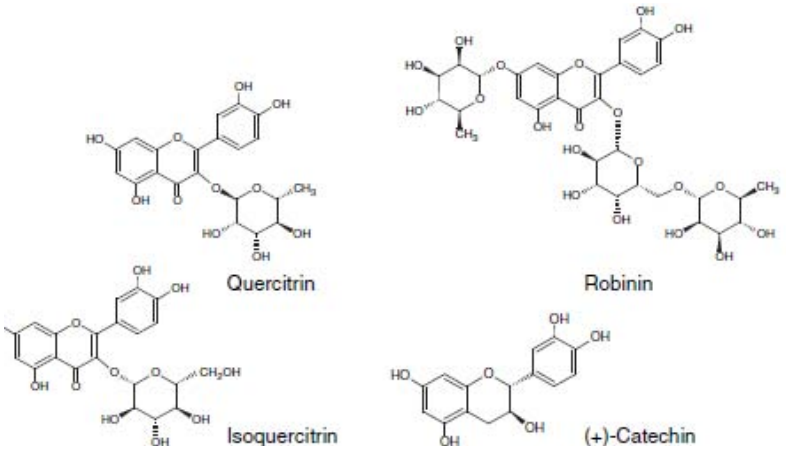
SEEDS HAVE BEEN FLOWN AS ONE OF THE MANY EXPERIMENTS ACCOMMODATED IN THE EXPOSE-E FACILITY THAT CAME BACK WITH THE FLIGHT OF ESA ASTRONAUT CHRISTER FUGLESANG, ONBOARD THE SHUTTLE STS-128 IN AUGUST 2009.

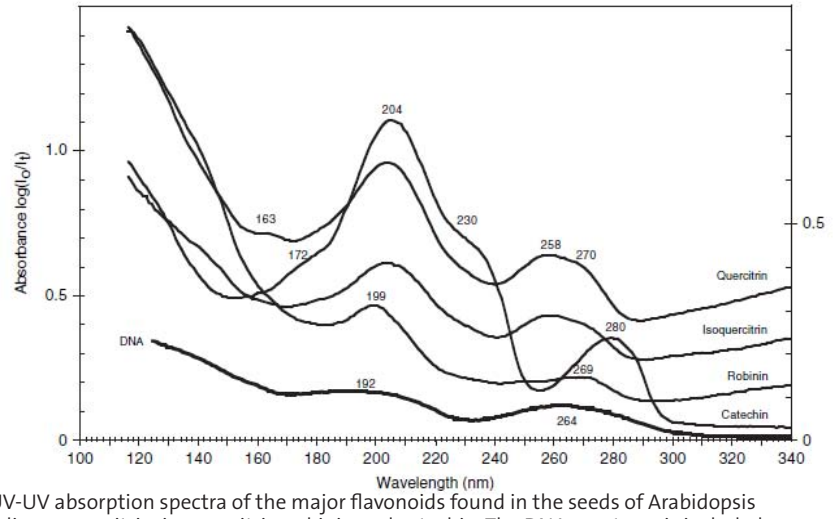
EXPOSE was in turn one of the many modules that the European technology Exposure Facility, EuTEF was housing. EuTEF was extensively described in the Newsletter May 2008 after its launch onboard STS-122, on 7 February 2008. Thus having been exposed to outer Space for 18 months, EXPOSE-E with among others the SEEDS experiment material, has been back on Earth since August 2009, and we now see the first scientific results dripping in. SEEDS is only one of several experiments flown in EXPOSE-E, the others named LIFE, ADAPT, PROCESS and PROTECT will be given



Seeds deposited in a monolayer behind magnesium fluoride windows

ample space in later issues of the Newsletter. Beginning of December 2009 preliminary results were revealed at ESTEC in Noordwijk, The Netherlands, and although the SEEDS scientists have not yet fully analysed the material, we here prepare for a later reporting on the data, by describing how seeds of the plant species *Arabidopsis Thaliana* - now well known to the readers, as this plant is central to a large number of investigations dealing with genetic material in plant in Space – and Tobacco seeds, have been selected, investigated, prepared for, and flown in EXPOSE-E. The main question investigated in SEEDS is how it could have been possible that harmful UV radiation[1] on ancient Earth didn't completely eradicate all primitive genetic material, the DNA. In that context certain theories reaching all the way back to the period in the development of the Earth, where plants could not yet live, are tested in this experiment. A host of educated assumptions are made in that context, as we evidently have no material to prove the theories, but SEEDS presents an intriguing sequential reasoning for how DNA as we know it has been able to develop, despite the harmful characteristic of UV light and its known detrimental effect on genetic material.





VUV-UV absorption spectra of the major flavonoids found in the seeds of Arabidopsis thaliana: quercitrin, isoquercitrin, robinin and catechin. The DNA spectrum is included for reference, Courtesy of Zalar et al, 2007 (VUV stands for Vacuum UV)

In SEEDS is how it could have been possible that harmful UV radiation[1] on ancient Earth didn't completely eradicate all primitive genetic material, the DNA. In that context certain theories reaching all the way back to the period in the development of the Earth, where plants could not yet live, are tested in this experiment. A host of educated assumptions are made in that context, as we evidently have no material to prove the theories, but SEEDS presents an intriguing sequential reasoning for how DNA as we know it has been able to develop, despite the harmful characteristic of UV light and its known detrimental effect on genetic material.

Based on the above, the logic of flying SEEDS is the following:

On primitive Earth no atmosphere with the composition as we know it now existed and this allows significant room for speculation on how life arose. In addition it is now well known which effect radiation coming from diverse parts of the UV spectrum have on DNA material, and finally we know - because we can measure it - that a certain part of the harmful UV spectrum is screened away by our atmosphere as it has been in newer geological time, basically all what has a wavelength shorter than 290 nm, so that only what has longer wavelength is let through to the surface of the Earth. Those are some of the important facts that allow certain interesting assumptions to be made having importance for the SEEDS experiment.

Primitive life has at some point been based on the early DNA and later leading to higher life forms, but at the same time the effect of a part of the UV spectrum would have abolished that, had there not been protection arrangements, that would allow not having DNA destructed continuously by UV radiation. This is where plants come in, in an environment where - in the primitive plants - there was a need to protect DNA against UV-B and in particular UV-C. And this is all about which part of the light is being absorbed, whereby it would have a disruptive effect on DNA, by cutting and modifying the coherence of the base pairs that make up the DNA strands.

The figure above shows some of the 'protectors' as they are assumed having been existing in primitive plants also, the flavonoids. There are a number of other molecule types as well, which we for the sake of keeping this relatively simple will leave out of consideration here.

If you check the curves in the second figure, showing the absorption in different parts of the UV spectrum, you will notice that DNA and flavonoids have absorption peaks approximately in the same parts of the spectrum, and with some overlap, such that one could say that between appr. 150 and 260 nm, flavonoids, in particular - if several different types are considered - show a broad absorption in that interval. DNA shown as the curve with the lowest absorption is seen to have these peaks very much corresponding to those of the flavonoids. (lower curve in the figure)

It is known that plant leave cells tend to even move flavonoids around to the area most exposed to solar light and it is also known that DNA in the cell is surrounded by flavonoids. So we are at the conclusion now, indicating that flavonoids should have the function of absorbing the harmful UV

1. UV light spectra and some of its effects (on the atmosphere) were described in an earlier newsletter, when we described other facilities being launched onboard the same Shuttle as EXPOSE-E with SEEDS and the other experiments, namely the SOLAR facility, see in particular SolACES in Newsletter May 2008. The SOLAR facility is still working, from its position on the Columbus external platform with the part of SOLAR named SolACES monitoring in particular the variations and intensity of the UV spectrum irradiated by the Sun.

radiation directed towards the DNA, before DNA is hit and damaged, and flavonoids thus functions as an effective shield against harmful UV light.

The experiment

The first figure in this chapter shows the 4 x 9 pits in which the seeds have been accommodated in a monolayer fashion, behind specially prepared glass windows. It also shows which types of seeds are flown, of which some have been genetically modified. As Earth's atmosphere as said, shields off the overwhelming part of the UV light under a wavelength of 290 nm, and the absorption curves we saw, show, that we are interested in looking at what happens around 260 nm and maybe even lower, the need to do 'extra-atmospheric' experiments should be evident. On the basis of experiments done on Earth in a cyclotron[2] using such radiation wavelengths in narrow bands, filters and the absorption characteristics of flavonoids have been tested, on which basis seeds were prepared for a real-life experiment onboard EXPOSE-E. - a final argument for flying such an experiment is the continuous 18 months long exposure to the Space environment.

By means of genetic manipulation, *A. Thaliana* seed mutants and Tobacco seeds of the genus is *Nicotiana*, have been produced that e.g. have no or a very low concentration of flavonoids. Now that the scientists have the seeds back, all kinds of genetic screening as well as germination of seeds are being done, and from the host of earlier ground based experiments where seeds have been exposed to diverse types, durations and intensities of radiation and vacuum, it will be possible to conclude where in the genome it has been influenced by Space exposure, and how serious the effect has been on the seeds that have been exposed to the harsh Space environment for 18 months. This in turn will all be used for adjustment of the theories that have been the basis for the experiments.

In a later article those results will be reported, and we will at that occasion also in detail explain how the experiment was put together, such that the overall logic becomes apparent.

2. A Cyclotron is a large and complex radiation research set-up, that is able to show – under the correct conditions – in which wavelength different molecules absorb electromagnetic radiation, or here UV light. Concretely, the cyclotron at the Institute for Storage Ring Facilities, ISA in Aarhus, Denmark has been used for these ground experiments preparing for SEEDS.

References

Zalar et al.: Directed exospermia: II. VUV-UV spectroscopy of specialized UV screens, including plant flavonoids, suggests using metabolic engineering to improve survival in space. *International Journal of Astrobiology 6 (4): 291–301 (2007)*

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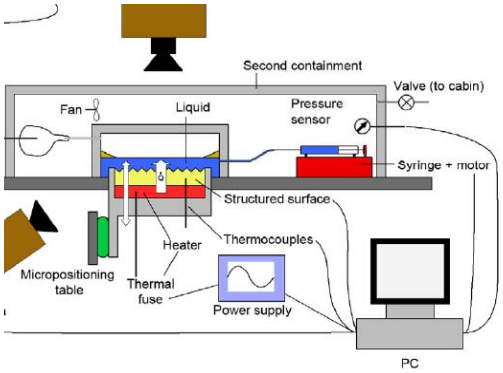
PARABOLIC FLIGHT CAMPAIGN NO. 51, NOV 2009 - WHAT CAN YOU LEARN IN 20 SECONDS?

THE LATEST ESA PARABOLIC FLIGHT CAMPAIGN (PFC) THAT WAS PERFORMED IN THE PERIOD 2-5 NOVEMBER 2009, CARRIED 14 INDIVIDUAL EXPERIMENTS. ONE PARABOLIC MANOEUVRE OFFERS AROUND 20 SECONDS OF MICRO-GRAVITY. AROUND 30 SINGLE PARABOLAS ARE FLOWN IN THIS WAY, IN SERIES, MOSTLY FIVE IN A ROW, AND ON 3 DAYS PER CAMPAIGN. IN THE FOLLOWING EACH EXPERIMENT TITLE IS FOLLOWED BY A SHORT DESCRIPTION, WITH THE OBJECTIVE OF GIVING A PICTURE OF WHICH ACTIVITIES ARE UNDERTAKEN AND WHICH OBJECTIVES ARE DEFINED FOR THIS CAMPAIGN. FOUR STUDENT EXPERIMENTS WERE ONBOARD THE FLIGHT.

EXPERIMENT 01: MARANGONI CONVECTION AND FILM DYNAMICS ON STRUCTURED SURFACES.

Coordinator: T. Gambaryan-Roisman

The Marangoni effect, is supposed to mean the mass transfer that takes place along an interface due to surface tension gradient. In turn, surface tension can be influenced by either temperature gradients in the fluid or concentration differences. It is the study of these small forces under different conditions that is the focus of the above experiment. When in the low gravity part of the parabola, the pure effect can be observed, due to absence of gravity. This experiment serves as preparatory activity for an integrated experiment to be performed in the Fluid Science Laboratory in Columbus onboard the ISS.

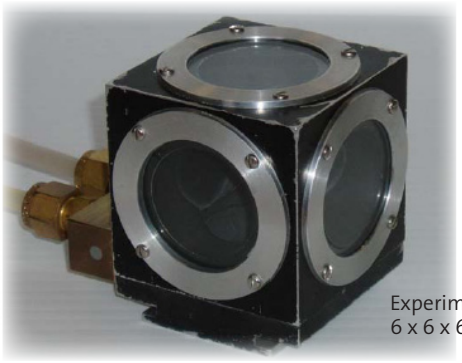


Experimental set-up. Enlarge the view to see details. (pdf version)

EXPERIMENT 02: ELECTRIC AND/OR MAGNETIC INTERACTIONS IN THE AGGREGATION OF SI (1-5 MICRONS) AND FE (1-3 MICRONS) PARTICLES UNDER MICROGRAVITY.

Coordinator: R. J. Slobodrian

This experiment is attempting to prove the correctness of one of two equations that the team has developed for prediction of how two particles of the given size behave in a closed gas chamber during the parabolic flight micro-g phase. This is investigating the effect of electrical charges and/or effect of intrinsic magnetic properties.

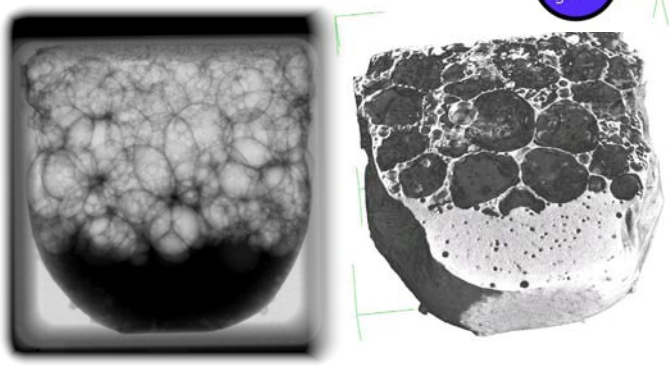


Experimental cell, roughly 6 x 6 x 6 cm with windows

EXPERIMENT 03: METALLIC FOAM EXPERIMENT WITH X-RAY DIAGNOSTICS (XRMON-1)

Coordinator: F. Garcia-Moreno

This experiment is a continuation of an experiment with a similar title on board ESA PFC no. 46 in 2007 and MASER 11 in May, 2008. Sounding rocket flights offer microgravity with a duration of 6-10 minutes, whereas a PF provides only in the order of 20 seconds. The earlier PFC 46 demonstrated that capillary forces dominate fluid movement in a metallic foam under microgravity. MASER 11 allowed for a complete foaming-up cycle in addition to obtaining a host of additional data on cell wall ruptures. This PFC now focused on the effect of adding stabilising particles like SiC and TiB2. As can be understood from the materials tested, this experiment supports research into industrial processes for producing these materials.



Left: X-Ray image from flight. Right: 3D representation of sample. Courtesy F. Garcia Moreno

EXPERIMENT 04: AGGLOMERATION STUDIES IN NANO-PARTICULATE METAL AEROSOLS

Coordinator: B. Guenther

This is an experiment under the ESA-EC project "IMPRESS". The focus is specifically on high-surface-area catalytic powders and coatings. The larger surface area (mostly obtained via a high degree of porosity), and the higher reactivity for use in catalysts – are the qualities looked for in these materials. The production of such materials happen via a vapour phase – melting a small sample and letting an inert gas stream transport the vapour. Performing this under microgravity allows identifying the basic processes in that context. This gives the possibility for better understanding of the process parameters. In particular it is expected that a slower aerosol flow in microgravity will allow better forming of high-porosity materials.

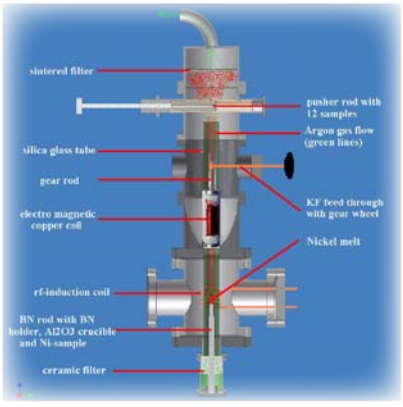


Figure: Concept shown of a complete flow tube device. Inside the top part a sintered steel fibre filter is implemented for separating powder and carrier gas. The carrier gas then continues to the top exit towards the diaphragm

EXPERIMENT 05: PROGRA2-VIS – PROPRIETES OPTIQUES DES GRAINS ASTRONOMIQUES ET ATMOSPHERIQUES - VISIBLE DOMAIN.

PHYSICAL SCIENCE

Coordinator: J.-B. Renard

The Author writes: "PROGRA-2 is dedicated to the study of optical properties of solid particles, in order to establish a database."
The earlier occasion was onboard ESA's 49th PFC in November 2008. Onboard that flight meteorite dust particles of the size of 125 microns were investigated.
The recent 51st PF flight was used for the investigation of meteorite dust particles of several tens of micrometers as well as carbon particles that can mimic the material found in comets.


Particles floating in the red laser beam

Particles under a certain size – less that 20 micron – cannot easily be observed as individual particles, which is crucial for the objective as these will agglomerate more and more the smaller they get. On the other side, particles of 20 microns or more can best be kept floating under microgravity conditions, which is the direct justification of this type of experiments. Particle studies under a very particular illumination scheme, are contributing to form a database for observation of diverse particles in the solar system at large.
See further details on the dedicated site here.

EXPERIMENT 06: THE EFFECT OF CHANGED GRAVITY CONDITIONS FOR EYE-HAND COORDINATION.

LIFE SCIENCE

Coordinator: J. McIntyre

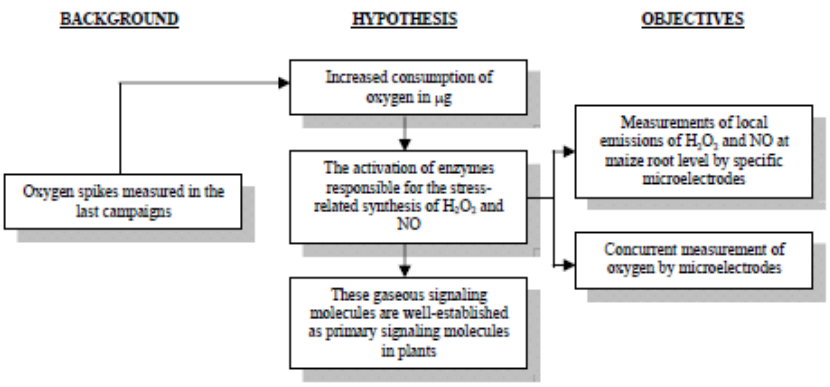
This experiment is investigating the influence of the part of the balance organs that register the presence or absence of gravity in addition to the direction of same. On Earth in 1-g we can investigate the influence of different body on different tasks but only onboard e.g. a PF or a spacecraft can we investigate what happens under the total absence of gravitational influence.
The experiment looks at these aspects in relation to eye-hand coordination, judgement of load in grabbing tasks etc., and further, the concept, that humans normally base their judgement of dimensions of objects they look at, with the height of the eye level over the ground as reference, is being tested in different situations.

EXPERIMENT 07: RECONSTRUCTING THE FASTEST CHEMICAL AND ELECTRICAL SIGNALLING RESPONSES TO MICROGRAVITY IN PLANTS.

LIFE SCIENCE

Coordinator: S. Mancuso

Contrary to what most probably would assume, this group hypothesizes that reactions in roots to changes in gravitational direction or magnitude elicits an immediate reaction to such a change. The hypothesis is based on observations in earlier PF experiments, that there seems to be a rapid change in the oxygen transport, observed with micro-electrode arrays. This electrode array is now again used to investigate this hypothesis. A reason for this rapid oxygen transport should be the activation of enzymes central to where one would expect responses to 'stress' to take place.
A further goal will be to test to which extent such responses would be represented by a synchronised response over a larger area. The Multi-electrode array would allow such observations to be made as well.



EXPERIMENT 08: SHORT-TIME INFLUENCES OF ALTERED GRAVITY ON THE KINETICS OF PHAGOCYTES' OXIDATIVE BURST .....

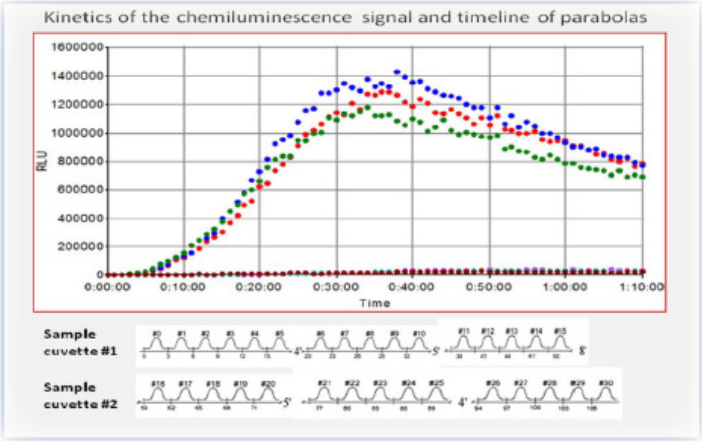
Coordinator: O. Ullrich

Phagocytes are a specifically differentiated branch of white blood cells. They play an important role in the body's immune response by - as a defence mechanism - eliminating diverse cell material. Since the early Spacelab days, the immune system has been investigated, in particular the behaviour of the diverse cell types involved, under the assumption that the function of the immune system suffers under microgravity influence.
Observations on earlier PF campaigns have shown, that phagocytes, that are involved in initiating the immune response to antigens, respond to periods of microgravity with an increased chemo-iluminescense – a marker in this case of the connection of the compound luminol that reacts with oxidative potentials the TLR2 or **t**oll-**l**ike **r**eceptor 2 site, on the cell membrane, which recognizes foreign substances. This all takes place after phagocytosis has been started by injection in the reaction chamber of zymosan and luminol before the first parabola.
Luminol is a marker for the so called "oxidative burst" of the cells, the production of **r**eactive **o**xygen **s**pecies (ROS), which are important for the destruction of the particles eaten by the cell. In this case, the cells are simulated to phagocytosis by zymosan, a yeast cell wall component. After the injection of zymosan and luminol into the reaction chamber, luminol is oxidized by the ROS and emits a light signal which corresponds to the amount of ROS. Therefore, the immune reaction can directly be followed in a kinetic measurement by the detection of this chemo-ilumines-

LIFE SCIENCE

cense reaction with a so-called photo-multiplier, a device that can amplify very faint light responses. It could be demonstrated in two PF campaigns, that the light signal is strongly reduced during the microgravity periods, which indicates that this immune response is inhibited by the lack of gravity.

The figure here – X-axis indicating time in minutes and Y-axis giving RLU or Relative Light Units - illustrates measurements from an earlier PF campaign, with the lower panels indicating the progressing parabolas flown. If you look carefully, you will see two superimposed dotted lines along the x-axis, which represent the control experiments, performed after exactly the same protocol, but on ground, without any change in gravity.



EXPERIMENT 09: MICROGRAVITY STUDIES OF THE EFFECT OF VOLUME FRACTION AND SALINITY ON FLOW BIREFRINGENCE IN SAMPLES OF SODIUM FLUOROHECTORITE DISPERSED IN WATER.

Coordinator: H. Hemmen

PHYSICAL SCIENCE STUDENT

Behind this - to the untrained eye - fairly cryptic title hides an interesting experiment.

'Birefringence' can also be called 'double-refraction'[1] which simply means the effect of seeing matter through a medium as for example the mineral Calcite (used here, but there are many others) in an image borrowed from Wikipedia, where light passing the crystal is polarised differently in different parts of the material. Bi-refringent material is used in situations where there is a wish to utilise or manipulate the polarisation of light.

In this PFC experiment the quality of the bi-refringent material Sodium-fluorohectorite (NaFh) particles have been produced, that is a slate type particle found in clays, and for the experiment produced synthetically. These particles, with this bi-refringence property, are very thin, with thickness up to only 150 x 10^{-9} meter, or nano-meters, and a length in the region of 20 x 10^{-6} meter, to 20 microns. They are thus long – 500-1000 times longer than they are thick - thin plates and because of these characteristics, they willingly stay suspended in water for a while.

Exposed to a water flow, these plates will orientate themselves in the flow direction, at a certain flow profile – here a 'peristaltic' flow profile, which resembles the way our intestine transports digested food through our system. During the microgravity phase in-flight, the flow is stopped for short periods during the microgravity phase, at which time only molecular movements in the fluid will have effect. In this manner pure Brownian movements[2] – the molecular

1. Refraction is simply the scientific term for the fact that a light beam changes direction – it refracts – by passing from material to another. Think of the difficulty of judging depth of the water when looking down through the surface to the bottom.

2. Brownian motion (named after the Scottish botanist Robert Brown is the seemingly random movement of particles suspended in a fluid (i.e. a liquid or gas) or the mathematical model used to describe such random

movements in fluids and gases as an effect of temperature -can be studied. On ground, study of this phenomenon is disturbed by the sedimentation of particles on solution, that takes place as an effect of gravity.

In this experiment an ingenious combination of physical reality factors as identified, should make it possible to reveal a better understanding of the effect of Brownian movements.

movements, often called a particle theory. Source: http://en.wikipedia.org/wiki/Brownian_motion

EXPERIMENT 10: EROSION OF DUST BEDS BY A SOLID STATE GREENHOUSE EFFECT AND THERMOPORESIS.

Coordinator: G. Wurm / T. Kelling

Matter in the universe is not only in the form of planets and stars, which is what we non-space scientists mostly think off. Material from the size of the smallest dust particles to kilometre size comets is the topic of this experiment, more specifically to understand how bodies in the heavier end of the spectrum could grow from aggregation of dust particles.

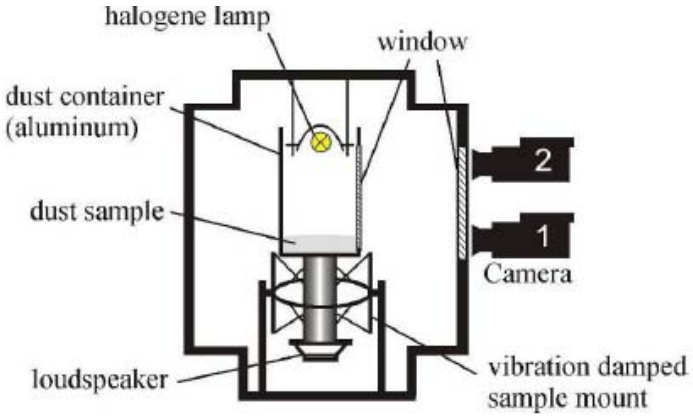
The theory here is fairly complex but one of the main applications of this experiment is to understand the role of dust aggregation and erosion in the formation of our solar system.

By applying the same physical theory this team is also searching for the origin of dust storms on e.g. Mars. One of the many differences between Earth and Mars is, that Mars has a very thin atmosphere and that the composition is also very different. But the most important effect of the present experiment is the fact that the atmospheric pressure on Mars, as an effect of the thin atmosphere is very low, as low as a few millibars. For comparison the Earth atmospheric pressure is in the region of 1000 mbar, as an effect of both the composition and the thickness of our atmosphere.[1]

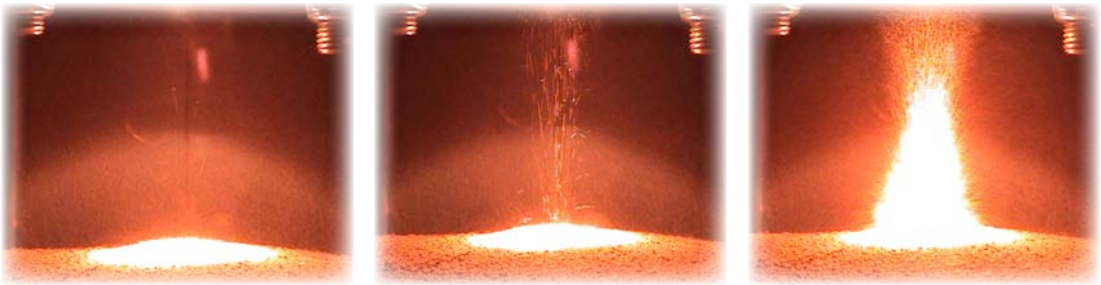
With such a low gas pressure as Mars has, other small forces come into play for moving small dust particles around. And that is what this experiment is concerned with.

This team of scientists has demonstrated by calculations that micro-size particles are mostly influenced by temperature effect on Mars. The experiment investigates if radiation-based temperature effects would be significant enough to lift these particles off the surface of Mars, in light of the very low gas pressure acting on it. If this can be proven, we have a theory for a potential origin of dust in the Martian atmosphere and early solar systems, namely from celestial bodies that have such characteristics, as e.g. Mars.

The experiment is therefore designed so as to determine the gravity dependency of this dust lifting effect in order to estimate its importance for smaller bodies in early stellar systems but also for Martian-like planets and Mars itself.



Experimental Setup.
A dust sample (JSC Mars 1A) is placed in a vacuum chamber (**p** approx. 5 mbar). A halogen lamp is placed within the chamber above the dust sample and shines on the dust sample. In addition, the temperature of the dust sample is monitored by temperature sensors. The dust sample is installed in a vibration damped sample mount. Not shown in this figure are the pressure sensors, the rack itself and the several connections for the computer, the vacuum pump and the electronics.



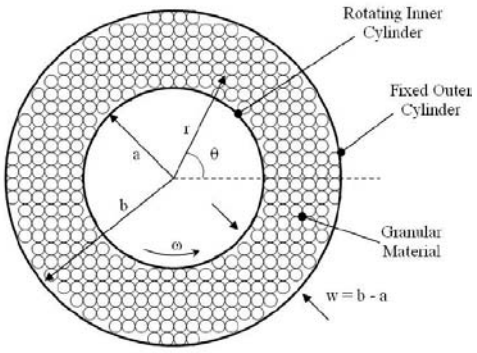
Images from the PFC 51 experiment by the student group. Bottom row, left to right, with the same light intensity the effect of illumination in combination with falling levels of gravitational load is seen, 2 g, 1g and 0g.

1. Air does have a weight in a gravity field. One cubic meter of air and "standard conditions" i.e. at the temperature 20 degrees C and pressure of 1013 mbar, weighs in the region of 1.2 kilogram, and we can calculate the pressure that the specific thickness of our atmosphere will exert on us and the Earth surface, as an effect of the mass.

EXPERIMENT 11: SIMULATING ASTEROIDAL REGOLITHS: IMPLICATIONS FOR GEOLOGY AND SAMPLE RETURN.

Coordinator: B. Rozitis

Asteroids are defined as being smaller than planets and larger than meteoroids. The ones we know are those that orbit our sun and some of them have a considerable size, often 50-100 km across.
This experiment is focused on how one would be able to obtain material samples from such bodies, by looking at the flow of granular material in a microgravity environment. On the surface of such asteroids, a similar low level gravity will be found, due to their relative small size. In such an environment, one needs to keep material under control in order to collect it, as otherwise is will spread in all directions.
In a closed environment onboard this PF a particle flow will be created by mechanical means. The movements and flow type will be recorded by a high-speed camera.



a: inner cylinder radius b: outer cylinder radius
w: width of shear region r: radial distance - θ- angular distance ω- inner cylinder rotation rate

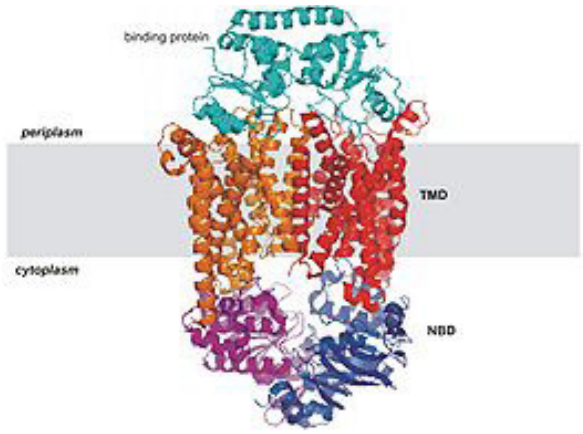
EXPERIMENT 12: ABC TRANSPORTERS IN MICROGRAVITY

Coordinator: S.V. Araujo

The motivation for this experiment is the often reported change in drug kinetics in space crews.

The name ABC transporter is derived from **A**TP-**b**inding **C**assette transporters. These transporters get the energy for the transport by binding ATP, the universal energy source of our organism, and which is an end product of metabolising different fuels, such as sugar and fat. The term 'cassette' is an expression from gene technology, used to describe a DNA sequence - a part of a larger DNA context - that codes for one specific chemical function. Active transport across cell membranes to a very large extent happens via such active mechanisms. They consist of two trans-membrane domains, and two ATP binding domains. Apart from transporting drugs, ABC pumps are transporting small molecules, lipids (fat) of different kinds. Bacteria use this strategy for transport of their nutrients. The ABC importer shown here is just one of many specialised versions.

This experiment is studying if microgravity per se would have any influence on ABC transporters involved in transport of drugs across the cell membrane, based on diverse earlier findings pointing in that direction. The cellular model used is based on biotechnological and genetic engineering, using a human ABC transported gene, inserted into the DNA of an insect, which in turn starts an overproduction of the selected transporter. The transporter molecules are located on the cell surface, and once the production has been ongoing long enough, one can harvest the overproduction of transporter via biotechnological manipulation, in the form of vesicle shaped structures. It is these vesicles that in turn are used for the test of the velocity of transporting relevant molecules from the outside and into the cell (they consist of a reconstructed membrane segment). After the experiment has been running for the planned time, vesicles are harvested and the amount of matter transported into it can be estimated by use of gas chromatography, and other techniques. This first experiment is also targeted to test the use of the applied technology in microgravity.



Structure of an ABC importer (bringing into the cell): It transports Vitamin B12 into the cell (outside here is top, cell membrane is grey, and inside cell is bottom part) Length of the seen crystal structure is 2.6 Ångstrøm of 2.6 x 10^{-10} meter
Source: Hvorup et al. http://www.pdb.org/pdb/explore.do?structureId=2QI9

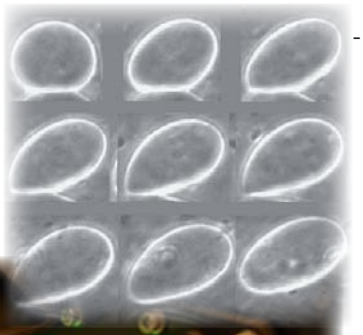
EXPERIMENT 13: DYNAMICS OF A VESICLE SUSPENSION UNDER SHEAR (BIOMICS)

Coordinator: T. Podgorski

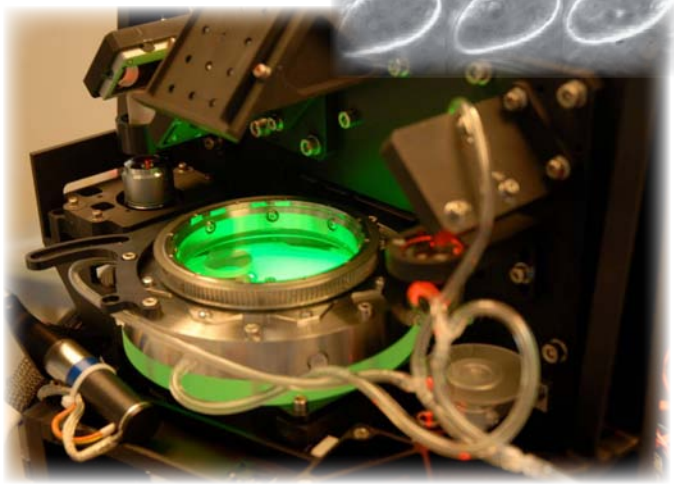
In the Newsletter January 2009, we reported on a MASER-11 experiment that was one of the forerunners for this present one, at that time termed the BIOMICS experiment.
With background in that story, this group now flies a revised experimental set-up, utilising the PFC's offered 20 seconds microgravity, alternating with 1 g. The 6-10 minutes microgravity onboard Sounding Rockets for microgravity, are well suited for more steady state studies. This allows for different experiment foci, where the special quality of PF experiments is the fact that the vesicle sediment between parabolas, allowing to study in particular the dynamics of sedimented vesicles lifting off from the walls. The same 'shear-flow' chamber is utilised, that allows the flow to lift regimented vesicles off the wall of the chamber Looking into the volume of the working chamber with a holographic microscope, allows - after post-flight processing - to identify the position of vesicles in 3D and analyse the evolution of their spatial distribution under flow. (grey insert)

This experiment is a typical example of research at the interface between Physical and Life Sciences, revealing the importance of purely physical phenomena in the dynamics of some biological systems.

What this is good for? Eventually, and as more repeats of the experiment increase in sophistication, this material will form an important basis for a better understanding of the interaction between blood cells of diverse types and vessel walls in the human circulation. These - basically flow-mechanical details are still not fully understood at this time.



Insert, grey: Migration away from a wall in shear flow due to hydrodynamic lift forces. Start top left, end bottom right. Courtesy of BIOMICS group.

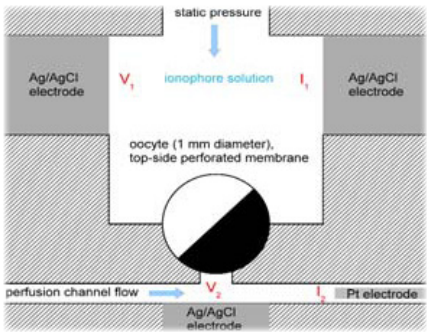


Shear flow chamber mounted on the holographic microscope. Courtesy of BIOMICS group

ELECTRO-PHYSIOLOGICAL STUDY INVESTIGATING CELLULAR EFFECTS OF WEIGHTLESSNESS INDUCED MUSCLE ATROPHY

Coordinator: M. Egli

This experiment is testing the hypothesis, that "microgravity induces the reabsorption of muscle and bone via selective attenuation of mechanically gated calcium entry."
So what does that mean? The hypothesis is based on the knowledge that Calcium ions - Ca++ - transport into the exercising muscle cells is among many other things, a precondition for the muscle cell's ability to build a stronger muscle. During exercise Ca-ions enter the cell across the cell membrane via a specific calcium pump arrangement, see also Experiment 12 above for comparison. This is a direct response to mechanical impulses for the exercising muscle, and Ca++ inside the cell starts off a cascade of reactions that leads to growth of the muscle, as an effect.
The experiment is therefore studying the effect of microgravity on the Ca++ pump, but a Ca++ pump in a different type of cell, more accessible to such investigations. Using an elegant micro-fabricated-chip design, amphibian oocytes[1] (very large cells) are placed within a vertical cylindrical channel where they settle upon an aperture that conducts to a second chamber underneath. When securely settled the oocyte blocks the hole completely, isolating two separate compartment (above and below the oocyte), both equipped with electrodes. As a first step, the upper chamber is flushed with an ionophore[2] solution that establishes electrical continuity between the inside of the cell membrane and the electrical amplifier by making small pores in the membrane. Because the cell completely seals the hole, the ionophore added to the above chamber does not contaminate the lower chamber. As the membrane above the hole is left intact, current is forced to flow through the channels in the oocyte membrane only.



Detail sketch of the cross-sectional view of the recording chamber inside the Oocyte recording micro-fluid-chip. It consists of three layers. Courtesy of Marcel Eegli et al.

Now, the intact cell membrane can be exposed to different active components via the second chamber, permitting the measurement of the electric membrane property under the influence of different drugs while exposed to microgravity.

1. Oocytes are unfertilized eggs, taken from female Xenopus frogs. These cells are expressing channels which are similar to the ones of muscle cells.

2. Ionophores are lipid-soluble molecules to transport ions across the cell membrane.

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RECENT EVENTS ....

08 FEB: STS-130 - Launch of Node-3 and adjoining Cupola unit onboard Space Shuttle Endeavour, KSC, US, was taking place at 4:14.08 am. CET a.m. EST. After 14 days in Space, Endeavour landed at Kennedy Space Centre on 21 February, 10:20 p.m.

The main goal of the mission was to deliver the Tranquility Node 3 and the Cupola module to the International Space Station.
The shape of the patch represents the Cupola, which is the windowed robotics viewing station from which astronauts will have the opportunity not only to monitor a variety of the station operations, but also to study our home planet.

(From left) Mission Specialist Stephen Robinson, Mission Specialist Nicholas Patrick, , Pilot Terry Virts, and Kathryn Hire, Commander George Zamka and Mission Specialists Robert Behnken. Image credit: NASA

26 MAR: Sounding Rocket MAXUS-8 launched, Kiruna, Sweden.

Maxus 8 payload: Four experiments are planned, with the titles:

- Cyto-skeletal mechanisms of gravisensing in Chara
- IMPRESS. Microstructure formation in Ti-46Al-8Nb and Ti-46Al-8Ta during solidification
- Morphology of metal alloy agglomerates
- In-situ X-ray monitoring of advanced metallurgical processes under microity and terrestrial conditionsCompared to the latest launched sounding rocket.,

MAXUS rockets are launched via a structure as the one indicated to the left.

02 APR: Soyuz TMA 18, 22S launched wuth the three-person crew: Commander Aleksandr Skvortsov, RSA Flight Engineer Mikhail Korniyenko, RSA and Flight Engineer Tracy Caldwell-Dyson, NASA

Alexander Skvortsov will serve as an Expedition 23 flight engineer and commander of Expedition 24. NASA astronaut Tracy Caldwell Dyson will serve as a flight engineer for Expeditions 23 and 24. Mikhail Kornienko will serve as a flight engineer for Expeditions 23 and 24.

05 APR: STS-131 - Space Shuttle Discovery - lifted off from Kennedy Space Center 6:21 am. EDT bringing the Multi-Purpose Logistics Module (MPLM) Leonardo, with MELFI-3 and MARES

Seated are NASA astronauts Alan Poindexter (right), commander; and James P. Dutton Jr., pilot. Pictured from the left (standing) are NASA astronauts Rick Mastracchio, Stephanie Wilson, Dorothy Metcalf-Lindenburger, Japan Aerospace Exploration Agency (JAXA) astronaut Naoko Yamazaki and NASA astronaut Clayton Anderson, all mission specialists. Courtesy of NASA/JSC.

DATES FOR THE AGENDA ....

13-17 June:	European Life Science Symposium, Trieste, Italy
15 June:	Soyuz flight 23S, - three person crew to the ISS

Updated 03 June 2010

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UPCOMING TOPICS:

MAXUS-8

Launched from Kiruna, Sweden on 26 March 2010, data from experiments onboard the Sounding Rocket will start dripping in, in time for the next HSF Science Newsletter. ESA seeks to run two Sounding Rocket campaigns per year.

Bedrest with Artificial Gravity (MEDES)

ESA has performed a number of bed rest studies over the last decade. These are crucial as simulation studies of the real Space travels, as well as for general public health.
Artificial gravity using a human centrifuge will study the effect of occasional gravity loading in this manner, on the detrimental effect of bed rest - as a simulation of Space

Overview on AO-2009/ILSRA-09/BR-09 and CFI results

In 2009 ESA launched another call for proposals for future important experiments and science onboard the International Space Station, ISS. A preliminary status will be reported together with general outlook regarding the coming years' experiments onboard the ISS

Increment 23/24 experimental programme

Starting in April 2010, increment 23 onboard the ISS will have its beginning. Increment 24 starts around one month later and ends in September 2010. An account of the planned experimentation will be given

AMS Testing

The Alpha Magnetic Spectrometer (AMS) arrived on 16 February at ESTEC for exhaustive testing before it will be lofted to International Space Station (ISS) with Space Shuttle next July this year. The purpose of the AMS is to help scientists to better understand fundamental issues on the origin and structure of the Universe by observing antimatter and dark matter. As a by-product, AMS will gather a lot of other information from cosmic radiation sources on stars and galaxies millions of light years from our home galaxy.

Next Shuttle flight

Next up - to launch on 14 May - is STS-132 - Utilisation Flight 4 (ULF4), bringing the Russian module MRM1 to the ISS.

Next Shuttle flight with ESA astronaut

Scheduled for a 29 July launch, Shuttle flight STS-134 / ULF6, will loft the Alpha Magnetic Spectrometer (AMS). ESA astronaut Roberto Vittori will be onboard STS-134.

11th ESA Life Sciences Symposium

Trieste - Italy, 13-18 June 2010
register at www.congrex.nl/10a09

In collaboration with
31th Annual ISGP Meeting
5th ISSBB Symposium
ELGRA Symposium

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