newsletter

NEWSLETTER OF THE EUROPEAN LOW GRAVITY RESEARCH ASSOCIATION

NUMBER 6, DECEMBER 2008

Dear ELGRA members,

Exactly three decades ago, in December 1978, Dr. Lebeau (then ESA's Deputy Director General and Director of Planning and Future Programmes), Dr. Wolff (Chairman of the ESA Life Sciences Working Group) and Prof. Weiss (then Chairman of the ESA Materials Science Working Group), conceived the idea of forming an association of European scientists with the aim of furthering their interest in exploration, research and development of their sciences in a low gravity environment. At that time the advent of Spacelab and the possibility of research in low gravity environment on other platforms such as sounding rockets had led to a widening European interest in this type of research. As experimenters were widely dispersed geographically, the formation of an "association" seemed opportune in order to foster cooperation and coordination that is essential for success in this pre-internet era. Less than a year later, on November 22, 1979, our European Low Gravity Research Association, ELGRA, was formally registered in Munich, Germany. The 'founding fathers' of the society were: Prof. Bonde-Petersen (Denmark), Dr. Malméjac (France), Prof. Napolitano (Italy), Dr. Padday (UK), Dr. Stott (UK), Prof. Weiss Germany), and Dr. Wolff (UK).

A lot has happened during these 30 years. ELGRA has become the main platform for European scientists, both in physical and life sciences, using micro- and hyper-gravity as one of their research tools. Using (micro)gravity is now not only limited to mostly basic research but has also found its way in applications as is reflected in *e.g.* a large number of successful ESA Microgravity Application Programs, MAPs.
While Spacelab and sounding rockets were the main initial facilities, we now have the ISS as major micro-g laboratory. Also other platforms such as free flyers (Bion/Foton), aircraft parabolic flights and ground based simulator are used more frequently.
So, while there seems to be quite an array of platforms to be used for scientists to conduct microgravity-related research, the research possibilities are still very much lacking behind regular ground based research. Budgetary constraints would be one of the main reasons for this situation; a still very much divided European political landscape also does not contribute to increasing science opportunities. Although closer relations between major space agencies in the world have been established in the last decades, especially with the construction of the ISS, there is still room for improvement. I do hope that the scientific output emerging from future initiative such as a Lunar or Mars mission but also less ambitious projects could benefit from a closer cooperation of all parties involved. I do believe that ELGRA could and will contribute to this process. It is an exciting time for our community, especially now the European Columbus laboratory is up and functioning. However, logistical problems are still at stake now the Shuttle is nearly phased out and especially sample return possibilities are limited.

You have, or soon will, receive the Proceedings of the last ELGRA Symposium in Florence (Italy) held together with the Italian Association for Aeronautical and Space Medicine (IMAS). This special edition of Microgravity Science and Technology, MST, very well reflects the current status of our present research. As ELGRA we are pleased that we have established firm relations with MST and it publisher Springer. We are investigating the possibility to have MST as a regular journal for all ELGRA members.

Please note in your schedules that ELGRA organizes its next biannual symposium – the 20th since its foundation – from 1-4 September 2009 in Bonn, Germany. Prof. Ruth Hemmersbach and Prof. Rainer Willnecker, both from the German space agency DLR, are the local organizers.

As for previous ELGRA symposia we expect large student participation and we will do our best to subsidize their venue. In addition, we organize a contest for the best student studies in both Physical and Life Sciences as we did before. The winners, in addition to receiving a special ELGRA award, will expose their work in front of the ELFRA audience in a general session.
The Symposium gives us the opportunity to award the ELGRA medals. Every two years, ELGRA honors two of our more esteemed members in Life and Physical Sciences for their outstanding contribution to the field of Microgravity sciences. It is also the time where the new Bureau of the Association will be elected, during the General Assembly. I would like to remind you that the volunteers interested in contributing to our Association can contact me directly. It is indeed the role of the current bureau to propose new volunteers who want to serve in the future management Bureau.

ELGRA represents its members and is an active organization in a number of international scientific meetings such as the joint meeting with ESA and the International Society for Gravitational Physiology (ISGP), the American Society for Gravitational and Space Biology (ASGSB) and the French Space Agency CNES, in Angers in June earlier this year. As ELGRA we are looking into the possibility to have more collaborative meetings.

We have all the reasons to be optimistic for the near future. The recent ESA Ministerial Conference in The Hague provided a significant new budget for the European micro-gravity research community. Early 2009 will also be the time that ESA will open a new announcement for research proposals, Topical Teams and MAP's.

I wish you an excellent 2009 and I am looking forward to welcoming you all in Bonn to make our next Symposium a great success!

Yours sincerely,

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INSIDE

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A. DECOMPRESSION SICKNESS (DCS): LIFE AND PHYSICAL SCIENCE PERSPECTIVES

Background and basic considerations for monitoring DCS during spacewalks (extravehicular activities)

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DEFINITION

Decompression sickness (DCS) is a clinical syndrome caused by rapid reduction of pressure in the body which results in formation of bubbles within body tissues. These bubbles is the result of desorption of dissolved gases that can not be sustained in the dissolved state when pressure decreases. DCS symptoms range from mild joint nuisance or pain to permanent deficits or even death. Hyperbaric DCS refers to decompression from a higher than ambient pressure (1 bar) to a lower pressure value (down to ambient pressure) and it may occur in pressurized tunnels or caissons employed in underground or underwater construction works, in hyperbaric medical chambers aiming at faster post-surgery rehabilitation of patients as well as in scuba diving. Hypobaric DCS refers to decompression from ambient pressure to a lower pressure (partial vacuum) value and may occur during a loss of pressure accident in high altitude flights, from long exposure in high altitude chambers or in space during extravehicular activity (EVA). In particular, during EVAs crewmembers go from an ambient cabin pressure to the space suit pressure of ~0.3 bar and this entails a potential risk for DCS.

ETIOLOGY, SITES OF FORMATION AND CLINICAL MANIFESTATION

During decompression the body pressure decreases and as a result tissues get supersaturated with nitrogen (inert gas) oxygen and carbon dioxide and oxygen (metabolic gases). The human organism tends spontaneously to equilibrate this excess level of dissolved gases. The small amounts of metabolic gases are rapidly controlled by the respiratory and circulatory systems. On the contrary, the inert gas can leave the tissues only through the venous system and be finally expelled by the lungs at much slower rates than metabolic gasses. The control of nitrogen by the organism and the high percentage of nitrogen breathed from ambient air make it the gas most implicated in DCS. In in-vivo systems, supersaturation limits for the production of a decompression gas phase are orders of magnitude lower than those found in-vitro in quiescent fluids. This was attributed to the fact that microbubbles preexist in tissues.
Bubbles are formed mainly in the skin, joints and the spinal cord. These bubbles may move from the sites of origin directly into the veins but not into the arteries due to the higher gas pressure in arteries than in veins. There is experimental evidence of bubbles in human veins and mainly in those draining kinetically active tissues. The most common are the subclavian and femoral veins, while jugular, branchial and popliteal veins have been also found to contain bubbles after many decompression exposures. These bubbles will altogether gather in vena cava (superior and inferior).
After vena cava, bubbles will pass to the pulmonary filter. The pulmonary filter can trap bubbles thus preventing their passage to arterial circulation. However, if the pulmonary filter is overloaded with bubbles some bubbles will eventually pass to arterial circulation through the left ventricule. Bubbles passing to arterial circulation will then progressively move to peripheral tissues.
The clinical manifestations of DCS are usually divided in mechanical effects (bubbles impinging on nerve endings and thus causing pain and tissue tearing) and blood-bubble interfacial effects. Interfacial effects usually refer to bubbles appearing as foreign bodies in the organism which initiate a defense mechanism. This defense mechanism triggers a cascade of reactions: vasoconstriction, leakage of liquids from the intravascular to extravascular spaces, platelets aggregation causing ischemia, blood viscosity increase, capillary flow resistance increase, capillary pressure increase, venous return decrease and blood flow decrease.

FACTORS AFFECTING DCS

The incidence and severity of DCS are affected by both external and individual (human) factors. One of the main external factors is the pressure profile into which the human body is subjected. The pressure profile includes the pressure difference, the length of exposure and the rate at which decompression takes place. Another important external factor is the composition of the gas breathed in. Oxygen pre-breathe depletes nitrogen from the body, thus helping in the prevention of DCS. Exercise has been also found to play an important role on the incidence and severity of DCS. It has been found experimentally that both adynamia (lack of weight bearing loads) and akinesia or hypokinesia (lack or reduction of movement) during or prior to decompression reduces the occurrence of DCS.
Apart from the above external factors, individual human factors make subjects exposed to the same conditions before and during decompression to react differently regarding DCS. Some of the more important individual parameters seem to be the age, gender, body fat, previous DCS occurrence and injury. However, the susceptibility to DCS may also vary for the same individual from one day to another.

EVA AND DCS

There has been less DCS occurrence during EVAs than statistically expected. During the 110 manned missions of U.S. astronauts and Russian cosmonauts until 1993 no serious DCS has occurred during EVAs. It has been argued that it is rather the reduction of stress assisted nucleation in space, due to adynamia and lower body hypokinesia, that aids to such effect since there is no experimental proof of any physiological mechanism doing so. Other possible parameters leading to no DCS occurrence during EVAs are the 100% oxygen prebreathe and the slow depressurization protocol followed.
EVA preparation protocols are designed in order to prevent serious DCS symptoms, and are based on

statistical evaluation of previous decompression experiments. Although up to now no serious DCS symptoms have occurred, these preparation protocols cannot assure the safety of crewmembers performing EVAs due to the big variation of individual and day-by-day susceptibility but also due to the multiple factors affecting DCS occurrence. Furthermore, it is not known if these protocols can be efficient for populations on which little data exist such as women, previously injured people, etc. The long time needed for EVA preparations makes it almost impossible for astronauts to use it in emergency situations. All the above together with the increasing need for EVAs in the following years, underline the importance of developing an in-vivo non-intrusive technique for the detection of bubbles in the body of astronauts in their space suits (bubbles are precursors of DCS). On-line in-vivo bubble detection would also help further investigation of EVA preparation protocols and possibly lead to greater flexibility and time saving that would improve the work efficiency in these activities.

CONSIDERATIONS FOR MONITORING DCS DURING EVAs

Basic functional specifications

By far the most important feature of an in-vivo bubble detector is to be capable of detecting bubbles in the human body timely and accurately. Small sensing electrodes must be attached firmly and stably to the human body. In addition, the detector should be portable and lightweight, in order to adapt to the space suit. The whole setup must not obstruct the movement of the astronaut and must be readily accessed and easy to operate. The detector must inform the astronaut in a clear way (audible or visual signal) on his current status of bubbles' presence in his body. Apparently, the technique should conform to safety and health regulations for use in humans.

Sites on the human body for bubble detection

At first sight one may think that bubble monitoring should be conducted on the sites of origin of bubbles in the circulatory system (especially in the venous system) as this would provide the earliest alarm for the prevention of DCS. However, these sites are dispersed in the body and it cannot be known a priori in which one, bubbles will grow first. Furthermore, the small concentration of bubbles in one site makes their detection very difficult. The other option would be to measure bubbles in veins where they gather as they travel away from their formation sites towards the heart. On the contrary, detecting arterial bubbles may be a wrong strategy when aiming at DCS prevention. As explained above, bubbles enter arteries only if they have passed through the venous system and lungs. Bubbles in arteries are ready to attack various organs and tissues, including the brain and this is too late for alarm.

From the above it is evident that in order for a detector to get strong signals, representative of an appreciable number of bubbles, and still in good time for countermeasures, the detector must focus on large veins located close to the heart e.g. vena cava, where bubbles from different parts of the body progressively accumulate. For this same reason, traditional Doppler measurements are also performed close to the heart. However, difficulties with focusing the signal at the presence of other intervening media (tissues, bones etc.) may dictate other more convenient measuring points such as spots along the human limbs (wrist, arm, leg, ankle etc) or other large veins draining kinetically active tissues such as the femoral, popliteal and subclavian veins.

Bubble size

Under decompression conditions, initially only few small bubbles are present in the tissues. As time goes-by these bubbles progressively grow larger and other new bubbles also appear. The fewer and smaller the bubbles that can be detected the better. Apart from the alarm (yes/no) bubble detection, quantification of bubbly flow by measuring volumetric gas fraction and bubble sizes would be important for the judgment of the severity of the situation. Such quantification would also help for an in-depth study of DCS and of the factors affecting it. During decompression incidents a number of predictive models estimate bubble sizes from few μm to about 60μm, depending on pressure, exercise, and exposure time. Usually, a traditional Doppler detector senses bubbles above that range.

Blood flow and bubble flow characteristics

Of particular significance for an in-vivo bubble detector is whether different bubble flow behavior e.g. under steady and pulsatile flow, affects their reliable detection. Blood flow in different parts of the body is unidirectional and weakly or strongly pulsatile. The period of pulsation depends on the heart rate. Heart rates recorded during EVAs range from 43 to 174 min^{-1}.The mean flow rate depends on the vessel diameter, while the amplitude of pulsation depends on the vessel's size and its proximity to the heart. In addition, blood being a suspension of deformable cells in an aqueous solution (plasma) has flow properties depending on shear rate, vessel diameter and hematocrit (red cell concentration).

Bubble sensing techniques suitable for EVAs

Considering in vivo measurements of bubbles generated by decompression, ultrasound (acoustic) methods have been traditionally used. The scattering and absorption properties of acoustic waves by bubbles have been used in different ways to detect bubbles. The most popular acoustic method for bubble detection in humans is the Doppler scattering method. The produced Doppler frequency shifts are typically in the audio range 0-10KHz and can be monitored aurally by human observers. Although the Doppler method is simple, in real use many problems arise related chiefly to the human factor involved in the interpretation of the audible signal. In addition, the sensitivity of Doppler ultrasonic devices varies with bubble velocity and the measurement is very sensitive to the positioning of the probe.

Techniques common for monitoring industrial bubbly flows, e,g optical, and ionizing radiation (x-ray and γ-ray) are apparently not suitable for EVAs. Also, Magnetic Resonance Imaging has limited temporal resolution and the equipment is bulky. Electrical techniques may be a tempting alternative for in vivo measurements during

EVAs. They can be very fast, simple to apply, the equipment is lighter and less voluminous and body movement is not expected to interfere with measurement. However, so far no version is available for applications on humans.

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From the growth and detachment of single bubbles to massive bubbly flows

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INTRODUCTION

This report aims to make the connection between liquid degassing (bubble growth and detachment) and bubbly flow which is essentially the precursor of DCS. Gas bubbles can be generated on solid surfaces covered by a liquid as a result of desorption of dissolved gases when the liquid becomes supersaturated with respect to dissolved gases. This report starts from basic phenomena controlling single bubble growth on a solid surface, extends to growth of multiple adjacent bubbles and their subsequent detachment from the surface into the liquid and, finally, copes with characterization of multiple bubbles flowing with the liquid (bubbly flow). Here only the case of thermal degassing is examined in which bubbles are produced locally on a hot spot surrounded by cold liquid layers. Thermal degassing is more general than decompression degassing (in fact, it encompasses it) since in addition to mass transfer involves also heat transfer processes. As regards bubbly flows, the recent research performed in our laboratory is presented on novel techniques that allow measurement of gas/liquid fractions and bubble size distributions at conditions such as those met during DCS in human veins and arteries.

BUBBLE GENERATION

Bubble generation due to oversaturation of a liquid with respect to a dissolved gas (degassing) can be realized by either a decompression or a thermalization step. Local thermalization is preferable from an experimental standpoint as it creates a controllable number of bubbles. According to this design, a miniature submerged heater is suddenly heated and as the surrounding liquid becomes supersaturated a bubble forms at the heater's surface. Subsequently, the bubble grows with transfer of mass of the dissolved gas from the bulk of the liquid to the bubble surface.
In a series of ESA (European Space Agency) Parabolic Flight Campaigns, we exploited the low-g conditions achieved during the free-fall of an airplane to study the bubble dynamics during degassing of several liquids. Microgravity conditions are necessary for eliminating the effects of bubble buoyancy and natural convection in order to obtain results amenable to rigorous theoretical interpretation.

SINGLE BUBBLE GROWTH

A detailed mathematical description of the process includes the solution of transient heat and mass transfer equations in the gas and liquid phases (3-dimensional geometry) along with the appropriate boundary conditions on the surface of the bubble and the heater. These equations are of the convection-diffusion type where the flow field responsible for the convection terms is generated from the growing bubble. The problem includes a moving boundary with the motion being part of the solution. In addition, the very high temperature gradient along the surface of the bubble induces a Marangoni motion which transfers hot fluid from the heater to the remote parts of the bubble surface, tending to equilibrate bubble and heater temperatures.
Although the complete problem can be easily formulated, its solution is not possible with the present day computer resources. An initial attempt to simulate the problem of bubble growth on the thermistor was based on a spherically symmetric (1-D) model of a spherical bubble growing at a constant temperature. The problem was solved using a well known similarity transformation and

has lead to a power law relation between bubble radius and time with an exponent value equal to 0.5. However, the corresponding experimental curves were best-fitted by lower (than 0.5) exponent values.

A next step was to approximate the problem by a 1-D model but now the assumption is that the bubble grows at a uniform but time dependent temperature. Comparing the evolution of the average bubble temperature estimated from experimental growth curves with the measured temperature of the heater reveals important information for the phenomena dictating bubble growth. Two typical experimental growth curves for single bubbles grown in Phosphate Buffer Saline are shown in Figure 1. Theoretical results are given as dotted lines. Apparently, bubbles grow faster as the heat flux increases.

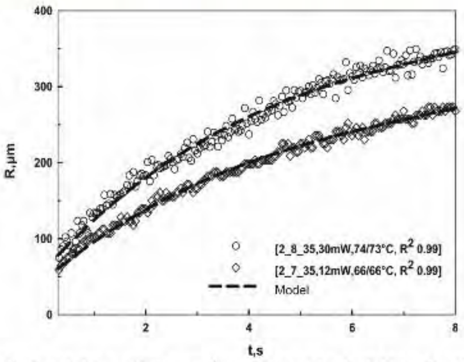

Fig. 1. Evolution of the radius of single bubbles for two different values of the heat flux supplied by the heater.

MULTIPLE BUBBLE GROWTH AND DETACHMENT

At higher power levels, two or more bubbles are noticed to grow simultaneously at different locations on the heater's surface. Such a group of simultaneous bubbles (designating a bubble generation) grows for less time than single bubbles do and finally detaches thus allowing for more bubble generations to appear during the same heating period. The evolution of bubbles size -up to detachment- of several generations (G) of bubbles is shown in Figure 2.

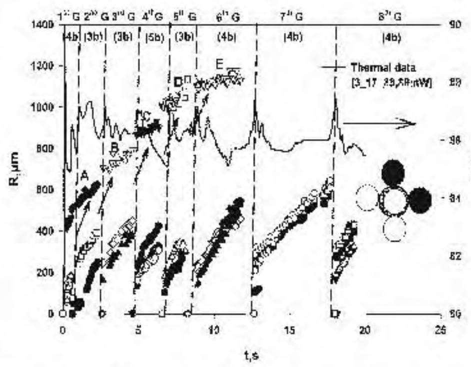

Fig. 2. Multiple bubble growth evolution curves (radius vs time).

Careful comparisons reveal that multiple bubbles grow at lower rates than single bubbles at equivalent thermal conditions, a fact which implies that multiple bubbles growing in proximity can deplete the dissolved gas in their neighbourhood.

Multiple bubbles detach at some point along their growth due to g-jitters. Interestingly, they detach synchronously to each other and at much smaller sizes than single bubbles do. This is attributed to the higher temperatures employed to produce multiple bubbles which are capable of destabilizing the contact line of the bubbles with the heater.

MASSIVE BUBBLY FLOWS

Once multiple bubbles detach from their nucleation sites they form a bubble cloud which can be dragged by a liquid stream if flow conditions are imposed e.g., in blood stream. Thus, it is easy to realize that detecting and sizing bubbles intravascularly may indicate DCS severity in humans. Given the limitations of the traditional Doppler bubble detection technique, we have made an effort over the last years to examine the behavior of such bubble cloud and its interaction with the liquid flow.

Computational fluid dynamics (CFD)

Pulsatile blood/bubble flow simulations were performed initially inside a 2-D vertical column having the diameter of human vena cava (21mm) in order to provide basic insight to the problem and then in a 3D artery, Figure 3.

Fig. 3. Contours of air volume fraction for pulsatile flow 0.6Lit/min, artery length 500 mm and diameter 5-20 mm, pulsation 60 bpm, 50% pulse amplitude, 3% air volume fraction. The picture refers to 300 μm bubbles

Experimental bubble detection and sizing

We are developing an electrical impedance tomography technique for registering the temporal distribution of the gas and liquid phases during bubbly flows. A strategic selection of probe geometry and an algorithm for signal reduction have been developed. Figure 4 shows indicative electrical signals where the effect of bubble size is evident.

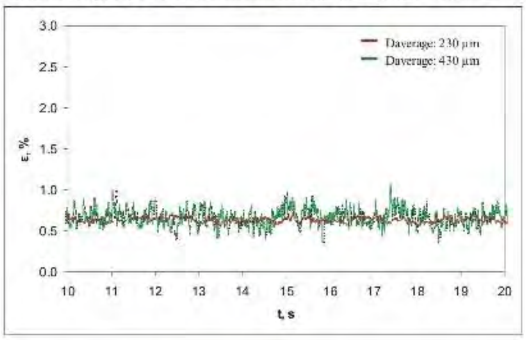

Fig. 4. Air volume fraction (ε%) electrical signals for bubble clouds with average diameters: 230 and 430 μm.

In adittion, we are developing an acoustic spectroscopy technique for bubble detection and sizing. The attenuation of the ultrasound signal and the alteration of the phase velocity due to bubble presence in the liquid are employed in the signal reduction algorithm to give a measure of the quantity of bubbles and bubble size distribution.
So far, results from both techniques are promising as they show excellent sensitivity to variations in both gas fraction and bubble size and agree reasonably with bubble sizes obtained from high resolution optical images, e.g. Figure 5.

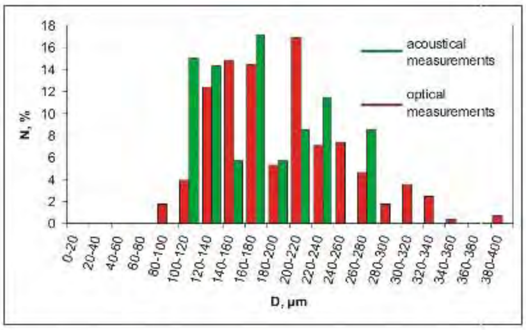

Fig. 5. Comparison between acoustic and optical results (% vs bubble diameter) for an air volume fraction 1%.

Funded by an ESA/GSTP project, we are currently preparing for doing tests on anesthetized swines.

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Ultrasonic detection of vascular gas bubbles in evaluation of decompression procedures

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Decompression may lead to formation of gas bubbles in the body, which in turn may lead to decompression sickness (DCS). This is what we know, or at least what we think we know, because although the evidence is strong, it is difficult to actually prove a causal relationship between gas bubbles and DCS. The intermediate steps in the cascade of events leading to DCS are still only partially understood. We don't know exactly how or where bubbles form and we don't fully understand the mechanisms behind injury caused by bubbles. Studies on bubbles and DCS have focused on gas bubbles in the vascular system. This is mainly because these bubbles, as opposed to tissue bubbles, can be reliably detected by use of ultrasound. But there are also studies indicating that vascular bubbles, through complex immunological processes, are the main culprit of development of serious (neurological and cardiopulmonary) decompression sickness [1]. Still, the relationship between the presence of detectable vascular gas bubbles and the occurrence of DCS is ambiguous. Intravascular gas bubbles have been observed in large quantities in divers with no symptoms and, conversely, there are studies reporting cases of decompression sickness not accompanied by detectable gas bubbles. However, most studies indicate a higher incidence of DCS with increasing number of bubbles. The studies also indicate that the bubble/DCS relationship depends on the type of exposure, e.g. bounce dive versus saturation dives, but also for similar exposures there is considerable variation between the studies.
Doppler ultrasound instruments are most commonly used for detection of vascular gas bubbles. The number of bubble signals is usually graded semi-quantitatively on a scale from 0 to 4 according to the Spencer code or the Kisman-Masurel code [2].
The most extensive study on bubble/DCS correspondence in bounce diving was presented by Sawatzky in his master thesis [3], where he systematically analyzed maximum Doppler ultrasound scores and DCS incidence in 1,726 nitrox (nitrogen and oxygen) dives and 1,508 Heliox (helium and oxygen) dives. In general, DCS did not occur if no vascular bubbles could be detected, and grade 4 bubbles were accompanied by DCS in 10-50% of the cases, depending on bubble detection procedure. These results correspond closely to what we have observed in similar dives using ultrasound imaging for bubble detection [4].
There are few systematic studies on bubbles and DCS in saturation diving. A saturation dive is a time and resource demanding undertaking and it is rarely possible to include more than 8-10 divers in each exposure. Also, the DCS incidence with current saturation diving procedures is extremely low, adding to the problem of establishing a bubble/DCS correspondence. Most studies do indicate that there is a correspondence also in saturation diving, but the number of cases of DCS not accompanied by detectable bubbles seems to be higher than for subsaturation diving.
For hypobaric exposures the existing data are not easily interpreted. 2 major studies with 1322 and 2044 subjects respectively, give distinctly different outcome. Conkin et al. found a 1.5% DCS incidence with grade 0 bubbles [5], whereas Pilmanis et al. found 19% [6]. Kumar et al. concluded that Doppler ultrasound measurements were useful in making therapeutic decisions on DCS when confronted with non-specific symptoms at altitude [7]. Due to the ambiguity of other published data this should be done with caution.
When a correlation is established between observed vascular bubbles and the occurrence of DCS symptoms, this correlation can be used to calculate DCS risk when testing a decompression procedure. We have designed a method based on Bayesian statistics [8] where each

bubble grade is assigned a DCS risk based on established data. This set of risks is combined with maximum observed bubble grade in a number of dives for the tested procedure. In this way we can estimate the DCS risk and, more importantly, calculate a 95% credible interval for the estimate. A credible interval is a posterior probability interval, used for purposes similar to those of confidence intervals in frequentist statistics.

It is a common misunderstanding that bubble detection can be used for diagnosis of DCS in individual cases. This is not so. The occurrence of detectable vascular bubbles can only say something about the risk of developing symptoms of DCS. However, when used in testing new procedures, bubble detection is a valuable tool. We have found that our Bayesian method can reduce the number of dives needed for table validation by approximately 95% compared to the standard evaluation method, where risk is based on the observed frequency of DCS symptoms. It is also important that bubble detection can lead to a procedure being rejected as unsafe before a single case of DCS is encountered, so the hazard to the test subjects is reduced.

There are various approaches to the design of decompression procedures, and there is an abundance of dive computers with different algorithms for calculating safe decompression. The expenses of testing have prohibited proper validation of many of these procedures. With a 95% reduction in the number of test dives needed for evaluation compared to the traditional method, bubble detection will facilitate validation of new decompression procedures. We believe that this will improve safety for people involved in activities with variable barometric pressure.

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SURF imaging and decompression induced microbubbles

Andreas Møllerløkken[1] and Svein Erik Måsøy[2]

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2: The ultrasound research group, Department of Circulation and Medical Imaging, Faculty of Medicine, NTNU.

The purpose of all decompression procedures is to prevent injury to the diver, and it is generally agreed that these injuries are caused by the formation of gas bubbles in the body. Gas bubbles form in nearly all decompressions, and the risk of developing decompression sickness (DCS) increases with the number of gas bubbles [1]. Paul Bert demonstrated the relationship over 100 years ago [2], and his hypothesis was later central to Haldanes theory [3]. Today we know that bubble formation during decompression is not simply a consequence of inert gas supersaturation, as numerous experiments indicate that bubbles originate as pre-existing gas nuclei [4].

A systematic study of the phenomena accompanying decompression is complex and difficult, as practical measurement methods to monitor the processes taking place in body tissues are lacking. However, the introduction of ultrasound to detect vascular gas bubbles generated during and after decompressions has made it possible to compare different decompression situations and models without going to the binominal endpoint DCS or no-DCS. Recently, a Baysian approach to validate decompression procedures has also been developed, an approach which is based on detection of vascular gas bubbles [5].

Gas-filled microbubbles are not just interesting for researchers and clinicians working with hyperbaric problems. The introduction of contrast agents for ultrasonic imaging, especially for cardiology and abdominal applications are also a highly specialized application working with gas filled bubbles. Ultrasound contrast agents are generally of a size of 1-4 µm, they are transpulmonary and provide strong reflections which can be detected. Modern contrast agents are usually filled with perfluorocarbon gas, stabilized in a lipid monolayer shell.

The ultrasound research group at the Department of Circulation and Medical Imaging at NTNU in Trondheim has developed a new method for detecting contrast agents, which gives better resolution and improves the sensitivity compared with traditional techniques. The method is called SURF (Second Order UltRasound Field) Imaging, and instead of one pulse being transmitted as in traditional ultrasound transducers, the SURF method transmits two pulses simultaneously. One pulse is used to manipulate the size of the microbubbles, and the other is used for detection of the change in size. By utilizing the nonlinear nature of the contrast agents (gas bubbles are easier to expand than to compress), one can filter out specific parts of the reflected signal in order to detect the agent of interest [6].

In relation to decompression induced microbubbles, it is accepted that the process of bubble formation starts by microscopic bubble nuclei. De novo formation of gas bubbles requires an unrealistic pressure gradient in relation to normal decompression activity. But, by definition, no one has actually seen these bubbles in nondiving subjects. They are believed to be in the order of 1 μm, and there are no detection systems available today which can highlight such small bubbles. However, the SURF technology is well suited for decompression induced microbubbles, since it can be designed to detect specific size gas bubbles, and filter out all other disturbing signals. The result is that in a standard ultrasonic picture where you can not see any bubbles at all, the SURF can visualize the presence of bubbles if they are in the same size as ultrasound contrast agents. And in theory, one can build transducers based on the SURF technology which can detect microbubbles down to 2 μm.

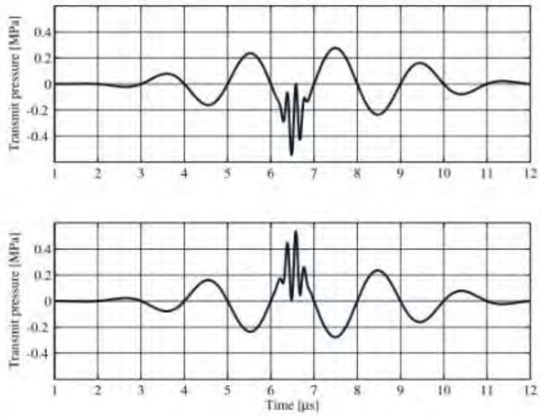

Figure 1: SURF-pulse complexes for contrast agent detection and imaging. For additional information, please visit: http://www.ntnu.no/surf/

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Altitude decompression in simulated microgravity

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The space suits used during extravehicular activity (EVA; “space walks”) have an internal pressure of approximately 1/3 of that on the International Space Station, where the pressure is 1.0 bar. On the ground, such decompressions are associated with unacceptable rates of venous gas emboli (VGE) and decompression illness (DCI), even after one hour of nitrogen washout by breathing oxygen before decompression. Nevertheless, no DCI events have been reported from the US and Russian space activities so far.

In recent studies, the Russian pre-EVA/EVA decompression regimen was simulated in an altitude chamber. Twenty subjects were decompressed to 0.38 bar after 1 h of oxygen breathing, and continued to breathe oxygen for 2 hours (n=10) or 6 hours (n=10). Subjects were strictly supine and performed intermittent arm exercise of moderate intensity. Every 5-15 min pre-cordial Doppler ultrasound was used to monitor the subject's heart for VGE and the subjects were also monitored for symptoms of DCI.

There was only one subject in whom large numbers of detectable VGE (KM Doppler scores ≥ III) were measured. During the preceding medical examination this subject reported a tender right lower arm. He had these symptoms for 19 days and also visited a physiotherapist. During the examination he showed slight right-sided weakness and it was believed at the time to be a muscle strain or tear. An x-ray taken five days after the experiment showed fractures of the scaphoid bone and of the head of the radial bone. This subject had KM Doppler scores of grade III or above after 56 minutes at altitude and at 5 occasions during the ensuing 38 minutes before recompression. One attendant that worked inside the chamber and performed intense physical work in upright position while opening a medical lock, had both a large number of circulating VGE (KM Doppler scores > III) and symptoms of DCI.

The horizontal posture and the complete lower-extremity unloading can be regarded as simulated microgravity, and this appeared to prevent substantial formation of VGE. This lends support to the notion that Russian cosmonauts have a very low, if any, risk of DCI. The unintentional exposure of a subject with a relatively recent arm fracture to altitude decompression suggests that the local inflammatory process and/or local endothelial damage in the fractured area could be a locus of minor resistance for formation of, or entry of, decompression gas bubbles in the blood.

B. READ BEFORE DISCUSSING THE WETTING POWER OF A LIQUID AND USING THE CONTACT ANGLE

M. G. Velarde, Madrid, Spain (mgvelarde@pluri.ucm.es, www.ucm.es/info/fluidos)

A thin liquid layer

Consider a liquid layer with an open surface or a shallow liquid layer (thickness *h*) enclosed between two flat solid plates or two other fluid phases. Is it so obvious that the stability and evolution of the liquid layer is describable using *standard* thermodynamics and hydrodynamics? According to Derjaguin, Landau, Verwey and Overbeek this depends on *h*. If the layer is a hundred nanometers (nm) thick or less, their DLVO theory demands consideration of the kind and size of the liquid molecules involved, as well as their interactions and the interaction of solid and liquid molecules. At macroscopic level details of the micro-level interactions demand augmenting standard theories with new forces called "surface forces" (not "surface tension"). In the few-nm range all molecules tend to *repel* each other due to the overlapping of their outer electron "orbits" (Born repulsion). A model is the r^{-12} Lennard-Jones repulsion force where "*r*" denotes intermolecular distance. Separated a few tens of nm, repulsion is replaced by attraction (London-Van der Waals/Lennard-Jones r^{-6} force).

When the intermolecular pair potential is $1/r^n$ the effective energy of (attractive) interaction between two *planar* surfaces separated (in vacuum or air) by a distance *h* is $G(h) \sim 1/h^{n-4}$, with $\Pi(h) = -[\partial G(h)/\partial h]_T$, a *(disjoining) pressure*, as suggested by Derjaguin. With an enclosed liquid such a force may lead to attraction or repulsion. With a *non-polar* liquid, like an oil, the L-VdW ("long-range") interaction with $n = 6$, yields $\Pi_{L\text{-}VdW}(h) = -A/6\pi h^3$ (*A*, Hamaker characteristic constant). Such a law is supported by experimental data in the range $h < 30$ nm. Across a *polar* liquid, like pure water, *A* may decrease an order of magnitude when passing from, e.g., 1 nm to 102 nm. Its values are comparable with the thermal energy $\kappa_B T$ at room temperature *T* (k_B is Boltzmann's constant). If *A* is *positive* the L-VdW force (or pressure) is *attractive* and its contribution to disjoining pressure is *negative* inducing instability of a uniform liquid film bound to break in drops. Such is the case for an oil film deposited on a Teflon® coated frying pan. It can only be made stable by gravity if enough oil is poured. When L-VdW is *repulsive* (*A* negative) we have a *positive* disjoining pressure across the thin liquid film which is stable.

The size, form and molecular structure as with aqueous solutions near solid surfaces leads to "structural"/"hydration" forces. Besides, most solid surfaces in aqueous solutions acquire negative charge thus leading to electric double layers (*EDL*) in the fluid. Such *EDL* interaction is generally (short-range) *repulsive* force and decays exponentially. For two semi-infinite solid plates $\Pi_{EDL}(h) = Ce^{-\kappa h}$ ($1/\kappa$, Debye length; *C*, characteristic parameter of the system). In most cases the *repulsive* EDL force decays faster than the corresponding *attractive* L-VdW force, with increasing distance.

A liquid drop

Let us now consider a liquid drop. Disregarding gravity, at equilibrium its form is spherical (radius $\Re$). The liquid pressure inside the drop, p_1, is higher than the air pressure outside the drop, p_a. The in/liquid-out/air overpressure is $p_1 - p_a = 2\gamma/\Re$, where γ is the surface tension (Laplace law). At thermodynamic equilibrium the over-pressure follows from the vapor pressure, p_v , in the air:

$$\frac{2\gamma}{\Re} = \frac{RT}{v_m} \ln \frac{p_v}{p_{sv}} \quad \text{(Kelvin Law), or}$$

$$p_v = p_{sv} \exp\left(\frac{2\gamma v_m}{\Re RT}\right) > 1$$

and hence

$$p_v(\Re, T) > p_{sv}(\Re \to \infty, T); \quad p_{sv}(T)$$

$p_{sv}(T)$ is the saturated vapor pressure (corresponding to $\Re \to \infty$); R, T and v_m are universal gas constant, absolute temperature in Kelvins, and liquid molar volume. A liquid drop can be at equilibrium with (over)-saturated vapor only (for a radius $\Re$ at a single p_v value) and cannot be at equilibrium if under-saturated.

The wetting power of a liquid and thermodynamic equilibrium

When the drop is placed on a solid surface three possibilities exist: i) *partial* wetting (fig. 1) like with a water drop on glass, mica or silicon-wafer surfaces; ii) *complete* wetting (the liquid spreads along the surface and the time-dependent contact angle tends to zero with time) like with a "pure" oil drop on a glass surface; and iii) ideal *non-wetting* case: $\theta = \pi$ like a mercury drop placed on a glass surface or a water drop or an aqueous solution drop on a Teflon® surface (in practice $\theta \approx 120°–140°$). Partially wetting the drop cannot stop and remain at thermodynamic equilibrium on a *bare* solid. (Over)- saturation implies the appearance of an *adsorbed* layer on the solid surface according to e.g. Langmuir's adsorption isotherm. At equilibrium the chemical potentials of water molecules in the liquid phase, vapor phase and adsorbed phase are equal.

Fig. 1. Partial wetting case. The contact angle θ is measured inside the liquid, ℜ is radius of the drop and L is radius of the drop base on the solid substrate.

Hydrodynamic singularity of the three-phase contact line

Approaching complete wetting as the liquid drop spreads, $\theta(t) \rightarrow 0$ with time. The vapor-liquid-solid contact line must move but the flow near the line is *singular* as the velocity is finite with vanishing liquidsolid separation distance. Thus the *shear stress* (or pressure) and the *viscous dissipation* both tend to infinity there. The total force on the solid, obtained by integrating the stress on the surface becomes logarithmically infinite. These difficulties bring the continuum approximation into question but the problem is solved when we to take "surface forces" (DLVO theory) into account.

DLVO framework

To visualize the role of the overall disjoining pressure Fig. 2 (compare with Fig. 1) shows various cases where the outcome of adding (Born +)L-VdW and EDL forces is plotted: partial wetting (2); complete wetting (1; dominates); and non-wetting (3; L-VdW dominates). If $\Pi(h)$ is positive and decays monotonically to zero with increasing h, an adsorbed liquid layer can grow indefinitely with increasing pressure, p, until $p/p_{sv}=1$, and vapor would condense massively (complete wetting). With $d\Pi/dh<0$, disjoining pressure truly disjoins, tends to separate two surfaces away. Thus conjoining pressure is used when $d\Pi/dh>0$.

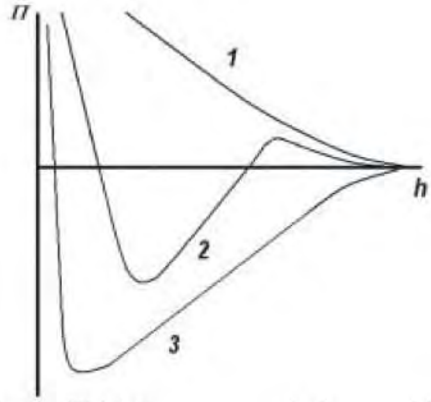

Fig. 2. Disjoining pressure isotherms: (1) EDL repulsion forces dominate (complete wetting); (2) combination of L-VdW attraction and EDL repulsion (partial wetting); and (3) L-VdW attraction dominates (non-wetting).

Summary but no conclusion

Remaining at the strict *phenomenological* level to describe processes far from boundaries in a *homogeneous* phase two independent variables suffice to describe a system, say *T* and volume, *V*. Then $P = P(T,V)$ is the equation of state. If interfaces exist then another form of pressure (surface tension), g , enters with a corresponding equation of state, $\gamma = \gamma(T,S)$, where *S* is area. Derjaguin's pressure, Π, appears when we have regions at the nano-scale (10^2 nm) range. Its corresponding equation of state is $\Pi = \Pi(T, h)$. These three equations of state permit generating the entire *equilibrium* thermodynamics of the system. Besides, the addition of Derjaguin's pressure also eliminates the singularity of the three-phase contact line occurring when using the standard hydrodynamic equations only.

Acknowledgments

The ideas expressed here come from work done with V. M. Starov, and discussions with Yu. S. Ryazantsev and R. G. Rubio.

A1. ELGRA 2007 BIENNIAL SYMPOSIUM IN FLORENCE (IT)

Family photo

The last Biennial symposium of ELGRA was held in FLORENCE, ITALY, on SEPTEMBER 4-7, 2007. The symposium has been organized jointly with the XX national meeting of the Italian Association for Aeronautical and Space Medicine, AIMAS, at the Institute of Military Aeronautical Sciences, in an architectural complex which is considered one of the most beautiful examples of "functionalism"in Europe.
Due to the large number of participants, the scientific program was mostly organized in parallel sessions. Very interesting joint sessions with AIMAS were also arranged. The symposium was enriched with a welcome of the local authorities in the Salone dei Cinquecento at Palazzo Vecchio, a gala dinner in the court of the Palazzo del Bargello with a baroque concert, and a visit to the Specola Museum and Tribuna di Galileo Galilei. On the last day, a training with an aeromedical evacuation helicopter demonstrated the technical and organizational aspects of search and rescue, SAR, operations.

Dr. Monica Monici (ELGRA local organizer), General Manlio Carboni (AIMAS), General Settimo Caputo (AIMAS).

During the symposium, ELGRA prizes have been awarded to the winners of the student competition in life and physical sciences. Six selected teams were invited by ELGRA and ESA to attend the symposium, presenting oral communications and posters. The winners of this "student contest", one team for life sciences and one team for physical sciences, were elected by the audience attending their presentations.
The ELGRA symposium is traditionally the opportunity to reward two of the most renowned and distinguished ELGRA members. In Florence, the ELGRA medals were given to Dr. Jan Vreeburg, for his outstanding results in microgravity fluid dynamics and to Prof. Gérard Perbal, for his exceptional work in plant physiology in microgravity.
In the frame of the symposium, two events of special interest were organized: i) a round table with representatives from ESA, chaired by Dr. Daniel Beysens and Dr. Jack van Loon concerning the perspectives of low gravity research within Europe and, particularly, the new program ELIPS 3 and ii) a workshop on the concept of a large radius human centrifuge for physiological studies chaired by Dr. Jack van Loon.
The ELGRA General Assembly is an important item during the biennial symposium. It is the organ for the election of the Management Committee. The Management Committee members Dr. Valerie Legue and Prof. Felice Strollo resigned from their office in September 2007. Dr. Daniel Beysens having finished his term as President, the Assembly elected a new President, Dr. Jack van Loon. New members Dr. Javier F. Medina and Prof. Floris L. Wuyts have also been elected.
Participants stimulated the symposium by presenting and discussing the results of their research and thereby contributing to the advancement of gravity and space flight related sciences. In particular, the exchange of ideas among experts from the two scientific societies ELGRA and AIMAS has given many new insights into problems of mutual interest. As for the Santorini ELGRA Symposium in 2005, a special issue of Migrogravity Science and Technology has been published with a collection of more than 30 of the most significant contributions that have been presented at the symposium either as oral communication or poster. The collected work provides an excellent overview on the wide range of subjects discussed and the quality of the research presented at the symposium.

Gala dinner in the court of the Palazzo del Bargello

ELGRA medals

ELGRA President Daniel Beysens gives the ELGRA Medal to Prof. Gerald Perbal

Prof. Gerald Perbal
Laboratoire de Cytologie et Morphogenese Vegetale, Site d'Ivry, Universite Pierre et Marie Curie, Le raphael, Case 150, 4 Place jussieu, 75252 Paris Cedex 05.

From roots to gravi-1: twenty five years for understanding how plants sense gravity

Plant organs are able to sense gravity by the means of specialized cells called statocytes. In roots,which are the most sensitive organs, the statocytes are located in their tip (the root cap). In the 70's, when I started to work on gravitropism at the University Pierre and Marie Curie, it was known that statocytes contain voluminous amyloplasts (statoliths) that sediment under the influence of gravity. However, the role of these organelles in gravisensing was strongly disputed. In 1974, I attended a session of a meeting on gravitropism in Wurzburg, where I presented results that supported the involvement of statoliths in the perception of gravity. This meeting had a strong impact on my research, since at that time the Council of Europe was looking for people interested in performing experiments in Space. It was the way I entered the Space Science. Our first experiment (ROOTS) was carried out in the Biorack Facility (ESA) in the frame of the Spacelab D1 mission (1985). We had a very efficient help from CNES which developed a very fine hardware to grow lentil seedlings and to chemically fix them at the end of the experiment. The results obtained were surprising since we observed that in microgravity the statoliths were located at one pole of the statocyte and not distributed at random as it was expected. The goal of the following experiment (Spacelab IML-1 mission, 1992) was to determine the threshold stimulation time at 1g (created by centrifugation). It was estimated at 25s. We also demonstrated that cell cycle was modified in microgravity and the following experiment dealt more with root growth and cell cycle under various gravitational stresses. The results obtainedindicated that the first cell cycle was slower in microgravity (Spacelab IML-2 mission, 1994). In the frame of the SMM/03 and SMM/06 missions (1996, 1997), we proved that the statoliths are attached on actin filaments by motor proteins (myosin) that make these organelles move in one preferential direction in microgravity. The analysis of gravisensitivity with clinostats incited us to compare gravisensitivity of lentil roots grown in microgravity or on a 1g centrifuge (SMM05 mission, 1997). It was found that the latter were less sensitive than the former. We showed that this was due to the fact that the statoliths are not distributed in the same way in both cases (microgravity or 1g centrifuge). All these studies led us to propose a mode of gravity sensing by plants in which elements of the cytoskeleton and stretch activated ion channels are involved (Perbal and Driss-Ecole, 2003). The last experiment (GRAVI-1) which has been carried out (in ISS with the EMCS facility, 2007) dealt with the threshold acceleration that is perceived by roots. It was estimated at 3.8×10^{-4} g which is very low. Space experiments were certainly the most exiting and fruitful part of my academic activities.

ELGRA President Daniel Beysens gives the ELGRA Medal to Dr. Jan Vreeburg

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Liquid dynamics from spacelab to sloshsat

The European participation in manned spaceflight had a strong impact on research in the natural sciences. Preparation for Spacelab required many decisions on organization, funding and allocation of resources. Lessons were learned from results obtained in precursors like Skylab or in unmanned programs such as TEXUS. Difficulties originate from the differences in science funding rules between ESA member states. ESA with scientists from the major disciplines instituted Working Groups that acted as consultant bodies. In formal contacts the users were represented by the Investigators' Working Group, organized according to major experiment facilities and chaired by the project scientist. European experiment hardware has been realized by aerospace industry by methods that are different from the traditional development of an instrument in a university laboratory. Validation of instrument performance in microgravity requires special techniques. The training of Payload Specialists to perform research in the Fluid Physics Module included theory and laboratory work. Duties for public relations were less than today. The ESA approach with multi-user facilities and Payload Specialists differs from NASA's practice to launch an investigator with a singular experiment. Delays in planned flight opportunities frustrate participation by industrial scientists. Unmanned spacecraft are preferable for certain types of research and lead to development of telescience. The dynamics of spacecraft with partially filled tankage benefit from conditions that conserve system momentum. The momentum of the rigid part of a spacecraft can be tracked accurately. Observation of liquid behaviour in a spacecraft tank is a challenging problem. A validated model of liquid effects on spacecraft manoeuvres makes servicing missions more efficient and less costly. Damping of liquid motion is not fully understood; experiments in space may provide fundamental contributions.

Student Contest

From the submitted proposals, six (6) teams won the Student Contest and were invited to come and present their work in the ELGRA 2007 Symposium supported financially by ELGRA and ESA. These teams are:

- *Achromatic and chromatic perception in microgravity*
  Irene Lia Schlacht[1], Henrik Birke[1], Stefano Brambillasca[2], Balázs Dianiska[3]
  1: TU Berlin, 2: Politecnico di Milano, 3: Budapest University

- *Analysis of ferrofluids exposed to magnetic fields in micro-gravity*
  Elisabeth Krause[1], Alice Verweyen[1], Ulrike Endesfelder[1], Anne Angsmann[1], Sebastian Bürgel[2]
  1: University of Bonn, 2: ETH Zürich

- *Can facilitation increase the h-reflex in micro-g ?*
  Betzler Felix, Schlabs Thomas, Wagenseil Boris, Gewies Marcel, Abels Wiltrud, Schulz Juliane, Dr. Kowoll Rainer, Prof. Dr. Gunga H.C.
  Center for Space Medicine Berlin (ZWMB)

- *Experimental studies on the aggregation properties of dust in planet-forming regions*
  Heißelmann Daniel
  Technical University at Braunschweig

- *Singing gravitation detector*
  Bertrand Dujardin[1], Jonathan Vanpeteghem[2]
  1: Katholieke Universiteit Leuven, 2: Hogeschool West-Vlaanderen.

- *Viscous fingering in microgravity*
  Andalsvik Yngvild Linnea, Storhaug Gunhild, Olluri Kosovare, Skaugen Arvid, Lindem Torfinn, Løvoll Grunde, Måløy Knut Jørgen
  University of Oslo

Students group photo with Thodoris Karapantsios (ELGRA Vice-President and Student Contest coordinator) on the right end.

Students awards during the Gala dinner by Dr. Daniel Beysens (ELGRA President)

Award to I. L. Schlacht

Award to A. Verweyen and E. Krause

Award to F. Betzler and T. Schlabs

Award to D. Heisselmann

Award to B. Dujardin and J. Vanpeteghem

Award to Y. L. Andalsvik and G. Storhaug

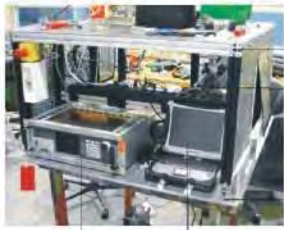
Best oral presentation
(voted by the participants)

Analysis of ferrofluids exposed to magnetic fields in micro-gravity

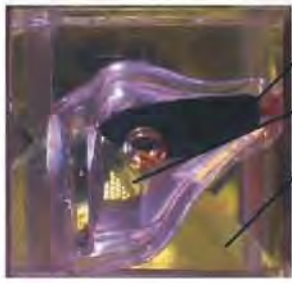
Elisabeth Krause[1], Alice Verweyen[1], Ulrike Endesfelder[1], Anne Angsmann[1], Sebastian Bürgel[2]
1: University of Bonn, Germany
2 :ETH Zürich, Switzerland

We present an analysis of ferrofluid observations in micro-gravity that were recorded during the 8th ESA Student Parabolic Flight Campaign in July 2005. The objective of our experiment is to analyze the flow of a ferrofluid that is exposed to different magnetic fields in an otherwise force free environment. This is realized by placing a glass containment filled with ferrofluid between two Helmholtz coils, which produce well-controlled magnetic fields, and recording the flow of the ferrofluid with two video cameras. During every parabola, the airplane, and thus the axes of our experiment setup inside the plane, rotate in space around the plane's y axis; this causes shear forces and friction. We decided to switch off these distortions in order to observe the free motion of the ferrofluid by using a so-called ESP (Electronic Stability Programme). Usually, this piece of equipment is used in cars to prevent sliding in bends. The experiment is mounted on an axis in y-direction of the airplane. The ESP is attached to the magnet's rotation axis, and provides a signal proportional
to the magnet's rotation velocity. This signal triggers a servomotor such that the ESP - and thus the whole magnet - is kept on a stable axis. The rest of the base plate is occupied by a programmable power supply unit for the generation of the magnetic fields and a notebook that controls the power supply.
We want to understand the flow of ferrofluids in the absence of gravity, in this environment the energy density of the ferrofluid is given by the difference of surface energy density and energy density of the magnetization of the ferrofluid. As there are only few observations of ferrofluids in micro-gravity published, we decided to start with covering a broad parameter range during flight 1, and to study the most promising points to more detail during flight 2. The overall question is how the shape of the ferrofluid varies with the strengths of the applied field; in this context we are especially interested in the following transition points: the minimum field strengths for Rosensweig instabilities to occur, and the saturated magnetization of the ferrofluids. A first inspection of the data after flight 1 showed, that in absence of gravity the magnetization of the ferrofluid saturates much earlier than expected from ground tests. Therefore we had to repeat a number of field configurations from flight 1 at smaller field strengths during flight 2. Additionally, we tried to measure the magnetization of the ferrofluid as function field strengths using a reverse field method: The ferrofluid is magnetized at a constant field level, and the magnetic field is switched off. The field is reversed and the field strength at which the magnetized, and thus elongated ferrofluid, is demagnetized (and thus loses its shape) is measured. For this, the magnetization of the ferrofluid can be calculated.
A first analysis shows that the experiment worked well and produced data of good quality for a physical analysis. The ESP-sensor provides an easy to implement position control that can be recommended to other groups with acceleration sensitive experiments. In this report, we compare the measurements in micro-gravity with ground based tests. Our analysis shows that approximations similar to those describing ferrofluid in a 1-g environment hold in micro-gravity. Due to the increased wavelength of these surface perturbations in reduced gravity we do not observe Rosensweig instabilities during the 0-g phase of the flight. We obtained 3-D models of the ferrofluid motion from the recorded projections, and describe the goals of the forthcoming analysis of these data.

experiment set-up



The test cell



On cleaned images the largest continuous black area is selected and the boundary coordinates are extracted. Boundary points that are near to a wall of the containment or directly next to a masked pixel (scratches, light reflexes), are flagged as bad points, as these do not necessarily resemble well the shape of the ferrofluid.

projection of the ferrofluid surface at B = 40 Gauss

2007 ELGRA General Assembly

Minutes

The 2007 ELGRA General Assembly starts on September 6th, 2007 at 17:30 at the Institute of Aeronautical Military Sciences, Florence (Italy).

Agenda

1. Opening by the president / Adoption of the agenda
2. Words in honour and memory of Ron Huijser and Wofgang Briegleb
3. Approval of the minutes of the previous General Assembly
4. President's report
5. Treasurer's report
6. Auditor's report
7. Discharge of the treasurer
8. Acceptance of new members
9. Election of two Auditors
10. Election of new Management Committee members

1. Opening by the President / Adoption of the Agenda

The ELGRA President, Daniel Beysens, opens the Assembly.
18 members are present, plus several guests.
Upon request of the President the Assembly adopts the above Agenda.

2. Words in honour and memory of Ron Huijser and Wofgang Briegleb

The President says a few words about Ron Huijser and Wofgang Briegleb distinguished members of ELGRA that have passed away in 2005 and 2006, respectively. A moment of silence was kept to their honour.

3. Approval of the minutes of the previous General Assembly

The minutes of the previous General Assembly, held in Santorini on September 22nd, 2005, are unanimously approved by the Assembly.

4. President's report

The President reports about the status of the Association and about the work performed during the last term with the MC.

4.1 Communications to the members

Members have been contacted several times via e-mail to spread and request information. Updated information was also available on the ELGRA web site.

E-mails with the President Words have been sent at least twice a year. Finally the ELGRA Newsletter n.5 and Book ELGRA NEWS n. 24 has been published during this term.

4.2 Meetings of Management Committee

During the last 2-years term the MC met 4 times. The main discussions and consequent actions were concerned with the following activities.

i) The discussion and actuation of the ELGRA policy, such as Association development/addresses, fostering of the ELGRA role in respect of the members and of the microgravity community, consultancy and lobbing activity, services to the members.

ii) The edition of a special issue of MST with selected peer-reviewed papers from the Santorini 2005 Symposium

iii) The organisation of the 2007 ELGRA Biennial Meeting and of the General Assembly in Florence jointly with AIMAS (Italian Association for Aeronautical and Space Medicine).

iv) The early organisation of the 2009 Biennial meeting in Bonn.

v) The actuation of the ELGRA education policy, with the organisation of student contest and student special sessions

vi) The management of the association (e.g. updating ELGRA database, look for unpaid membership dues…)

vii) Discussions on the future development of the Association and on fostering the representation role of ELGRA in respect of the members and of the microgravity community in general.

viii) Organisation of the promotion and advocation of the community.

4.3 Promotion of the microgravity activity and of the ELGRA community.

The President, assisted by the MC, has been involved in different ordinary and extraordinary activities concerning relations with subjects external to the association aiming to the promotion of the microgravity research and of the ELGRA community.

i) The relations with EU (High Level Space Policy Group and Space Committee of the 7th Framework Program), ESA, national agencies, with participation to meetings with EU representatives and the French President (Mr. Sarkozy).

ii) Representative of the microG user community at ESA (LPSAC meetings, special meeting with ESA Directors after suppression of the LPSAC advisory committee)

iii) Advocation of the scientific community after ELIPS 2 budget reduction (alert letters, meetings)

iv) Co-chair of the Program Committee at the 2007 ISPS/ NARA meeting 2007

v) The preparation of various alert letters.

vi) Participation at EU FP7 proposals (USOCs KnowLedge Integration and Dissemination for Space Science Experimentation "ULISSE" Collaborative Project)

vii) Endorsement of various meetings: Toledo Soyouz 2006, Bagnuls courses 2007 (Sponsoring: 4 students), Angers Life Science meeting 2008 (ESA, ISGP, ELGRA, ASGSB)

4.4 ELGRA Meeting 2009

The president announces the next ELGRA Biennial Symposium which will be held in Bonn in September 1-4, 2009 organised by DLR. R. Hemmersbach and R. Willnecker have been appointed by the MC as local organisers.

In addition, the president announces the official proposals made for the ELGRA 2011 Symposium which are: Vienna (H. Kuhlmann) and Marseille (L. Tadrist).

5. Treasurer report/ 6. Auditor report / 7. Discharge of the Treasurer

The Treasurer, K. Kemmerle, reports on the financial status of the Association and shows the balance of the period January 2005-July 2007.

As only one elected Auditor (H. Dittus) is present, M. Cogoli volunteered to help the evaluation. These two Auditors state the correct financial administration of the Association by the Treasurer during the aforementioned period. The Auditors note that there are members who did not pay their annual fees but yet have asked to pay the reduced Symposium fees which are only meant for members. They suggest that this must not be allowed in the future.

The Assembly unanimously accepts the financial report and discharges the Treasurer.

8. Acceptance of new members

The status of the membership is presented and the new members are unanimously accepted by the Assembly.

9. Election of the Auditors

Hans Dittus and Marianne Cogoli are elected as Auditors for the new term.

10. Election of management Committee Members

The election is performed, according to the current procedure by secret ballot in three turns: first the election of the President, then of the vice-President and the General Secretary, and finally the election of the MC members, including the Treasurer.

According to the above procedure the following Officers and MC members have been elected:

President:	Jack van Loon	(17 votes)
Vice-President:	Thodoris Karapantsios	(18 votes)
General Secretary:	Hendrik Kuhlmann	(18 votes)
Members:	Daniel Beysens	(17 votes)
	Monica Monici	(16 votes)
	Florian Wuyts	(18 votes)
	Javier Medina	(18 votes)
	Kurt Kemmerle (Treasurer)	(18 votes)

The President gratefully acknowledges the high merit and quite significant work performed by Felice Strollo and Valerie Legué who have finished their term at the Management Committee.

The President closes the Assembly at 19:00

A2. ELGRA 2009 Biennial Symposium, September 1st - 4th, 2009, Bonn, Germany

Scientific/Organizing Committee
(ELGRA Management Committee)
Dr. Ing. Jack van Loon, President
Prof. Dr. Thodoris Karapantsios, Vice-President
Prof. Dr. Hendrik Kuhlmann, Gen. Secretary
Dr. Kurt Kemmerle, Treasurer
Prof. Dr. Daniel Beysens, Member
Dr. F. Javier Medina, Member
Dr. Monica Monici, Member
Prof. Dr. Floris L. Wuyts, Member

Local Organizing Committee
Prof. Dr. Rainer Willnecker, Chair
Prof. Dr. Ruth Hemmersbach, Chair

Organizing Secretariat
Mrs. Astrid Herrmann, Assistant

Under the auspices of:
DLR German Aerospace Center
- Institute of Aerospace Medicine
- Institute of Materials Physics in Space
- Microgravity User Support Center
  Rheinische Friedrich Wilhelms University of Bonn
- Faculty of Zoology

Venue

The symposium will take place at the University Club of Bonn, a beautiful and suitable accommodation located a few steps from the river Rhine in the centre of Bonn. The University Club is a pleasant conference site hosted by the University of Bonn and conceived as a meeting point between scientists. Next to the conference site there are a lot of hotels of all categories in walking distance.

Bonn is the former capital of West Germany and today known as the German United Nations City hosting 12 UN organisations settled at the banks of the Rhine. A history of more than 2000 years has given the city most varied facets. Historical sights, highlights of art can be admired at the different houses of the Bonn Museum Mile, picturesque impressions along the romantic Rhine, the international life or the political life of Bonn and much more. Take the time for a visit, it is worth your while. More information at: www.bonn.de

Social Program

The social program of the symposium will include a reception at the town hall of Bonn, the possibility to visit a concert of the Beethovenfest, and an evening cruise on the river Rhine. A trip to the German Aerospace Center in Cologne will also be offered, including a visit of the research facilities of DLR and the European Astronaut Center.

Call for Abstracts

The Elgra meeting in 2009 offers the possibility to present research on all topics from the fields of science under altered gravity conditions (microgravity, hypergravity and simulations), including Life, Physical and Materials Sciences, Fluid Physics, Physiology, Biotechnology and others. Oral presentations and poster sessions will be performed. Sufficient time will be reserved for discussions on present research activities and future science perspectives.

Important dates and deadlines

Submission of abstracts	:	March 31,2009
Notification of acceptance	:	May 29, 2009
Early Registration	:	June 15, 2009

Further Information on Symposium and Student Contest

www.elgra.org

B. OTHER MEETINGS

ESF Workshop to make recommendations on "Science-Driven Scenario for Space Exploration"

by Thodoris Karapantsios

Eighty-eight scientists and national representatives from ESA Member States met in Athens on 15 and 16 May 2007 in a workshop organised by ESF and sponsored by ESA, with the aim of establishing recommendations to ESA's Directorate for Human Spaceflight, Microgravity and Exploration on a science-driven scenario for space exploration. The discussion was initiated by the ESSC-ESF Ad Hoc Group on exploration, and concentrated on a series of science goals and mission concepts for the short term (up to 2020), medium term (2020-2030), and long term (after 2030). The workshop participants met in plenary and splinter sessions to refine the findings of the Ad Hoc Group report for the three target bodies: Mars, Moon and Near earth Objects (NEOs). The workshop participants agreed on a set of recommendations and findings that form the core of the so-called Athens declaration.

There are four components of Europe's Exploration Programme illustrating the overarching science goal 'Emergence and co-evolution of life with its planetary environments'. Those are: 1. Robotic exploration of Mars, 2. Robotic exploration of Moon, Near Earth Object sample return, and 4. Human exploration of Mars and the Moon.

In particular regarding the fourth component, a driver of exploration programmes is to advance human presence in space. Future manned missions should make use of humans as intelligent tools in the exploration initiative, with the following specific scientific goals:

• reach a better understanding of the role of gravity in biological processes and in the evolution of organisms at large

• determine the physical and chemical limits of life (from microorganisms to humans)

• determine the strategies of life adaptation to extreme environments

• acquire the knowledge recuired for a safe and efficient human presence in outer space (from the International Space Station via Moon to Mars).

In terms of the enabling science and technology needed to reach these goals, further knowledge is required to enable a safe and efficient human presence in outer space:

• responses of the human body to parameters of spaceflight (weightlessness, radiation, isolation, etc.) and development of countermeasures

• responses of the human body to surface conditions on Mars and on the Moon, and protection measures

• development of efficient life support systems including bio-regenerative systems which can be done on Earth conditions, to be further adapted to specific mission conditions

• development of a habitat providing a living and working area on Mars and the Moon

To reach these goals experiments must be supported to better understand the role of gravity on biological processes on the International Space Station (multigeneration experiments in microgravity and long-term adaptation of humans to microgravity), on the Moon (multigeneration experiments at 0,17 g and long-term adaptation of humans to low gravity), and on Earth (multigeneration experiments under hypo- and hypergravity).

ESF Workshop to evaluate and define the future of ELIPS program

by Daniel Beysens

At the request of ESA, the European Space Sciences Committee (ESSC) of the European Science Foundation (ESF) organised a workshop in Sasbachwalden (Black Forest, Germany) in February 2008. Earlier meetings of this kind were organized in Bischenberg (2001) and Obernai/Evian (2005). These meetings aim to evaluate the achievements and to define future strategic and scientific priorities of the ESA programme in Life and Physical Sciences in space (ELIPS). The workshop was split in two parts, physical sciences (PS) and life sciences (LS), taking place consecutively during the same week. Each disciplinary workshop gathered some 80 persons, scientists from Europe and Canada as active participants and agency representatives (ESA and national) as observers. The physical sciences part was subdivided into three general themes: fluid physics, materials science, and fundamental physics; the life sciences part was also sub-divided into three general themes: biology, physiology, and astrobiology. A general introduction to each workshop was provided by ESSC-ESF, detailing the objectives and the format for the outcome. ESA also prepared a series of general and disciplinary overviews and briefings. A synthesis meeting consisting of the rapporteurs and chairs of the various sessions of the two workshops plus a limited number of selected observers then met on 14 April 2008 in Brussels to finalize and approve the contents of the evaluation report.

Many ELGRA members actively participated in these meetings and discussions like, J.-C. Legros as chairman for physical sciences, H.-J. Dittus, as rapporteur for fundamental sciences D. Beysens (ELGRA management committee member) as chairman for fluid physics. Other ELGRA management committee members; H. Kuhlman and T. Karapantios (ELGRA vice-president) and J. van Loon (ELGRA president) contributed to this evaluation.

We expect from this effort a better understanding from the politicians of the needs and strategy of our community in life and physical sciences in space related research. It is essential that especially the Columbus, as most important European investment in this field, is now ready to work. In the report it is stated that we also have to think and plan beyond Columbus as main experiment platform. Columbus and ISS have a limited life span and questions

in relation to gravity in life and physical sciences will not all be solved at the time Columbus is decommissioned. Other platforms line sounding rockets, free flyers and ground based facilities should be made available for the science community. The ESF meeting also identified the need for more dedicated experiment facilities, in both biology and physical sciences. The participants identified that a better communication between various disciplines (between e.g. biology and human physiology but also between life and physical sciences) should be pursuit in the future. ELGRA, as the European science organization which covers both life and physical sciences, could be the preferred platform to implement this cross communication.
We think the organizers M. Grady (chair LS for the meeting, Open Univ. UK), J.C. Legros (chair PS for the meeting) and the ESF-ESSC members J.P. Swings J.C. Worms, J.P. N. Walter organized a very fruitful meeting. As ELGRA we surely hope that the recommendation by the science community will be implemented so progress and quality of our sciences can be improved.

The final report can be downloaded from: http://www.esf.org/research-areas/space.html

Organization of the meeting:
Physical sciences workshop : Chair: Jean-Claude Legros

Fundamental physics : Chair: Gregor Morfill Rapporteur: Hans-Jörg Dittus
□ Physics of plasmas and solid/liquid dust particles
□ Cold atom clocks, matter-wave interferometers and Bose-Einstein condensates

Materials science : Chair: Hans Fecht Rapporteur: Ivan Egry
□ Thermophysical properties of fluids for advanced processes
□ New materials, products and processes

Fluid physics : Chair: Daniel Beysens Rapporteur: Christian Eigenbrod
□ Fluid, interface and combustion physics

Life sciences workshop : Chair: Monica Grady
Physiology Chair: Helmut Hinghofer-Szalkay Rapporteur: Kevin Fong
□ Integrative gravitational physiology
□ Non-gravitational physiology of spaceflight
□ Countermeasures

Biology Chair: Michael Lebert Rapporteur: Ralf Anken
□ Molecular and cell biology
□ Plant biology
□ Developmental biology

Astrobiology Chair: Charles Cockell Rapporteur: Petra Rettberg
□ Origin, evolution and distribution of life
□ Preparation for human spaceflight exploration

ELGRA co-organized an international life science meeting
by Jack van Loon

ELGRA initiated and co- organized a broad international meeting on life sciences held in Angers (France) last June. The meeting was hosted by the University of Anger and local organizer Prof. Marc-Antoine Custaud. Other organizing entities were the European Space Agency (ESA), the ISGP (International Society for Gravitational Physiology), the ASGSB (American Society for Gravitational and Space Biology) and CNES (French Space Agency). It was the second time ELGRA had a combined meeting with the ASGSB. The first time was in Montreal, Canada in 2000. For this meeting ELGRA also supported 3 students to present their work. In addition, Prof. Thodoris Karapantsios, our ELGRA vice-president and expert in the field of bubbles, presented a key lecture on his work on the impact of bubbles in the human body when preparing for an Extra Vehicular Activity (EVA, space walk). The meeting had more than 350 participants mostly from Europe but also some 75 from the United States, more than 20 from Russia, as well as scientists from Canada, Romania, Japan and China and other countries. The success of such combined meetings should be further investigated in order to improve communication and reduce the number of meetings. Initial discussions between ELGRA and ESA on how ELGRA and ESA meetings on life and physical sciences have been taken place. These discussions also comply with a recommendation of the European Space Sciences Committee (ESSC) of the European Science Foundation (ESF) in a report that evaluates the future priorities of ESA's ELIPS-3 program, to improve interdisciplinary communication between the various European research fields in space and gravitational sciences. (see www.esf.org for additional info).

1. ELGRA-ESA Collaboration regarding Students Parabolic Flights
by Jack van Loon

ESA has again picked up the opportunity for students to apply for a parabolic flight experiment. The new program is called "Fly Your Thesis!". The announcement to participate to this first opportunity was closed last September. ESA, represented by Dr. Javier Ventura-Traveset, head of ESAC Communications & Education Office near Madrid, Spain, has invited ELGRA to assist in the overall process of experiment review and support the young investigators in preparation and reporting on their findings.

This exciting program will enable university students to fly their experiments in microgravity by participating in a series of parabolic flights on an Airbus A300 Zero-G aircraft. "Fly Your Thesis!" requires each team of students to design a scientific experiment to be performed in microgravity, as part of their Masters thesis, PhD thesis or research program. From the proposed experiments a Review Board will select up to 20 teams, who will be invited to elaborate a detailed scientific proposal, with the support of a scientific mentor. As a conclusion to this phase, the teams will present their projects to a Review Board during a dedicated workshop to be held at -ESTEC in Noordwijk, the Netherlands. The members of those teams will also visit the European Astronaut Centre (EAC) near Cologne, Germany. ELGRA will assist ESA in both review boards. Finally three or four teams will be selected to further develop and perform their experiment on an ESA Microgravity Research Campaign that will take place in Bordeaux, France, during the autumn of 2009. There, the student teams will work in close contact with voluntary scientists from the ELGRA membership. During the campaign, the students will accompany their experiments on board for three flights of 30 parabolas, experiencing about 20 seconds of microgravity during each parabola. Some of the other teams attending the ESTEC workshop may be selected to have their experiments performed in another gravity research facilities like drop towers or centrifuges. During the "Fly Your Thesis!" project, the participating teams will be supported by the ESA Education Office, ESA microgravity experts and members of ELGRA. ESA will offer financial support to cover part of the cost of the experiments, necessary travel and accommodation, and participation in a conference. This means that ELGRA members have the opportunity to participate in this program by assisting young researchers in their first steps in (micro-)gravity research. Future reports and publications will include the ELGRA supporting member(s). As ELGRA, together with ESA, we will try to couple student proposals with an ELGRA member(s). In order to foster cross-European collaborations we try to match students and mentors located in different countries within Europe. So you might be contacted in due time with the possibility to support this 2008/2009 parabolic flight campaign or for years to come. Also, you might point out this opportunity to your students.

For future experiments ELGRA is also asked to make an inventory of instruments that might be used by students for their parabolic flight experiments. ELGRA will set up a database of these instruments. So if you have instruments that have been used in the past during parabolic flights or that, with little modifications, might be used for future student experiments and can be included in this database, please contact me : j.vanloon@vumc.nl

'Zero-G' Airbus A300 for parabolic flights (courtesy ESA)

2. European Summer University : Origins of Life and Life in Space
by Jack van Loon

Since years a summer school on space and life sciences research has been organized in Banyuls-sur-Mer in France. The initial courses were supported by European Union funding but for the lasy years the support came directly from various participating universities as well as from ESA and ELGRA. The course was previously organized by our former ELGRA president Prof. Gerald perbal and after his retirement by Prof. Marie-Chistine Maurel from the Université Pierre-et-Marie-Curie. ELGRA first supported a number of students in 2007. Various ELRGA members also lecture at course. Last year 45 students form France, Germany, Switzerland, Italy, the United Kingdom and Spain participated last year in Banyuls. This year 37 participated in Florence. We want to alert you on this possibility for you (as a student) or for educators who might forward this possibility to their students.

Lectures were be given by European specialists on the origins of life, space environment, the role of gravity in molecular, cellular, animal and plant and human behavior, and the use of molecular tools in space biology. Additionally there were data analysis workshops and students working in small multinational groups in order to present a project design. We will inform you on next year's time and location of the summer school in due time.

European Summer University in Banyuls-sur-Mer, 28/8-7/9, 2007

European Summer University in Florence, 24/8-5/9, 2008

3. Facilities for artificial gravity
by Jack van Loon

Recently two new large scale facility for human gravity related research have been opened. Both facilities were presented during a meeting "Technology for Artificial Gravity and Microgravity Simulation" at ESA-ESTEC in Noordwijk, NL, last year December.
The First facility 'Desdemona' is a motion based simulator which can move vertically over 2 m and horizontally 8 m over a track. The horizontal track may rotate by itself allowing a sustained 3g load. Applications are for flying and driving, especially for those situations where a hexapod cannot provide sufficient motion cueing. Desdemona was designed originally for spatial disorientation training of (student) pilots but can also be used as a centrifuge. Desdemona is an ideal 'clinical' tool for vestibular examination of astronauts as well as for motion sickness provocation and desensitization in unusual g-environments. The system is located at TNO Soesterberg (NL) and developed in collaboration with AMST Systemtechnik, Ranshofen (AU). More information on this can be found at: http://www.desdemona.eu.

(courtesy: TNO)

Another new centrifuge has been developed to serve both the life and physical science community in conducting hypergravity experiments in a very versatile environment. The Large Diameter Centrifuge, LDC, has a maximum diameter of 8 meters. On its four arms a total of 6 free swinging gondola can be accommodated. Each gondola has a capacity of an 80 kg. payload that can be exposed to 20g. Each gondola is equipped with power and data lines. Different gasses can be supplied to each gondola. The gondola can house various instruments such as furnaces or modules for combustion sciences, fluid or plasma physics studies. The facility is also outfitted for (possibly future) long duration animal studies for basic research and in preparation for long duration space flight experiments. The facility is fully programmable. Both, rotation profiles as well as experiment monitoring and commanding is performed via standard Windows-based LabView protocols. The LDC is located at ESA-ESTEC and was build by Zeugma, Mafra (PT). More info at: http://www.esa.int/techresources/ESTEC-Article-fullArticle_par-28_1202207743187.html

(courtesy: ESA-ESTEC)

4. News from National Space Agencies

4.1. The German Program "Research under Space Conditions" (Space Life and Physical Sciences)
by Gunter Ruyters
Head , Life Sciences Program, German Space Agency (DLR)

The German Space Life and Physical Sciences Program is managed – like all other space programs and activities in Germany – by the German Aerospace Center (DLR) in its role as space agency for Germany. As such DLR has three major responsibilities:

- To establish the German Space Program with its three integrated parts (national program, DLR intramural research & development program, ESA microgravity program) on behalf of the German government
- To implement the program by e.g. giving grants to research institutes (universities, Max-Planck- and other research institutes), placing contracts to industry for the development of experiment facilities, and by providing flight opportunities
- To establish international coordination (bi- and multilateral)

Based on the federal government's political objectives the currently valid space program was approved by the German government in May 2001. This program defines the overall goals and objectives as well as the strategic cornerstones, by which these goals should be achieved. Forming part of the German national space program, the investigations on the effects of the special environmental conditions of space – especially microgravity and radiation – on physical, chemical and biological processes and phenomena as well as on living systems. Gravity, as omnipresent and perpetual constant, is a key factor here and for the evolution of life that has to be modified or eliminated to understand its role in detail as well as for investigating phenomena masked by the presence of gravity. This is achieved in space experiments.

These activities are embedded in terrestrial research, i.e. they do not comprise a special research field. Instead, new possibilities are opened up by spaceflight complementing terrestrial research. Thus, new discoveries in science and technology are made possible that not seldom are translated into innovative applications to the benefit of the people on Earth. Results of experiments conducted in space help to improve production processes for aircraft and automobile castings and to develop innovative medical devices.

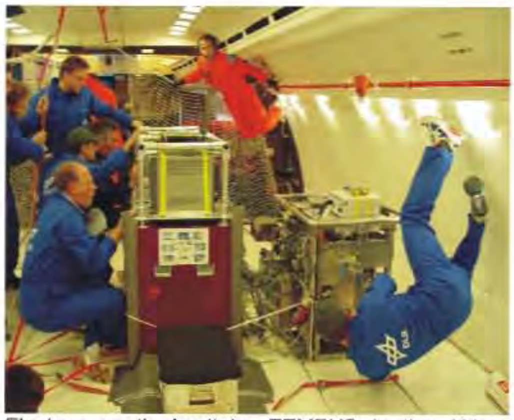
With its research under space conditions, DLR pursues four objectives, namely

- to investigate basic vital functions,
- to develop new methods of diagnosis and therapy in medicine,
- to expand the horizons of physical research and
- to conduct innovative materials research.

In implementing the program, the DLR Space Agency supports German scientists in biology, medicine, physics and materials research working at universities, Max Planck Institutes and other research institutions. In addition, DLR regularly commissions the space industry to develop equipment specifically designed for use in space. Also, DLR offers scientists a variety of flight opportunities ranging from the Bremen Drop Tower, via parabolic airplan flights with the Airbus A-300 ZeroG, TEXUS sounding rockets, research satellites such as the Russian FOTON to the International Space Station ISS. The ISS is predominatly used in the frame of the ESA program, but also via bilateral cooperation with other ISS partners.

Especially with the new opportunities on ISS and Columbus with its innovative experiment facilities the program will get a new push. A multitude of German and other research projects has been selected that now await realization. Consequently, there will be no lack of scientific work for astronauts to do in the next few years. Basic and application-oriented research on the ISS will add to the success story of the German Life and Physical Sciences Program. Thus, the results from space experiments will consolidate Germany's leading position in many fields of science and industry.

The German ESA astronaut Thomas Reiter with the 3D Eye Tracking Device during the Astrolab mission in 2006



The Electromagnetic Levitator TEMPUS in the Airbus A-300 ZeroG during the 10th DLR Parabolic Flight Campaign

4.2 News from the French Space Agency

by Francois Spiero
Human Spaceflight and Exploration CNES

France, through CNES and ESA, has had activities in life and physical sciences in space for several decades. Over the years, France has developed an expertise in many areas, with a focus on human physiology, fluid physics, fundamental physics, biology and exobiology.

More specifically, in physiology, CNES, in cooperation with DLR, has developed the instrument CARDIOLAB for cardiovascular research on board the ISS. There is also a cooperation with Russia on CARDIOMED, an equipment for medical operations on the Station. Besides, new perspectives in cardiovascular research with China are initiated. Other areas of interest in physiology are neurosciences and nutrition, for which many experiments are performed on the ISS in cooperation with several space agencies around the world. One has also to mention that in MEDES, a CNES subsidiary, many bedrest campaigns have been performed to simulate the effects of weightlessness on the human body.

As far as fluid physics is concerned, the highlight is DECLIC, an instrument to be flown in the near future on the ISS. DECLIC, which stands for DEvice for the study of Critical Liquids and Crystallization, is done in cooperation with NASA. CNES is also developing research in granular matter.

PHARAO, an atomic clock with a very high precision, is under development at CNES and is to be integrated in the Atomic Clock Ensemble in Space (ACES) project of ESA, which is supposed to be attached to an external pallet of COLUMBUS in a few years. It will provide a very high precision of time and may lead to several terrestrial applications.

France has been active for years in biology. CNES is now pursuing the development of an advanced incubator, called PHENIX, with a fluorescence capability. In exobiology, many French experiments are performed on the ISS (EXPOSE instrument) and also on the Russian platform FOTON.

Most of the experiments in the fields mentioned before are operated from CADMOS, the French center of the COLUMBUS ground segment, co-funded by ESA and CNES and located in the CNES premises in Toulouse. CADMOS is in particular the leading European center for physiology.

Last but not least, France provides parabolic flights to Europe thanks to the company NOVESPACE. Experiments on board the zero-g aircraft often prepare the ones to be performed later on the ISS.
In summary, CNES has a variety of activities in life and physical sciences in space, mostly done in European or international cooperation.

4.3 News from the Italian Space Agency

by Jean Sabbagh and Vittorio Cotronei
ASI, Italian Space Agency

Medicine & Biotechnologies – MED
The Italian Space Agency (ASI) Life Sciences Programme has the specific objective of gaining knowledge through space research and transfering it to medical applications on Earth. The primary goals of the Programme are:

- Understand life processes and adaptation mechanisms in the space environment;
- Boost medical research on ground with the results of the medical investigations in space;
- Foster the integration of multi-disciplinary expertise, both scientific and industrial, for programmes of high-level technology transfer.

The Programme is focused on five main application-oriented research areas which require special facilities and flight opportunities: Disorders of Cardiorespiratory and Motor Control (DCMC), Osteoporosis and Muscle Atrophy (OSMA), Biotechnological Applications (MoMa), Bio-regenerative Environmental Control (CAB), and Genomic, Proteomic and Metabolomic (GPM).
ASI provides access to different space platform, from parabolic flights to International Space Station, thanks to a cooperation mainly with ESA, NASA and The Russian Space Agency (RKA). To reach the goals of these research areas a scientific and industrial network has been created over the years. Today, more than one thousand researchers, 164 Institutes of research and 18 private companies are involved in this venture.
ASI has developed a national utilisation plan for the ISS thanks to the ASI-NASA MOU for Multi-Purpose Logistics Modules (MPLM), including development of reusable facilities. Today, 4 Italian facilities are on board ISS (Alteino, ALTEA, HPA, ELITE-S2) and a fifth one focused on animal research (MDS) is planned for 2009.

Astronaut Roberto Vittori, Italian national, using HPA in ISS

4.4 Short overview of microgravity research in The Netherlands

by G.G. van de Haar
SRON Netherlands Insitute for Space Research

The Netherlands has been involved in microgravity research already before the Spacelab era through experiments on sounding rockets. Almost from the start all Dutch activities were part of ESA programmes like FSLP, EMIR and ELIPS, and over 50 Dutch scientists have performed some 100 microgravity experiments on various platforms. The main field of activity is life sciences, followed by physical sciences. Experiments currently under preparation for ISS concern e.g. plant cells, colloidal crystals, organic matter and plasma research.
There is a relatively large number of Dutch PI's in ESA's present microgravity portfolio (7%) resulting in a steadily growing number of peer-reviewed papers, including a relatively large percentage of references worldwide (e.g. 3% in life sciences).
The Dutch government supports national microgravity activities since the mid 1980's. Facility development concerns e.g. the Gloveboxes (in MSG, Biolab etc.) and experiment containers.
Ground-based projects are performed with the Large Diameter Centrifuge and the Random Positioning Machine.
A recent highlight was the Delta mission in 2004, when Dutch ESA astronaut André Kuipers performed some 20 Dutch experiments. Many of the experiments generated interesting results, with also spin-off opportunities for applications in everyday life.
The mission also gave an impulse to national education activities: the Seeds-in-Space plant experiment was simultaneously performed by 80,000 school children. In addition, the Delta Researchers Schools project was created to better involve elementary school children with science and technology.
Based on the experience generated in the past decades, the Dutch microgravity science community looks forward to a promising Columbus era.

Dutch astronaut A. Kuipper

5. News from ELGRA Supporting Members

5.1 Kayser-Threde

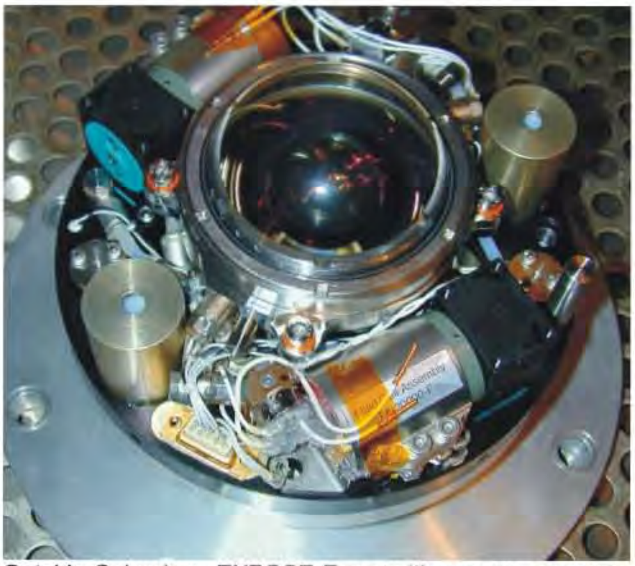
by Kurt Kemmerle

We are proud to tell you that:

- HCU/CTCU, the Heater Control Unit and Cabin Temperature Control Unit
- Ducts & Lines, the tubing system for the Life Support System
- the COF Video System
- about 100 individual boards of the SPLC (standard payload computers)

are working well in the Columbus infrastructure and payload racks on board ISS.

The Fluid Cell Assembly (see figure) and the Adaptation Optics, forming essential subsystems for the GeoFlow experiment arrived well in orbit and are fully operational since begin of August 2008.



Outside Columbus, EXPOSE-E, a multi-purpose exposure facility, is performing very well.
In the Russian part of the ISS, the 9th experiment run of the German/Russian Plasma Crystal Experiment has been performed successfully in the PK-3Plus facility.
The Eye Tracking Device has been used several times by the crew for investigations of the vestibular system.
Two student experiments: Test of Reaction and Adaptation Capabilities and Oil Emulsion Experiment (see photo from orbit) performed also very well.
So did the two commercialization experiments: Blood Measurement Instrument and Skin Care.
Since August 2007, ANITA, the Analyzing Interferometer for Ambient Air, is taking care of the quality of the astronauts' breathing air.
Also since last year, our Electrical Subsystems, Containers, and Recorders of MELFI are operational without any constraint.

Unfortunately, the flight units of the Facility Control Unit, the Power Supply Unit, the Pyrometer and the Ultrasound Diagnostics Device of the MSL (Materials Science Laboratory) rack are still on ground waiting for their trip into orbit beginning of next year. They are targeting to the Destiny module.
All of these equipments are performing well in orbit or on ground without creating troubles thus continuing Kayser-Threde's tradition in reliable, high quality and high performance space equipment. So we wish a scientifically demanding future to the ISS and its crew and exciting results to all scientists involved.
You want to see more – www.kayser-threde.com

5.2 Center of Applied Space Technology and Microgravity (ZARM) at the University of Bremen

by Hans J. Rath

ZARM is a research institute of the University of Bremen operating the ZARM Drop Tower, which is a microgravity laboratory unique in Europe. In comparison to orbital systems it represents a ground-based facility with permanent access, open to scientists from all over the world. The main users are investigating gravity–relevant phenomena of fundamental physics and applied sciences like fluid physics, combustion, material sciences and biology. Since 1990 the Drop Tower has offered an experiment time under high quality microgravity conditions of 4.7 seconds up to three times a day, which resulted in more than 4,000 experiments so far. On 2nd December 2004, the new catapult system was inaugurated. It allows doubling the experiment time to approximately 9.5 seconds - a feature no other drop tower can provide.
Moreover, there are two important factors that create extraordinarily precise experiment conditions in the Drop Tower Bremen: The drop tube can be evacuated in order to reduce air resistance and it is protected against exterior influences like wind and temperature by the tower building. Thus, ZARM acquires a world-wide unique quality of microgravity and has developed into one the most important university institutes for space technology in Europe.
Please check our homepage for more information: www.zarm.uni-bremen.de

5.3 Esrange Space Center
by Olle Norberg and Ola Widell

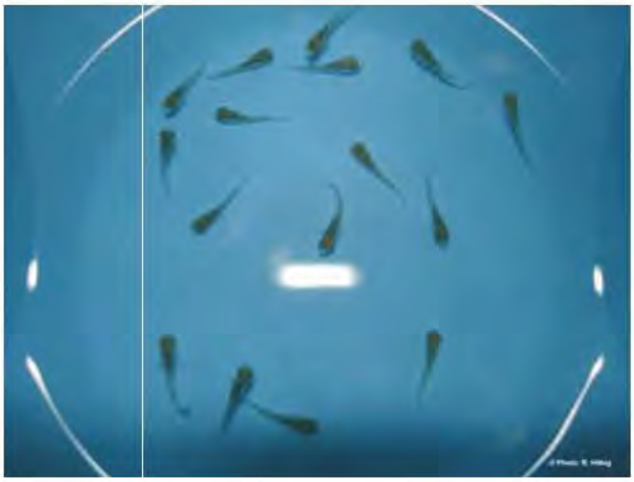
Esrange Space Center located in northern Sweden has during 45 years been a leading launch site for both sounding rockets and stratospheric balloons. Swedish Space Corporation (SSC) has a unique combination of maintaining launch operations, building payloads, providing space vehicles and service systems. Sub-orbital rocket flights and short to long duration balloon flights up to weeks are offered. The geographical location, land recovery area and the long term experience makes Swedish Space Corporation and Esrange to an ideal gate for space activities.

Within the German / Swedish cooperation EuroLaunch (signed in 2003), we perform operations at Esrange as the prime range including the capacity of global mobile rocket and balloon operations. EuroLaunch has the competence, equipment and the experiences from both DLR-Moraba and SSC/Esrange.

Sounding rockets are primarily used in supporting microgravity, space and earth science research. The European sounding rocket activities for microgravity research started in 1976 with the German Texus programme with the first launch from Esrange on 13 December 1977. Texus 44 and 45 was successfully launched in February 2008.

The Swedish Space Corporation (SSC) conducts the MASER Microgravity Rocket Programme since 1987, with the purpose of providing flight opportunities to the scientific community for performance of experiments under microgravity conditions. MASER 11 will be launched in May 2008.

Both the Texus and Maser programmes are launched with a VSB-30 two-stage rocket providing 6 minutes of microgravity. In 1990 the MAXUS programme was introduced as a joint venture between EADS and SSC. For the programme a single stage Castor 4b rocket providing 13 minutes of microgravity is used. MAXUS 8 will be launched in 2009.



6. IN MEMORIAM

Ron Huijser
(Amsterdam, 1951, - Leiden, 2005)

Ron Huijser died on December 10, 2005. He struggled bravely for years with his disease, a fight he lost in the end. He was a key player within the Netherlands with regard to microgravity research and was well known in the related international community, always actively exploring new scientific ideas and industrial concepts for Space implementation in order to promote and advance this area. In line with this he has always been a very active ELGRA member. He played this role, which brought him both professional satisfaction and motivation to continue his struggle, with admirable dedication till late 2005.
Ron was born on April 29, 1951 in Amsterdam. He studied physics at the University of Amsterdam and obtained his doctors degree in Experimental Physics in 1982. His thesis was on critical point experiments, for which he recognized the advantages of performing these in a microgravity environment. The development of a Critical Point Facility (CPF) for Spacelab, first at the university and later at the National Aerospace Laboratory NLR, marked his first steps in microgravity. Later on he joined Fokker Space (now Dutch Space) where he founded the microgravity group and worked for 18 years as its inspiring leader. He made important and numerous contributions to the development of various life science and physics experiments for sounding rocket missions (e.g. the Cells in Space CIS-1 - CIS-6 series; CODAG-1, Wet Satellite Model, MAIS experiment) and various experiment hardware for the ISS, always trying to optimize the instruments to achieve the maximum scientific output.
He worked in close collaboration with scientists from the conceptual phase up to the realization and interpretation of a space experiment, initiated required technology developments and recognized the need to perform adequate ground experiments beforehand. To this end, he led the development of a Random Positioning Machine and supporting equipments, which is now a commercially available and widely used instrument for microgravity simulation, stimulating ground research regarding the effects of microgravity on living organisms.
Ron used a pragmatic, novel development approach which made extensive use of early prototyping, in contrast with the traditional and more formal Space approach. He succeeded in realizing a laboratory environment of workshops at Dutch Space, based on his credibility and performance, with which could adequately and quickly respond to user needs, bypassing red tape both inside and outside the company.
He played a key role in the DELTA mission to the ISS with ESA astronaut André Kuipers, sponsored by the Dutch Government. Many of the experiments were developed by Dutch researchers and built by Dutch industry and research institutions and Ron coordinated the Dutch industrial support to the DELTA preparations and operations, knowing the onboard experiments well and contributing his extensive technical and operational experience.
One of his last achievements was the prominent Dutch industrial involvement in the development of the Life Marker Chip, a candidate instrument for ESA's ExoMars mission. He envisaged a synergistic combination of Dutch Space life science expertise and technical resources with leading Microsystems Technology available in the Netherlands for application in the new, appealing Aurora space program. This was another result of Ron's innovative and lateral thinking and the final plans for collaboration with the UK-led consortium were made by him just a few months before his death.
We will remember Ron as an inspiring colleague with an unusual combination of vision and both broad and in-depth expertise, but above all as a friend with which we share precious memories.

by Eric Boom, Guus Borst, Jack van Loon

Roberto Marco
(Valencia, 1941 – Madrid, 2008)

A quick and treasonous disease has carried away from us June 27th, 2008, when still in full creative maturity, our eminent colleague and close friend Roberto Marco. Roberto was a Full Professor of Biochemistry in the Autonomous University of Madrid and active investigator for more than twenty years on the effects of weightlessness on the embryo development and aging in Drosophila, and member of ELGRA from early times of the activity of the Society.

Roberto Marco graduated in Medicine and Chemistry in Valencia (Spain), where he also got the MD degree with a thesis on History of Medicine, a topic not related to his further research work, but never neglected, as a side activity and interest. He soon realized the limitations for a research career existing in Valencia in 1967 and decided to move to Madrid, to work in one of the institutes of the Scientific Research Council (CSIC) under the supervision of Prof. Alberto Sols, an oasis of scientific excellence and modern research concepts in the desert of mediocrity that then characterized the academic activities in Spain. In the Sols' laboratory, Roberto Marco performed a second PhD thesis work on the regulation of guconeogenesis, but, most important, he learned to do high level science, using rigorous methods and paying attention to the last results appeared in international publications. Roberto maintained for all his life a permanent admiration and gratitude for his master, Prof. Sols.

Following the Sols' advice, Roberto Marco moved to the University of California at Stanford, for a three-year postdoctoral stay in the laboratory of Arthur Kornberg, Nobel Laureate in 1959. This was a new and decisive contact with scientific excellence, in this case not isolated, but working in optimal conditions to develop a privileged and enquiring mind. Probably Roberto could remain in California, given his good publications record and the close relationship that he reached and maintained with Prof. Kornberg; however, he came back to Spain to work in the new laboratories of the Department of Biochemistry of the Autonomous University of Madrid and the Institute of Biomedical Research of CSIC, which soon was put under the name of the Roberto's master, Alberto Sols. There, he focused his investigations on the biochemical mechanisms controlling the embryo development and aging, mostly using the model system of the insect Drosophila. In particular, his major interests were the involvement of muscle and mitochondria in these processes, applying biochemical, molecular and cell biological methods. Roberto Marco has published more than 150 papers in high impact journals, such as Nature, J. Cell Biol., J. Biol. Chem, PNAS, Biochemistry and many others.

I never asked Roberto who or what was behind his interest and dedication to Space Biology. Probably his interaction with Jaime Miquel, an expert in aging born in Spain, who worked for many years in NASA, could have influenced him. Whatever it was, Roberto began in the 1980s a fruitful line of research, closely linked to his primary research interests, directed to know the effects of microgravity on the development and aging in Drosophila. In this field, Roberto was in Spain an absolute pioneer and he sustained for 20 years the prestige of the Spanish Space Biology in the European Space Agency. As an example, a major and decisive part of the scientific experiments designed in Spain to be performed in the Spanish Soyuz Mission, which took place in 2003 in the ISS, was contributed by Roberto Marco.

However, even considered in en European context, his research work was at the level of the best investigations on the effects of microgravity on living beings. Roberto belonged to a generation of space researchers who, by means of experiments flown in Biosatellites, Biokosmos, Biopan, Foton, and in the American Space Shuttle, using the European device Biorack, contributed to the European leadership in Space Biology, which promoted the construction of the "Columbus" module by ESA, recognized as the most important facility for biological research in the ISS. In the meeting organized in Toledo (Spain) in 2006, on the European Soyuz Missions, Roberto argued in favour of this European leadership and promoted the necessity of an intense use of the ISS by European scientists, establishing the necessary bilateral or multilateral agreements for the solution of logistic problems.

Among the major contributions of the work of Roberto Marco in Space Biology, I would like to mention two of them: firstly, the finding that microgravity accelerates aging, as a consequence of the increase in the motility of flies on exposure to the space environment. Second, the appreciation of the paradox resulting from the fact that the embryo development is largely normal in space, despite the numerous alterations found at the molecular and cellular levels. Roberto was increasingly interested in System's Biology, and distant from the reductionism which characterized for many years Molecular Biology. These ideas were the object of much of his teaching activity, in the University of Madrid and also in international courses, such as the Erasmus "Life in Space" which he attended for many years, or the "Virtual University" in which he participated, together with other five European Universities.

Roberto Marco was not only an outstanding scientist, but he lived with passion, enthusiasm and commitment the political events affecting Spain in the last decades; he knew and enjoyed the Spanish Geography, History and Art, and he loved good music, good painting and relaxed chat. Intimately treated, he manifested deep emotions for his family (wife, sons, daughters, grandsons...). He was fortunate in being fed with excellence from the very beginning of his career, but he brightly developed with effort and generosity what he learned from his masters and what he continuously learned from many sources for all his life. It was a great luck to have had the opportunity of sharing ventures and feelings with Roberto Marco.

by Francisco Javier Medina

7. Other News

7.1 The Declic instrument

Origin: CNES – NASA bilateral cooperation agreements

Initiator: CNES

Participants: CNES and NASA

Laboratories: CNRS/ICMCB in Bordeaux and CNRS/L2MP in Marseille

Goals: Study critical fluids at high and low temperatures
Study the formation of the structure of matter during the freezing of transparent materials
Study chemical reactions in supercritical fluids

Status: Delivery of the flight model to CNES: March 2007
Delivery of the flight model to NASA: April 2008
Launch towards the ISS: June 2009

info: http://www.cnes.fr/web/6831-declic.php

7.2 JEREMI Project

JAXA has recently selected for ISS a project named JEREMI. It has been developed in the framework of the International Topical Team 'Marangoni Instabilities in Systems with Cylindrical Geometries'. The overall scientific proposal was submitted jointly by Japanese and European scientist. The Kick-Off Meeting was in April 2008. In the experiments planned for mid-2011 will be carried out in FPEF of KIBO. The aim of the experiments are investigations are high precision measurements of surface-tension driven flows with particular emphasis on the flow and heat transfer in the gas phase and its influence on the hydrodynamic instabilities. In addition, the dynamics of suspended particles will be investigated which have been shown to exhibit certain particle accumulation structures (PAS) on a MAXUS precursor experiment.
Contact: V. Shevtsova (vshev@ulb.ac.be), H. Kuhlmann (h.kuhlmann@tuwien.ac.at).

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Special thanks to ESA-ESTEC (HME) for their continuous and substantial support to their science community through ELGRA.

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