newsletter

NEWSLETTER OF THE
EUROPEAN LOW GRAVITY RESEARCH ASSOCIATION

elgra

PRESIDENT'S PAGE

Dear ELGRA members,

Welcome to the 9th ELGRA Biennial NewsLetter. Since the previous issue, one of the major events has been a very successful biennial Symposium and General Assembly, in Vatican, Rome, 11-14 Sept. 2013.

The selected papers presented at the ELGRA Symposium will be published in two issues of Microgravity Science and Technology Journal (MST). The first issue is already released and the second one will appear in November or December. ELGRA negotiated with Springer and we received a unique opportunity - since summer 2014 all ELGRA members have free access to the journal via ELGRA WEB site. Now it is your journal and I would like to encourage you to consider submission of recent research work or a review paper to the journal. I believe MST offers a very good opportunity to make your research known to the interdisciplinary communities working under altered gravity conditions.

Another important outcome of the recent ELGRA Symposium held in Vatican in September 2013, is the birth of SELGRA (Student ELGRA). It is a nice platform at the student level for all gravity-related research in Europe and presently it includes 35 members. In this issue you will find a few pages about SELGRA written by Anna Garcia-Sabaté, the SELGRA President.

ELGRA is a long-lasting partner of ESA in the Education and Outreach Program. We conduct evaluation of proposals for the Spin-, and Drop-Your-Thesis programs of ESA and provide mentors for the selected proposals among the ELGRA members. Looking forward to developing the future of our scientific discipline, one of the sessions during the last ELGRA Symposium in Vatican, 2013, was devoted to the presentations of students. Furthermore, 5 contest winners as the authors of the best manuscripts received financial support of 300 Euros plus the ticket cost to attend the Symposium.

As researchers, you provide plenty of innovative results using microgravity platforms and ground-based experiments. The number of accessible microgravity platforms is limited, yet very diverse: drop towers, parabolic flights, sounding rockets and the International Space Station. ELGRA strongly supports utilization of the ISS for scientific experiments. Less expensive and easier accessible alternative for microgravity experiments is parabolic flights. It is my pleasure to let you know, that a new Airbus will fly soon. A joint Parabolic Flight campaign, shared by ESA with CNES and DLR, will take place in April 2015 to inaugurate the new airplane. However, the new airplane may increase complexity of the experimental facility and require renovation of the existing racks.

It is worth mentioning some very sad news related to the microgravity platforms. The unmanned Antares rocket and its Cygnus cargo module exploded seconds after launch on 28 October. They were carrying supplies and experiments for the ISS, among them were two ESA experiments, DCMIX (physical science) and GRIP (life science) which were not covered by insurance.

The researchers are also aimed at the new generation of suborbital carriers which are expected to be available in the coming years. Unfortunately, Virgin Galactic's SpaceShipTwo rocket plane broke up and crashed during a test flight on 31 October. This accident may essentially delay the access to such kind of platforms.

Although it is not part of microgravity research, it is worth noting the great success of the ESA in 2014: Rosetta mission – the first in history rendezvous with a comet. In this issue you will find a short story of this mission.

Despite our love to science and curiosity to discover, we need funding for successful missions and valuable results. The 2014 ESA Council meeting at ministerial level will take place at the very beginning of December in Luxembourg.

I would like to ask you to use all opportunities for *promoting* benefits of microgravity science to a large community and to raise public awareness and interest in this fascinating domain. We have to convince our national decision makers that while each of us is focusing on own particular area, doing own piece of research, all of our efforts put together are exactly that driving force that ensures the advancement of science and we need funding to continue.

Finally, please, note in your agenda that the 21th ELGRA biennial Symposium and General Assembly will be held on 29 September - 01 October 2015, Corfu Island, Greece. For more information about the event, please consult the ELGRA website (www.elgra.org). Do not hesitate to contact the local organizer by e-mail ("Thodoris Karapantsios" karapant@chem.auth.gr)

I wish you an excellent 2015 and I am looking forward to seeing you in Greece.

Sincerely yours

Valentina Shevstova
ELGRA President

Brussels University, Belgium

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ELGRA BIENNIAL SYMPOSIUM AND GENERAL ASSEMBLY 2013

"IN THE SPIRIT OF DISCOVERY"

The International Biennial Symposyum 2013 and General Assembly of ELGRA, jointly with the XXVI National Meeting of AIMAS, took place in Vatican City, from 11th to 14th September, under the auspices of the Presidency of the Italian Republic and Pontifical Council for Culture.

It was attended by 185 participants from many countries in the world. The organizers were Dr. Monica Monici from ASAcampus Joint Laboratory, ASA Research Division, Dept. of Experimental and Clinical Biomedical Science, University of Florence and Prof. Felice Strollo, Complex Operative Unit of Diabetology and Dietology, "Santo Spirito" Hospital, ASL RME, Rome.

An extensive series of topics were dealt with by experts and scientists from all over the world. For the Physical Sciences, the main topics were: convection; suspensions, emulsions and interfaces; vibrations; physical properties of fluids, divided in two sections: diffusion and two phases and high temperature phenomena, respectively. The Life Sciences sessions were devoted to plant biology in space; animal models in microgravity; long lasting mission, with a session concerning altered gravity and confinement and the other focused on risks for human health and countermeasures. Additionally, two session were devoted to facilities: simulation systems and models and instruments and diagnostics, respectively. The Symposium ended with a session on agencies, programmes and industries.

There was also a lively poster session, with 49 poster presentation.

Plenary lectures were presented by Prof. Gilles Clément, from the International Space University, Illkirch Graffenstaden, France and Prof. Dietrich Schwabe, from the Physics Institute, University of Giessen, Germany.

The medallist for the physical sciences was Dr. Daniel Beysens from the Ecole Supèrieure de Physique et Chimie Industrielle-Paris Tech & Commissariat à l'Energie Atomique-Grenoble (France) who gave a brilliant talk titled "Critical Point in Space: A Quest for Universality".

Regarding the life sciences, the ELGRA medal was given to Dr. Marianne Cogoli from the Space Biology group ETH Zurich (Switzerland) who presented an enthralling overview on several aspects of the in vitro activation of human lymphocytes in space.

During the last ELGRA Symposium held at the Vatican in September 2013, thanks to the initiative of Francisco Javier Medina, Carole Leguy and Andrew Winnard, all the students in the Symposium were invited to attend a special meeting to discuss the idea of forming a student ELGRA group, thus

SELGRA (Student ELGRA) it was established.

The Opening Ceremony of the Joint Symposium was particularly engaging. It began with a Panel Discussion titled "In the Spirit of Discovery: Perspectives in Space Research" which was attended by a group of invited experts: the Italian astronaut Paolo Nespoli, in the role of chairperson; the Responsible for European Science Exploitation and Utilisation on the International Space Station (ISS), Dr. Martin Zell, from the European Space Agency

Opening Ceremony

(ESA); the President of the Committee on Space Research (COSPAR), Prof. Giovanni Bignami; the Head of Physical Sciences in Microgravity at the German Space Agency (DLR), Dr. Rainer Kuhl; the President of the Italian Space Agency (ASI), Ing. Enrico Saggese. A Representative of the Pontifical Council for Culture participated in the discussion and addressed ethical issues in space research and the relationship between science and fait. During the Panel Discussion a video-message from the ISS was transmitted.

At the end of the Ceremony there was a guided visit to the Vatican Museums followed by a dinner buffet organized in a wonderful setting, with view on the Sistina Chapel and Vatican Gardens.

Another special event was the Gala Dinner of the Symposium which took place on the Nemi Lake, a small lake in the surrounding of Rome, which is famous for its sunken Roman Ships.

The Symposium was held successfully, also thanks to the help of many people who contributed to the organization thus allowing to have the unique opportunity to discuss scientific achievements in microgravity research in a beautiful location as Vatican City.

ELGRA Medals during the Gala Dinner

Student's award during the Gala Dinner

HOT TOPICS

SUB-ORBITAL SPACECRAFT FOR MICROGRAVITY SCIENCES

Jack J.W.A. van Loon, VU-University Amsterdam.

There are the ‘traditional’ short duration microgravity platforms such as drop towers, parabolic aircraft and sounding rockets, providing an average free fall time of about 9 seconds, 20 seconds and up to 14 minutes, respectively. However in the near future some other platforms will provide our science community with intermediate free fall times in the range of 3-4 minutes. Companies like Virgin Galactic, Blue Origin and XCOR are all planning to have their sub-orbital test flights early 2015. The activities of these commercial sub-orbital companies are mainly concentrated in the USA although, S3, a conglomerate of various European companies, are also working on a two-stage to sub-orbital system using an Airbus aircraft as first stage in flight. First flights for this system is

The first European sub-orbital pilot and next Dutch astronaut Harry van Hulten. Van Hulten will also be the first European astronaut in the role of pilot – commander of a spacecraft.

Example of sub-orbital platform the XCOR Lynx

Example of sub-orbital platform the Virgin Galactic SpaceShipTwo.

planned for 2017. Most of the activities and revenues for these businesses as based on tourists flights. For some 100 to 200 k$ one can see the Earth from some 100 km. altitude. However, only a portion of these costs (~20-40 k$) is required to bring a moderate sized payload along these flights. Such budgets can easily be included in our regular science research grants. Taken the premise that these space craft can fly on a daily basis, one can, for the first time, actually

Example of sub-orbital platform the S3 system.

plan for a longer duration microgravity experiment for relatively moderate means. Besides science, such sub-orbital flights can also be used for technology demonstration flights where instruments can improve their technology readiness levels (TRL) qualifying for longer duration mission in ISS or on other free flyer platforms.

Although these activities are mostly located in the United States there is going to be a European flavor to this all. Former F-16 and test pilot Mr. Harry van Hulten is selected to be one of the test pilots for the XCOR Lynx system. As such Mr. van Hulten will, most likely, become the next Dutch astronaut. As van Hulten stated:"This will fulfill my greatest ambition of going into space." Van Hulten is a very experienced test pilot who flew more than 3,000 hours in 42 different aircraft. The 43th machine will be an actual spacecraft!

OPINION!

Jack J.W.A. van Loon, VU-University Amsterdam, The Netherlands

Nearly 40 years ago, in 1975, we witnessed an event changing the relationship between 'the East' and 'the West'. It was the historic docking of a Soviet Soyuz space craft with an American Apollo module. Under the political leadership of U.S. president Richard Nixon and Soviet premier Alexei Kosygin the crews of the two space craft open their hatches on 17th of July and commanders Leonov and Stafford shook hand orbiting the globe. It was the hand shake of two men but symbolized the hand shake between two ideologies which were, at that time, engaged in a cold war. There is no doubt that this space flight initiative contributed to a better dialogue between the two ideological systems. Not only the actual docking but also the years of preparations for it and the common activities afterwards added to a better understanding between the East and the West. The cold war ended fully in 1989.

We now have an International Space Station where former political 'opponents' work together in the neutral territory of space, although, as we know from the present situation, working together in a space program does it not guarantee a full understanding and peaceful co-existence, but it does contribute to such a condition.

Currently there are serious frictions between several states. Besides the one mentioned earlier there is a worrying situation between China and Japan about the Senkaku / Diaoyus islands which pushes Sino-Japanese relations to, at times, a critical limit. One can also note trade, economic and technological disputes between China, the United States and Europe.

Seen the tensions between various, space faring, nations a common new space initiative might induce a positive contribution to a better mutual understanding. Such an initiative could be instrumental to bridge cultural differences and explores new avenues for both scientific and technological collaborations.

I very well realize that this plea is very ambitious indeed. However, dialogues and collaborations are always to be preferred over conflict and hostilities. So I invite the leaders in this world especially from the United States, China, Russia, Japan, Canada and Europe, maybe supported the United Nations office of Outer Space Affairs which has set itself the responsibility for "promoting international cooperation in the peaceful uses of outer space" to look into a common human space flight initiative. As a hint in this direction I would propose a visit of the Chinese Shenzhou space craft to the International Space Station, ISS. (see image).

Image: The Chinese Shenzhou space craft welcomed and embraced by robot arm assisting in docking to the ISS (edited combined images from NASA and CNSA).

BIOMICS: THE MECHANISMS OF BLOOD MICROCIRCULATION REVEALED BY MICROGRAVITY EXPERIMENTS

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PI of the BIOMICS project

Blood circulation is a longstanding problem that has received a continuous attention from physicians, biologists, physicists or fluid dynamicists. Two centuries ago, Poiseuille, a physician, physiologist and physicist made pioneering observations. While his name is in all fluid mechnics textbooks for the relation between pressure drop and velocity of a fluid in a tube, he also revealed the complex features of blood flow in the microcirculation where the diameter of capillaries and vessels is of the same order as the size of blood cells. His observations of the mesenteric microcirculation of the frog revealed that blood flow in the arterioles and venules features a plasma layer at the vessel wall in which there are few red cells, that “plasma-skimming” occurs at vessel bifurcations, i.e. an uneven distribution of blood cells, leading to inhomogeneities of the cell concentration (hematocrit) in capillaries, and that white cells tend to flow along vessel walls. So in summary, flow confinement results in a particular structure of the flowing suspension of cells, and to phase separation at bifurcations.

Indeed, blood circulates through a very complicated network of vessels with a wide range of diameters and velocities and it takes less than one minute for the heart to pump all cells down to the smallest capillaries where tissues are oxygenated, and back to the heart. While in the largest vessels blood can be considered as a simple, homogeneous Newtonian fluid for fluid mechanics purposes, this is not the case in the microcirculation where channels are arranged in multiconnected networks of small capillaries where models still fail to completely describe the flow.

Blood, a complex fluid

At the microscopic level and from the rheological viewpoint, blood is indeed a complex fluid whose behaviour is governed by the dynamics of red blood cells (RBCs) which make up 45 % of blood volume. From a biological viewpoint RBCs are rather simple cells (a mostly passive nucleus-free cell filled with a hemoglobin solution) with a simple function (oxygen transport, mediated through binding with hemoglobin to compensate for the low solubility of O_2 in water). However their hydrodynamic behaviour is still a challenge owing to their deformability and complex mechanical properties : their membrane exhibits bending resistance (due to the cytoplasmic membrane lipid bilayer) as well as shear and bending elasticity (due to the spectrin network), and they contain a viscous hemoglobin solution about 5 times more viscous than plasma. In addition, in full blood and due to the presence of plasma proteins such as fibrinogen, red blood cells can aggregate into structures called ‘rouleaux’ similar to stacks of coins at low shear rates or in confined configurations.

The dynamics of deformable bodies such as drops, bubbles, capsules, under simple shear flow is a longstanding fundamental problem. It is due to its direct relevance in the understanding of the rheology of complex fluids and the derivation of constitutive equations from microscopic considerations - a so-called bottom-up approach, as opposed to constitutive equations derived from macroscopic phenomenology and rheology.

Structuring mechanisms in channel flows

In his pioneering works on blood flows, Poiseuille observed the micro- circulation of frogs, which revealed that blood flow in arterioles and venules features a plasma layer near the vessel wall which is free of RBCs. The existence of this depleted layer can be readily related to the so-called Fåhræus-Lindquist effect, a decrease of the apparent viscosity of blood in small vessels as soon as capillary diameter becomes comparable to the size of RBCs ($d < 500\mu m$), due to the lubrication effect of this cell free layer.

In addition, this non-homogeneous concentration profile of blood cells in the cross section of small channels is the leading cause of phase separation at asymmetric capillary junctions : a higher concentration is observed in the channel receiving the highest flow rate, with possible consequences on oxygen delivery to tissues and pathologic issues such as occlusive phenomena.

Poiseuille noted that the thickness of this cell-free plasma layer is a function of red blood cell velocities, identifying the hydrodynamic nature of this phenomenon, which can be driven by wall-repulsion or shear gradients as we shall see. Indeed, when a soft particle (droplet, vesicle, cell) is placed in a shear flow near a wall, it moves away from the wall due to a lift force of viscous origin. It can be qualitatively understood in the framework of lubrication theory: as the deformable particle moves, fluid is pushed in a converging region, leading to an overpressure, and since the shape has a fore-aft asymmetry due to deformability, the under-pressure in the divergent region at the back is lower. Note that there is not lift for a spherical particle in Stokes flow due to the linearity and reversibility of the Stokes equation, nor for a rigid particle whose motion is symmetric and reversible on average.

On the other hand, hydrodynamic interactions and collisions between cells in the flow lead to small repulsions in the transverse direction. On average, these hydrodynamic repulsions arising from pair interactions are responsible for a phenomenon called shear induced diffusion in suspension flows. This diffusion is indeed distinct from Brownian diffusion, which is negligible at the scale of red blood cells. In contrast, shear-induced diffusion is a cooperative phenomenon whose amplitude is directly proportional to the probablility of collisions, that is to the local concentration of cells and shear rate. It is therefore nonlinear and strongly dependent on cell mechanical properties.

A quantitative understanding of the two ingredients leading to suspension structuring in channel flows, namely the migration of cells away from walls and the shear-induced diffusion due to hydrodynamic interactions, is a prerequisite to any attempt to model microcirculatory dynamics. Due a significant screening of these interactions by sedimentation in dilute suspensions, microgravity is a very useful tool to achieve a full description and perform precise measurements of lift velocities and diffusion coefficients.

The BIOMICS experiment (BIOMImetic and Cellular Systems) was designed as a tool to perform precise measurements related the dynamics of suspensions of cells in flow in microgravity conditions and already participated in a series of parabolic flight and sounding rocket campaigns.

The BIOMICS instrumentation: investigating the dynamics of dilute suspensions of cells in flow by digital holographic microscopy

In its nominal configuration, the core of the experiment is a Couette shear flow chamber designed and manufactured by the Swedish Space Corporation (SSC), made of two parallel glass discs, with a diameter of 10 cm and a gap of 170 µm. The bottom disc is fixed and the top one can be rotated at constant speed, allowing shear rates between 0.5 and 50 s^{-1}. An inlet at the center of the bottom plate and several outlets at the periphery allow filling with experimental fluids, vesicle injection and rinsing.

The observation system used to study the evolution and dynamics of the suspension is a digital holographic microscope (DHM) working with a partially coherent illumination designed and manufactured by the Microgravity Research Center (MRC). Digital holography allows to record rapidly the 3D information without scanning along the optical direction by changing the focus as with usual microscopy or confocal microscopy. The system uses a source of partial spatial coherence, created with a laser beam going through a rotating ground glass that reduces the amount of coherent artifact noise and the multiple reflection perturbations. It is a Mach-Zehnder interferometer in microscope configuration. The shear flow chamber is placed in one arm of the interferometer in front of a microscope lens, the direction of observation being perpendicular to the plates. The microscope lens, coupled with the refocusing lens, produces the image of one plane of the shear flow chamber thickness on the CCD. The second arm of the interferometer constitutes the reference beam and is also incident on the CCD where it is interfering with the object beam. The BIOMICS module developped by SSC for MASER 11, with its DHM (developped by Lambda-X) is depicted on Fig. 1. In parabolic flights, a DHM built by MRC was used.

By recording the holographic data resulting from the interference pattern thanks to a CCD camera, the digital holographic microscope provides the capability to refocus numerically vesicles that are out of focus with respect to the focus plane of the optical imaging subsys- tem. The phase and intensity information are extracted from every hologram by the Fourier method and the complex amplitude is computed and used to refocus it in any plane inside the shear flow chamber thickness. The image acquisition system is able to record 24 holograms/second. Digital holographic reconstruction coupled to specific algorithmic techniques for object detection permits to obtain the size, projected shape in the XY plane, 3D position, and an estimation of the mean velocity of each flowing object.

Hydrodynamic lift of vesicles and red blood cells

In modelling studies, both experimental and theoretical, a frequently used simple model is giant lipid vesicles, which are made of a simple lipid bilayer with no cytoskeleton (compared to RBCs). This membrane is inextensible, has a low bending energy, and a nearly constant volume in experimental conditions. In our first studies, vesicles were frequently used to validate theoretical models for their flexibility, ease of use, and because their mechanical and geometrical parameters can easily be tuned (size, shape, viscosity of the internal and external medium).

Parabolic flights are an ideal platform for this kind of study : we took advantage of the succession of gravity and microgravity phases to follow this protocol: during gravity or hypergravity, the sample sediments on the bottom plate, providing the initial condition, and in microgravity the suspension is sheared and the evolution of the distance from the wall is recorded. A series of ESA and CNES PF campaigns onboard the A300-ZeroG allowed to scan all possible parameters and check theoretical and numerical predictions with a great accuracy, both for the scaling laws governing lift and the intensity of the lift velocity as a function of mechanical parameters (see fig. 2 for instance).

For red blood cells, one could have expected a different situation. Indeed in physiological conditions, RBCs are tumbling, which means that on average the shape is symmetric with respect to the direction of flow. However, even in that case we measured a non-zero lift velocity, which indicates that the motion is not completely

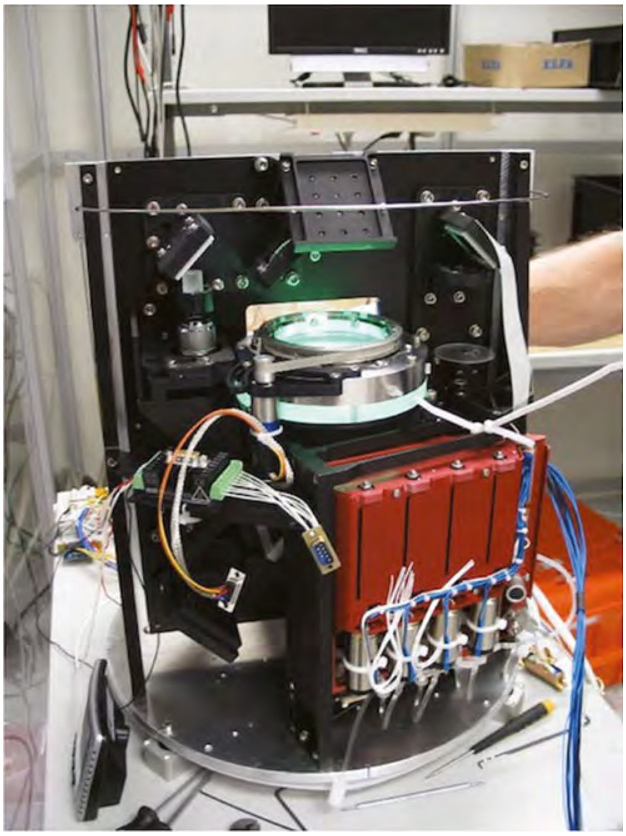

Fig. 1 BIOMICS module used in the MASER 11 flight. The green part is the shear flow chamber with its back illumination (for the overview camera), the red part is the injection device with its 4 syringes and motors, and the black breadboard is the DHM

symmetric, probably due to the deformability of the cell at finite capillary numbers.

When the external viscosity is increased, the lift velocity increases sharply. Our analyses of the orientation of cells in the flow revealed that most of them actually follow a different orbit: a rolling motion where the small axis of the cell is aligned with the vorticity axis. In the shear plane, the motion then resembles the tank-treading motion of vesicles and similar velocities were measured. By combining the unique advantages of microgravity and especially the succession of gravity levels in parabolic flights with a powerful optical technique, we have therefore been able to fully characterize the hydrodynamic repulsion between red blood cells and walls, an essential ingredient of blood dynamics.

Shear-induced diffusion and segregation

Over longer timescales, only accessible on microgravity platforms such as sounding rockets, a balance between lift, which pushes vesicles or red blood cells towards the middle plane between walls, and shear induced diffusion leads to a steady concentration profile. Such experiments were run in the MASER 11 and MASER 12 rockets. Once the equilibrium distribution is reached, the width of the particle concentration profile is directly related to the shear-induced diffusivity, which offers a nice way to measure this quantity.

Interestingly, the sensitivity of the lift - diffusion balance to vesicle or cell size and possible asymmetry in pairwise interactions between objects of different sizes or mechanical properties may lead to segregation in polydisperse samples. This can be seen by comparing the shape of the distribution of small and large vesicles in a bi-disperse sample in fig. 3. While small vesicles alone would show a distribution with a parabolic shape, when big vesicles are also present, a dimple in the distribution of small ones appears at mid-distance between walls, where big ones are concentrated. During an elementary interaction between vesicles of different sizes, the displacement of the smallest one is larger due to an asymmetric interaction which leads to cross-species diffusion terms in the equations. This segregation is actually reminiscent of an observation frequently made in flows of full blood, where platelets, or objects with a smaller sensitivity to lift such as nearly spherical leucocytes exhibit a stronger concentration near vessel walls while red blood cells have a higher concentration near the center of the channel. It is also an interesting track for microfluidic sep- aration technologies where the differences in lift, migration and diffusivities can be exploited for the separation of different species in semi-dilute or even concentrated suspensions.

Outlook

The BIOMICS experimental campaigns have significantly improved the quantitative understanding of basic mechanisms of blood microcirculation and provide input for more accurate models of confined blood flows. In a continuous effort to improve this knowledge and progress towards biomedical implications, interesting perspectives are foreseen. The first one deals with the dynamics of pathological cells. A prominent example is sickle cell anemia, a congenital disease that leads to polymerization of hemoglobin and therefore rigidification and change of shape of red blood cells under low oxygen concentration. An investigation of the hydrodynamic and rheological implications should pave the way to new diagnostic tools for this expanding disease which affects about 50 million people worldwide. Another route deals with the mechanical role of the glycocalyx, a soft layer made mainly of a glycoprotein brush that covers endothelial vessel walls and its influence of blood cell dynamics and blood apparent viscosity. It is known for instance that long space flight leads to a deterioration of this glycocalyx layer, which may be a cause for astronaut circulatory disorders.

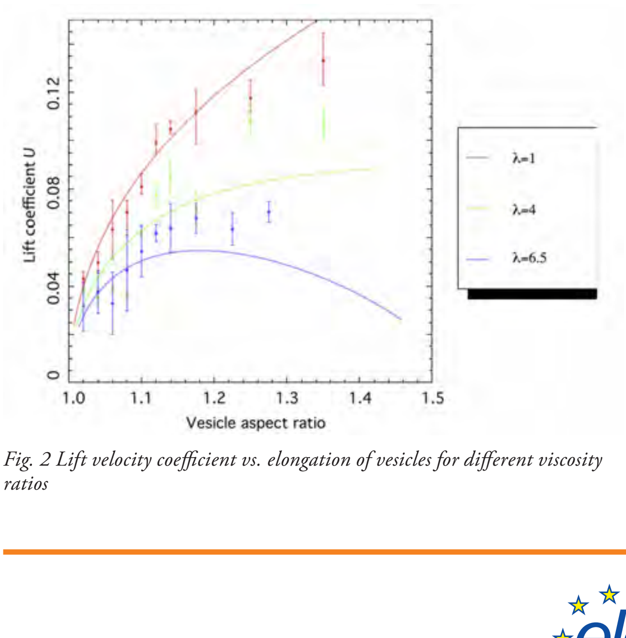

Fig. 2 Lift velocity coefficient vs. elongation of vesicles for different viscosity ratios

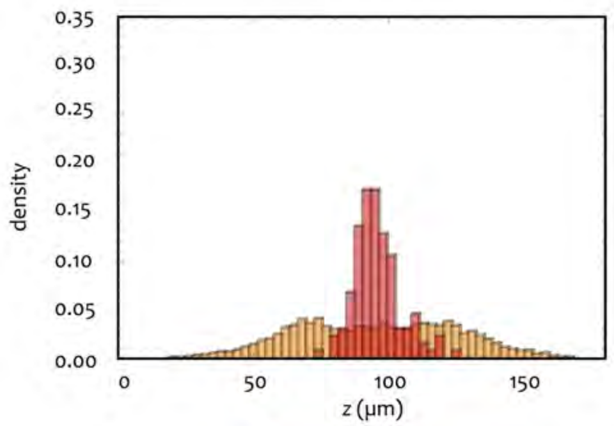

Fig. 3 : Steady distribution of vesicles in the thickness of the shear flow chamber in the MASER 12 BIOMICS experiment with a bi-disperse sample (red: big vesicles 20<R<30μm, yellow: small vesicles 5<R<15μm).

The BIOMICS experiment is the emergence of an ESA Topical Team coordinated by C. Misbah and involving a collaboration between soft matter physicists from LIPhy Grenoble (G. Coupier, T. Podgorski for experiments, A. Farutin, C. Misbah for theory and numerics) and the Microgravity Research Center at ULB Brussels (C. Minetti, N. Callens, F. Dubois). The MASER module was designed and developped by SSC and Lambda-X for the optical part. Continuous support to this project and access to sounding rockets (MASER 11 and 12) and parabolic flight campaigns was provided by ESA and CNES.

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ROSETTA, A QUEST TO UNDERSTAND HOW COMETS WORK

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What is a comet?

Comets are some of the oldest objects in our Solar System. By studying them, we can obtain crucial information about the physical and chemical conditions at the time of formation of the Solar System.

The core of a comet, the nucleus, is a solid body with a diameter of a few kilometers at most. This nucleus is very cold, since these objects typically reside very far from the Sun. The nucleus is thought to consist of a mixture of ices (frozen water, carbon monoxide and dioxide, ammonia), dust grains, and rocks. A comet is therefore often described as a "dirty snowball".

When a comet approaches the Sun, the ice at its surface starts to sublime – it is turned into gas – and this creates a temporary atmosphere around the nucleus. After interaction with solar UV, this gas is progressively ionized. It interacts with the solar wind, thereby creating a bluish ion tail in the anti-sunward direction. The grains and rocks embedded in the ice are set free and they form a whitish dust tail behind the comet, more or less along the comet's curved orbit.

DFMS mass spectrometer © BIRA-IASB

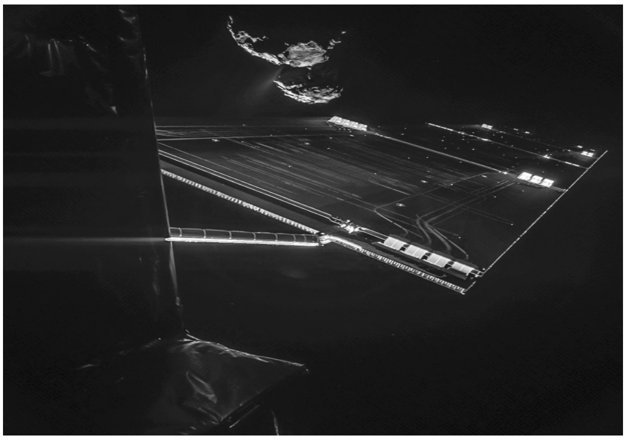

Photo of Churyumov-Gerasimenko and its dust jets taken from the Philae lander while attached to Rosetta, at a distance of 16 km © ESA/Rosetta/Philae/CIVA

Rosetta and Philae – Belgian contribution

Rosetta, launched in 2004, woke up from hibernation on January 20th, 2014. It approached the comet in early August to a distance of 100 km and less. On November 12th it tries to set down the Philae lander on the comet surface – one of the most challenging parts of its 10-year voyage to comet 67P/Churyumov-Gerasimenko.

During the summer of 2014 Rosetta started surveying the comet nucleus by taking detailed pictures of its surface and by measuring the composition of its atmosphere. The Belgian Institute for Space Aeronomy (BIRA-IASB) participates to this mission with a contribution to ROSINA. This instrument package consists of three detectors for studying the atmosphere. BIRA-IASB and its Belgian industrial partners IMEC and OIP have contributed to the construction of the DFMS mass spectrometer within an international consortium led by Uni Bern. The DFMS spectrometer can measure the composition of the atmosphere in exquisite detail. The Belgian Institute for Space Aeronomy was responsible for the development of the detector unit and the associated electronics.

Scientific interest

Apart from the hardware contribution to the ROSINA instruments, BIRA-IASB develops a model of the chemical reactions that take place in the gas that escapes from the comet surface. This model will examine the photo-chemical reactions produced by the interaction of solar UV with the gas. Doing so enables us to trace back the gas composition measured in the atmosphere to the composition of the volatile material on the comet surface.

Rosetta carries the small Philae lander that touches down on November 12th, 2014. The model results will be compared to the direct measurements that will be made by Philae. This comparison will help us to gain insight in the physical and chemical processes that occur near the surface and in the comet's atmosphere.

SCIENCE

ER-BODIES IN ARABIDOPSIS THALIANA SEEDLINGS ARE SENSITIVE TO SIMULATED MICROGRAVITY AND IONIZING RADIATION

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ER-bodies have been for the first time described in root epidermal and cortical cells of *Raphanus sativus* by H.T. Bonnett and E.H.Newcomb [1] as local dilations of granular endoplasmic reticulum cisterns (GER). Later, it was shown that ER-bodies are characteristic for other species of the family Brassicaceae, e. g. *Arabidopsis thaliana*, *Caparis spinosa, Cleome spinosa, Sinapis alba, Thlaspi arvense* producing glucosinolates (ß-thioglucoside-*N*-hydroxysulfates) and other sulfur-containing secondary metabolites [2–7]. Identification of the enzyme ß-glucosidase as the major protein component in ER-bodies [8] attracted a heightened interest to study their formation and function in plant cells. ß-glucosidase (EC 3.2.1.21) catalyses hydrolysis of terminal non-reducing ß-D-glucosil residues with release of ß-D-glucose, and its activity is required for various cellular functions including those of endomembrane systems, apoplast, and cytosol [9]. Now, it is known, that *A. thaliana* genome encodes 47 ß-glucosidases, which are grouped into ten subfamilies [10]. Performed during next years results of genetic and biochemical studies of ER-body biogenesis, functions, and importance in species of the order Brassicales have been summarized and discussed in the recently published review of R.T. Nakano et al. [10]. ER bodies are supposed to be involved in the response to wounding and some biotic stresses, and it is suggested that the possession of ER-bodies should confer a beneficial advantage for plant fitness [10, 11]. On the opinion of K. Yamada et al. [11], the high abundance of ER bodies namely in roots may contribute to the interaction between plants and possible pathogens and herbivores that inhabit soil. It is considered also a possible role of ER-bodies in response to different stresses, including metal-stress response [12,13], as well as it may be involved in cell division and cell wall lignification [14].

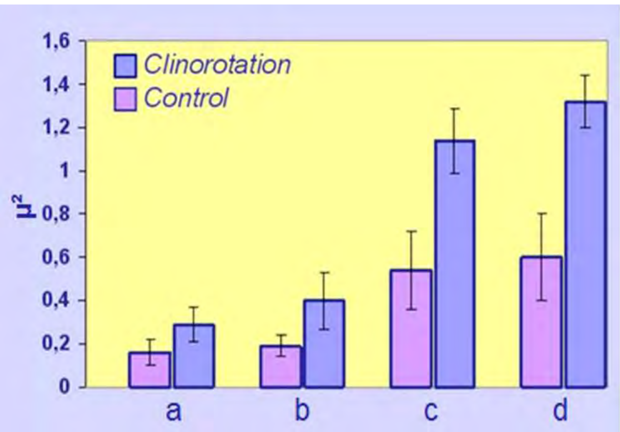

*Fig. 1. Total area of ER bodies per cell section in statocytes (a, b) and in cells of the root distal elongation zone (c, d) of A. thaliana 3- day old (a, c) and 7-day old (b, d) seedlings in control and under clinorotation. *Significant changes between control and experiment (<0.05).*

Recently, it was shown that ER-bodies in *Arabidopsis thaliana* root cap statocytes, epidermal and cortical cells of the root distal elongation zone are sensitive to slow horizontal clinorotation (2 rev/min). Earlier, changes in the endoplasmic reticulum volume and topography in root cells in real and simulated microgravity have been reported [15]. For example, a volume of GER long cisterns oriented parallel both one to another and a nuclear envelope increased significantly in cells of the root distal elongation zone of *Beta vulgaris* seedlings grown under clinorotation in comparison with control [16]. ER-bodies in root statocytes and in cells of the distal elongation zone of *A. thaliana* 3- and 7-day old seedlings have rounded or oval shape on the sections. In the stationary growth conditions, their total area was 0.19 ±0.05 μm^2 per cell in the distal elongation zone in 3-day old seedlings; in 7-day old seedlings, it was 0.60± 0.20 μm^2. Under clinorotation, ER-bodies grew in number and size more twice (fig. 1), their total area per cell was 1.14±0.30 μm^2 in 3-day old seedlings and 1.32±0.25i μm^2 in 7-day old seedlings [17]. Simultaneously, heterogeneity of ER-body

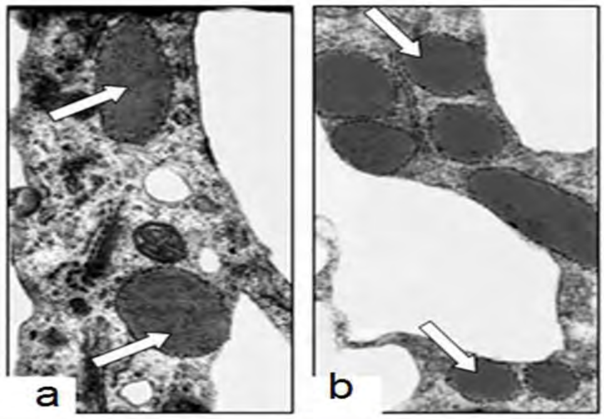

Fig. 2. Fragments of cells in the root distal elongation zone of A. thaliana seedlings. a – control, b – after X-ray irradiation with 0.5 Gy. Arrows show ER bodies. Bar: 1 μ.

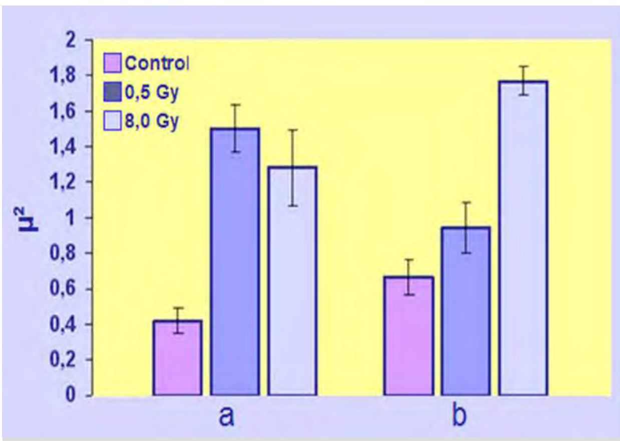

*Fig. 3. Total area of ER bodies per cell section in statocytes (a) and in cells of the root distal elongation zone of A. thaliana seedlings in control and after X-ray irradiation with 0.5 Gy and 8.0 Gy. *Significant changes between control and experiment (<0.05).*

dimension increased, especially in 7-day old seedlings. Unlike the increased volume of ER-bodies, a ß-glucosidase activity did not change under clinorotation.

It was suggested an opportunity to utilize *A. thaliana* as a biodosimeter by tracking the physical changes of irradiated species over time [18]. In this connection, we performed the study of ER-bodies in roots of *A. thaliana* seedlings irradiated by X-rays in doses 0.5 Gy (fig. 2), and 8.0 Gy on the X-apparatus RYM-17 with a dose rate 0.43 cGy/sec (Russia). As under clinorotation, ER-body number and area per cell in the distal elongation zone grew with radiation dose increasing (fig. 3). It was also established by using PCR that ß-glucosidase gene expression rose under clinorotation and X-irradiation in comparison with control, especially under increased term of clinorotation and irradiation dose.

All together these data, it may be suggested that the detected behaviour of ER-bodies under clinorotation and X–irradiation confirm a general rule for intensification of catabolic processes in cells in response to the influence of unfavourable factors, that provides organism resistance and adaptation, as ß-glucosidase belongs to hydrolases (EC 3.2). In addition, the absence of enhanced ß-glucosidase activity under clinorotation but increased gene expression indicates that this enzyme may contribute to cell protection in response to the unfavourable abiotic environment. Therefore, it is of great interest to further elucidation of the ER-body significance in plant tolerance not only to biotic stress but also to altered gravity and ionizing radiation by using corresponding mutants and the methods of cell and molecular biology.

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DUST ACTS AS GIANT GAS PUMP ON MARS
NEW RESULTS FROM DLR PROJECT 50WM 1242

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Introduction

As a terrestrial planet and our next neighbor, Mars is a planet of high interest for us. It shares many geological and physical processes with Earth, as well as it is the only planet in the Solar System with a low atmospheric pressures of a few millibar (ref 1).

In microgravity experiments we found out that the tenuous atmosphere in combination with the incoming sunlight on the dusty surface of Mars offers a unique transport mechanism for gas, not only above but within the Martian soil (ref 2). The observation of this gas flow delivers new possibilities of gas transport, where until now only diffusion was considered. Based on thermal creep this gas flow is calculated to pump gas with cm/s through the soil on Mars.

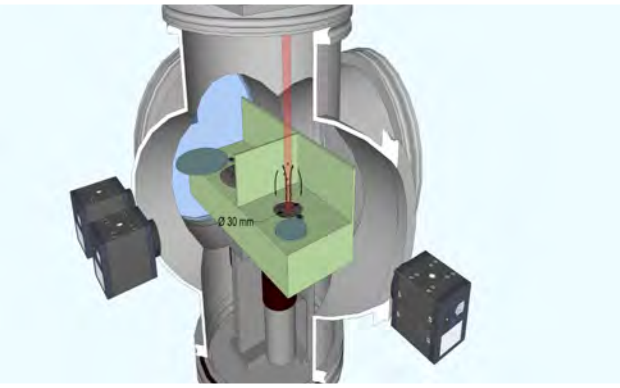

Figure 1 Vacuum Chamber

Experiment

Of great importance for this experiment was the chance to perform it in the Bremen Drop Tower, where it was weightless for about 9 seconds in catapult mode. The heart of the experiment is a vacuum chamber (fig 1), evacuated to a few millibar and with a dust bed placed in the middle of the chamber. The dust bed has a depth of 2 cm, a radius of 3 cm and it consists of Basaltic dust grains with sizes ranging from 1 to 125 µm.

The sample is illuminated by a red laser (655 nm, 8 mm spot diameter, 13 kW/m²) from above and tracer particles, moving due to the gas flow, can be observed by cameras from the side.

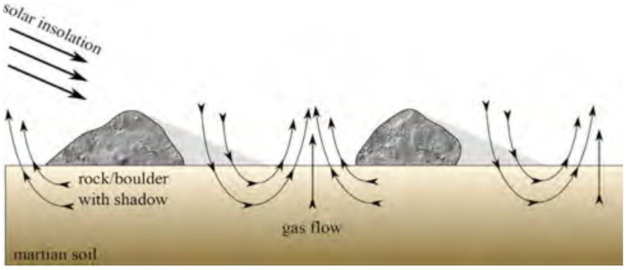

Figure 2

During the catapult launch and at the end of each microgravity experiment the setup is exposed to svere accelerations. To avoid sample loss due to these accelerations, the dust bed could be closed by a lid for catapult launch and the final deceleration.

Because of a light induced temperature gradient within the dust, thermal creep occurs and gas is transported within and above the dust bed. This can be observed by the camera as the dust particles leaving the surface follow particular streamlines.

Additional computational simulations show that the gas flow reaches even centimeters into the dust, with velocities on the order of cm/s and is therefore significantly more effective than diffusion, which was known to be the only transport mechanism of gas on Mars.

Other Benefits

Not only the gas flow within the dust bed can be observed by the camera, but the experiment as well offers even more scientific space: After closing the lid, moving particles are decelerated by gas friction in the chamber and therefore suspended over the dust bed within the laser beam. Now photophoretic forces act on the micron sized particles, moving them in the laser beam. These forces can be observed and measured within 1 second between closing the lid and landing of the capsule (ref 3). This can be used as a transport mechanism for dust grains in protoplanetary disks.

Another benefit is the obvious possibility of lifting dust on Mars, helping to understand a little bit more of the unsolved problem of the dust rich atmosphere and aeolian processes like dust storms.

Results

Where the sun heats up the surface of the Red Planet, a temperature gradient within the heated soil leads to a gas flow from the cold layers below to the heated surface above (fig 2). Because of the resulting pressure difference in the ground, gas from shadowed places will be soaked down into the soil and will be pumped up again.

We proved this concept in microgravity experiments where thermal convection is known to be absent. Beside implications for the cycle of dust and the cycle of carbon dioxide, the greatest application of our work is a big step in understanding the global cycle of water on Mars –for instants the rate of water vapor transport through the dust surface on Mars, which determines the timescale of the existence of ice in the subsurface.

PLANTS IN SPACE: GRAVI-2 EXPERIMENT

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Abstract

Gravity is considered to be an important environmental factor in the orientation of plant growth. In the case of roots, signal gravity is perceived by specialized cells located in the root apex and, so called statocytes. Even if it is well known that the movements of amyloplasts (located in the statocytes) induce a series of signalling pathways, the role of amyloplasts displacement is not clearly elucidated. The objective of the GRAVI-2 project is to study the impact of amyloplasts displacement on the calcium-dependant pathways and thus, better understanding the gravity perception in lentil roots. The Gravi-2 experiment was launched on flight SpaceX3 in April 2014 (http://lensesinspace.wordpress.com/) and was performed on-board the ISS in May 2014 with EMCS (European Modular Cultivation System). Lentil seeds were germinated on the International Space Station (ISS) in different situations: (1) continuously in microgravity conditions (*e.g.* 10^{-4} g), (2) 10^{-2} g during 8 hours after a growth period of 23 hours in microgravity, (3) 2g during 5 minutes after a growth period of around 31 hours in microgravity, and (4) 2g during 15 minutes after a growth period of around 31 hours in microgravity. The studies will be performed using complementary approaches including the analysis of amyloplast positioning, calcium localisation and the level of expression of genes.

1 Scientific context

Plants have the ability to sense and to re-orient their growth in response to various stimuli including light, gravity, wind, humidity and mechanical stimuli. The response of a plant organ to a directional stimulus is called tropism. Even the magnitude of gravity seems to be constant on the surface of the earth, its direction and its magnitude might be affected by various factors like for example, wind for the stems and soil parameters for the root system. Therefore, gravitropism can be regarded as a crucial factor in the posture control of stems (Moulia and Fournier, 2011) and in the penetration for roots into the soil (Roy and Basshamm, 2014).

In roots, specialized sensory cells (called statocytes) located in the root apex perceive signal gravity. Upon a gravistimulation, a change in the polarity of cell perceiving gravity signal was observed with an amyloplast sedimentation on the peripheral side (Perbal and Driss-Ecole, 2003). Transduction pathways were immediately activated with changes of calcium-dependant pathways. In parallel, many studies have demonstrated that cytoplasmic free Ca^{2+} concentration is affected by environmental stimuli. The regulation of this homeostasis involves a series of transduction events such as the synthesis and activation of calcium binding and targeted proteins including calmodulin proteins.

2 The objective of the GRAVI experiment:

In this first part of GRAVI experiment (GRAVI-1), the threshold acceleration and the presentation dose of the gravitropic reaction of lentil (*Lens culinaris* L. cv. Anicia) seedlings grown in microgravity (Driss-Ecole et al., 2008) were determined. Following a period of growth in microgravity conditions, seedlings were subjected to low accelerations for several hours. During root growth, the root orientation and curvatures were followed by time-lapse photography combined with still images downlinked in near real time to ground. The position of the root tip and the root curvature were analysed as a function of time. Based on this, the GRAVI-1 team observed that the embryonic root curved strongly away from the cotyledons (automorphogenesis) in microgravity, and then from 17 hours to 30 hours slowly straightened out (autotropism). The threshold acceleration perceived by the roots was found to be around 2×10^{-3} g (Driss-Ecole et al., 2008).

Considering the results obtained from GRAVI-1, GRAVI-2 aimed to investigate the response of the lentil root curvature as a compromise using threshold levels between 0.01g and 2g. Since calcium is considered to be an important second messenger involved in root gravisensing, the Ca^{2+} localisation in statocytes will be in focus and related to the positioning of the amyloplasts. The regulation of calcium-downstream gene expression will be analysed.

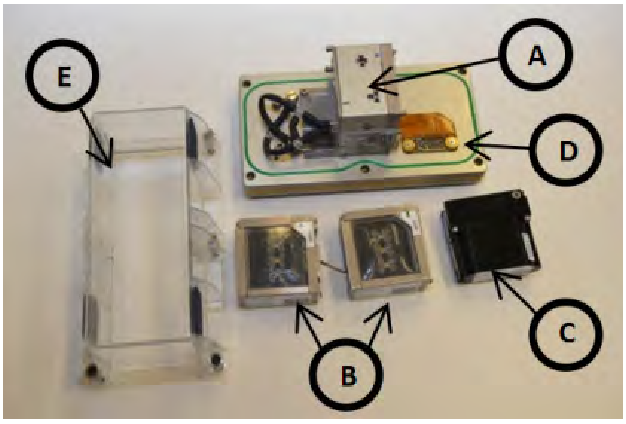

Figure 1a: The Gravi2 EUE consists of the Handler (A), the Culture Chambers (B) and the Fixative Unit (C). The EUE is mounted on the baseplate (D). The cover (E) and the baseplate (D) represent the Experiment Container.

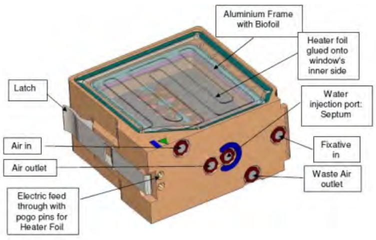

Figure 1b: A detailed overview of a Culture Chamber including locations of the various penetration units.

3 Hardware and equipment

Both the GRAVI-1 and the GRAVI-2 experiment hardware were designed for integration into a dedicated Experiment Container (EC). The EC is developed to support biologically experiments inside the EMCS, a rotor based facility with 2 centrifuges and 8 exchangeable ECs. The main features of the EMCS include automatically operated life support systems (airflow, water, light and temperature) as well as a gas scrubber. The centrifuges allow for a controlled speed from 0-2 *g*, while the EMCS cameras provide video and pictures during the experiment runs.

The Gravi2 experiment unique equipment (EUE) includes the handler; each holding two separate Culture Chambers (CCs) and a Fixative Unit (FU) (Figure 1a and 1b). The EUE's electrical connection and atmosphere uses the EC base to interface with the EMCS Holding Structure.

The culture chambers contained 24 lentil seeds each, arranged in a linear fashion and kept in place by seed holders. The Fixative Units enclosed 38 mL of chemical fixative each; the chemicals were prepared and filled into the FUs while on ground. The handler is the interface between the CCs, FUs and EC baseplate and provides some very important functions. First of all, fixative and air interactions were operated via the penetration units (needles) inside the handler. Secondly, the handler electrical pumps allowed the chemical fixation to take place while the ECs were still on rotor and during various gravitational stimuli.

4 Scenario

The experiment specific goals are addressed in the design of two runs (Figure 1). Four fixatives with different science objectives for analysis are used:

Fix #1: Analysis of amyloplast redistribution and cell ultrastructure using transmission electron microscopy.

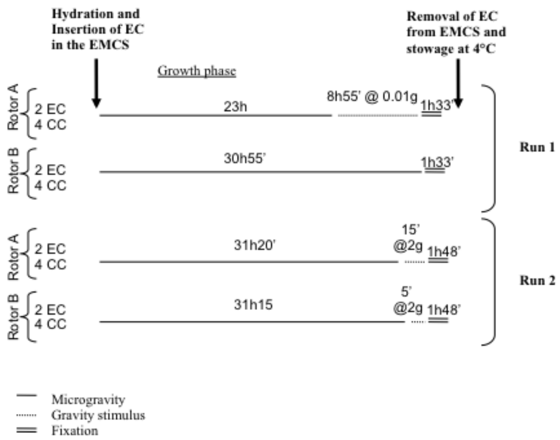

Figure 2: *The time line of GRAVI-2 experiment as performed in the European Modular Cultivation System (EMCS) on the International Space Station (ISS). The experiment initiated by a manual hydration of the Lentil seeds followed by an automated series of events including gravity stimuli and automatic fixation of samples in the centrifuge. At the end of the experiment, the astronaut removed the Experimental containers (EC) from the EMCS and then stored the Culture chambers (CC) at 4°C until the root sampling at Toulouse.*

Fix #2: Studies of protein localisation using immunolocalisation methods in light and electron microscopy.

Fix #3: Analysis of the localisation of free Ca^{2+}

Fix #4: Analysis of the level of target gene expression.

The Experiment Containers, the GRAVI-2 EUE and syringes prefilled with water for hydration, were packed and launched to the ISS. Crew initiated the experiment by manually injecting 4.5 mL of water into each CC, followed by the assembly of the hardware. The assembly took place inside the Biolab Glovebox, due to hazard level 2 of some of the fixative solutions. The fully assembled ECs were inserted inside the EMCS and the environmental control started (airflow and

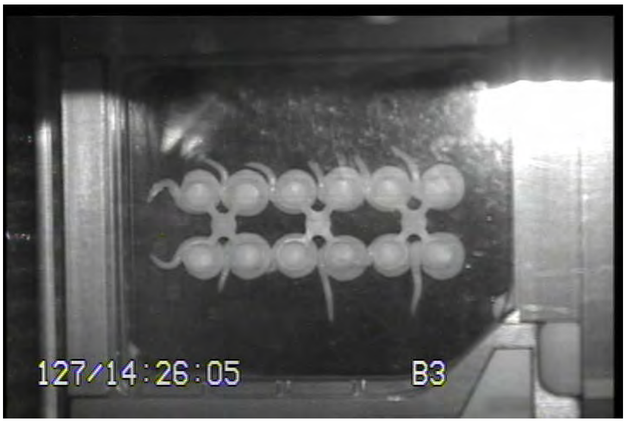

Figure 3: *One picture obtained after 31 hrs of growth in microgravity (run 1)*

temperature). Pictures of the lentils from all CCs were taken every 20 minutes during the growth period that lasted approximately 30 hours,, see timeline (Figure 2) for details

5 Conclusions

The GRAVI-2 operations were successful performed. Regarding the root growth, as expected and observed during the GRAVI-1 observations (Driss-Ecole et al., 2008), the embryonic root curved strongly away from the cotyledons, so called automorphogenesis (Figure 3). In some of the seedlings the root straightened out slowly (autotropism).

Microscopic and RNA-analyses on the samples started after the sample processing. First observations indicated a good preservation of the fixed tissues, as well as a good RNA fixation. The next step is to detect possible differences between the 4 gravitational exposures (0 g, 0.01 g, 1 g and 2 g).

Acknowledgment: *the astronaut who has very carefully and successfully carried out our experiment in space; the N-USOC team for its considerable help in the preparation of the GRAVI experiment and for its technical support during the carrying out the experiment in ISS; Airbus team for the design and building of the hardware and control of EMCS during the experiment. This work should not have been possible without the scientific and financial support of ESA and CNES. The scientific team thanks G. Perbal and D. Driss-Ecole for invaluable advices; J. Franchel, N. Brunel, E. Bretecher (University of Clermont-Ferrand) and GSBMS team (University of Toulouse) for technical support.*

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SPACE RADIATION AND PARTICLE EFFECTS ON THE IMMUNE SYSTEM AND DEVELOPMENT OF EPIDEMIES

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Abstract

Solar (w) and geomagnetic (Kp Index) activities can influence virus-host interactions and immune response in animals, provoking influenza epidemics. To verify this supposition, we have analyzed the influenza incidence and space weather data from periods 2009 to 2013 . Influenza-related data for 29 countries from 6 continents, have been studied to find the relation between influenza epidemic and space activity, including solar activity (solar radiation 10,7 cm, wolf number) and geomagnetic activity (kp-index).

Obtained results suggests that Space weather factors (Solar radiation, geomagnetic field fluctuations, etc.) are not an "electrical switch" which cause an immediate response, but rather a primer which initiates hidden long-lasting processes. Evident results of such hidden activity can manifest years after the onset of the causative cosmic/solar event.

Introduction

In the history of human beings, there has been numerous epidemics that killed a great amount of people. In recent centuries, the most serious epidemics was the devastating Spanish Influenza in 1918-1920. To achieve this we need better understanding of the epidemics predisposing factors including environnemental ones. Recents studies indicate that space weather's changes in heliogeophysical conditions can negatively affect ecological and biological systems, including human health and all kinds of human activities. Influence of space weather has been hypothesized. To investigate this issue we decided to compare the temporal changes of space weather factors (solar and geomagnetics indices) with epidemiological data concerning Influenza.

1) Material

The Geophysical DATA have been registered from Royal Observatory of Brussels (1):

- Solar radiation 10.7,
- Geomagnetic Index R(t),
- Wolf number (W(t),
- aa Index aa(t),
- Kp Index (Kp(t)

Data from influenza incidence from 1917, 1921, mortality data each week in Indiana State (USA)

For 2009, 2013 the number of patients diagnose with influenza.

2) Method

The Methode consist to compute of the Space Weather and the Data Influenza, cross correlation beetween the Data and the lag correspond to the five phase of the zoonotic disease emergence pathogene from animal to human.

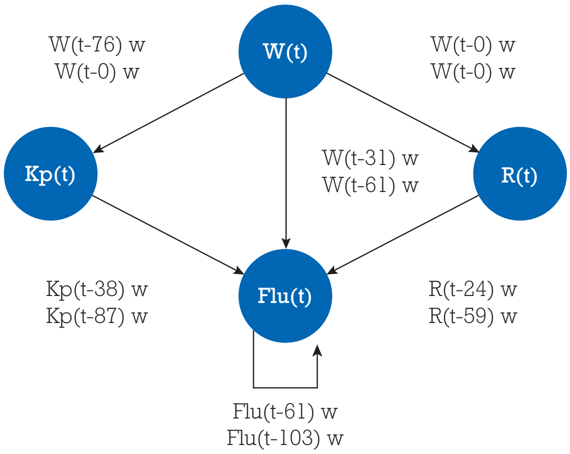
Phase Exclusive propagation to animals

Phase primary Human to infection and animal to human transmission

Phase Human to Human Transmission

Phase sustained Human to Human transmission

Phase Exclusive to Human



Interaction Graph between environemental Space Weather factors (R: solar Radiation, W: Wolf number, Kp: geomagnetic activity) and influenza (w: weeks)

The transfert from one phase to another take a lag that will be estimated by computation of the significative lag in the different Cross Corelation function by using the Matlab Poft function

This estimate the period between mutation due to influenza emerging to maximum or minimum of solar activity [2].

3) Results

3.1) Solar activity incidence

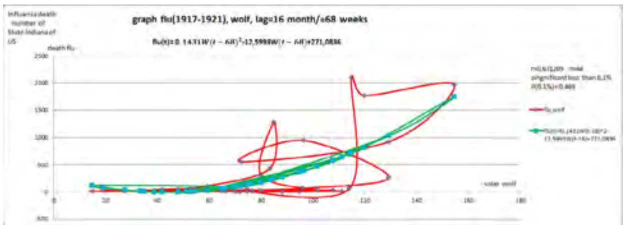


Fig 1: fitting of wolf and flu, lag=16 months ≈68 weeks 1917-1921

Table 1: wolf, flu 1917-1921 lag=16 months ≈68 weeks			
flu(t)= 0,1431W(t-68)² –12,5993W(t-68) +271,0836			
n=44	τ=19 months(68 weeks)	r=0,671209	P(0,1%)=0,469
Significant less than 0,1%			

We observe an obvious relation between wolf number and Spanish Flu activity. The coefficient of correlation of the formula of fitting is extremely significant: 0,671209.

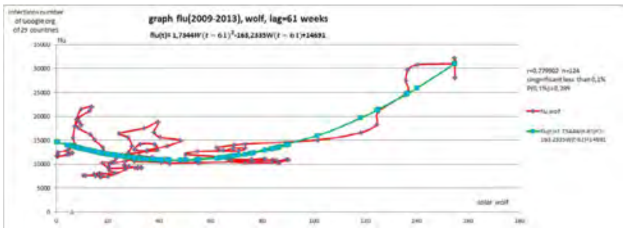


Fig 2 : fitting of wolf and flu, lag=61 weeks

Table 2: Wolf number, Flu 2009-2013 lag=61 weeks			
flu(t)= 1.7344 W(t-61)² –163.2335 W(t-61) +14691			
n=124	τ=61	r=0,779902	P(0,1%)=0,289
Significant less than 0,1%			

3.2) Solar radiation influence

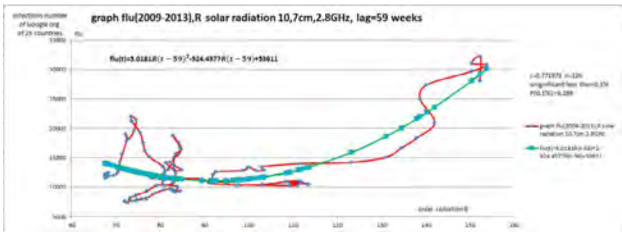


Fig 3: fitting of Solar radiation and influenza morbidity, lag=59 weeks

Table 3: Radiation 10,7cm, Flu 2009-2013 lag=59 weeks			
flu(t)= 5.0181 R(t-59)² –924.4377 R(t-59) +53611			
n=126	τ=59	r=0,771973	P(0,1%)=0,289
Significant less than 0,1%			

Results presented on Figure 3 and in Table 3 r=0,772 suggest that the most significant lag is at 59 weeks, and there is an obvious relation between influenza incidence and solar activity.

For the period 2009 2013 a 38 week lag can maybe represent the fact that the epidemic propagation develop in a much important population due to a human mobility much faster an increase than the 1918 one (lag 59 and 61).

3.3) Geomagnetique influence

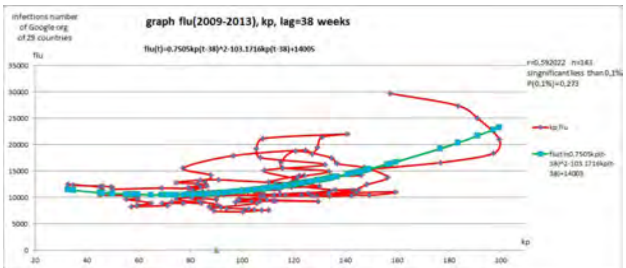


Fig 4: fitting of kp and flu, lag=38 weeks

4 Discussion

Among the classical factors admitted in accelerating the transmission of pathogens from animals to humans there are close contacts between animals and humans during hunting, trading of animals foods, animals husbandry practices, wet markets, domestication of animals or exotic pets, that provide high pathogen transmission and mutation probabilities. Among other important reasons there are bad or no hygiene, deficient immune response to pathogens and the action of the solar and cosmic background activity that is acting permanently on Earth since and before life appeared. The computation demonstrate that its action is well correlated with the increase of solar activity and the decrease at minimum of it.

It seems that virus mutations will increase dramatically at certain stage of the " Space Weather " and also the immune response of human will be affected as a preponderant factor combined to the others [2, 3]

Obtained results suggests that Space weather factors (Solar radiation, geomagnetic field fluctuations, etc.) are not an "electrical switch" which cause an immediate response, but rather a primer which initiates hidden long-lasting processes. Evident results of such hidden activity can manifest years after the onset of the causative cosmic/solar event., These factors are the globalization of the transport, the increase of the population and the acceleration of the mutagenesis and cross species transmission of the virus.

5 Conclusion

Growing evidences show the influence of the magnetic field sensing capabilities in many types of cells including human cells, cells in other animals, birds and insects[4,5]. This fact explains bio-regulatory effects of the geomagnetic field which become disturbing during such called geomagnetic storms caused by potent cosmic plasma flows originated from solar flares and other rays. People with compromised homeostasis-supporting systems (immune, hormonal, and others) become sensitive to such magnetic storms that manifests by different exacerbations from weak headache to heart attacks and stroke. Among negative consequences of frequent geomagnetic field disturbances there is immunological dysfunction which results in epidemic spread of virus and bacterial infections. Such correlation between increasing rate of geomagnetic storms (during periods of maxima in solar activity) through the Cryptochrome and epidemics has been demonstrated in numerous retrospective studies [6]

Indeed, during years of maximum solar activity, the number of severe geomagnetic storms increase. But statistical analysis of Data on background geomagnetic storms per year and solar activity showed that during solar maximum years there is typically a double peak in the frequency of geomagnetic storms [7]

- During the maximum of spot number, the average of geomagnetic storms appears at minimum,
- With the declining phase of the solar cycle the geomagnetic activity is more noticeable.

Maximum quantity of geomagnetic storm is marked ahead about 2 years prior/or at sunspot maximum and about two or three years after the maximum of solar activity, what we observe Influenza (flu).

In a previous paper we have introduced in the Model Flu - W (solar activity), the derivative of W, dW : Flu = 6.2014 W + 3.209 dW + 24.92 that pointed out the importance of the period Min-Max and Max-Min of the sun activity on intensity of influenza circulation in human population (Data from 1750 to 2000 SWPC Space Weather Operation) [8].

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ABOUT ELIPS AND ISS EXPLOITATION

ISS RESEARCH ACTIVITIES: OVERVIEW OF SCIENCE ACTIVITES DURING EXPEDITIONS 40-41

ESA research on ISS was on-going during Expeditions 40-41, the vast majority of which encompassed the Blue Dot Mission with ESA astronaut Alexander Gerst. Expedition 40 started in the night of 13-14 May 2014 with the undocking of Soyuz 37S, and Expedition 41 concluded on 10 November with the undocking of Soyuz 39S, bringing Gerst and his fellow crew members Maxim Suraev (Roscosmos), and Reid Wiseman (NASA) back to Earth. They had been on the ISS since 29 May as part of the six-member ISS crew.

The Expose-R2 facility was successfully installed outside the Russian Service Module of the ISS during a Russian spacewalk on 18 August. Prior to the external deployment the new sample trays with the three ESA experiments (BIOMEX, BOSS and PSS) and one from IBMP in Moscow (IBMP) arrived on Progress 56P in July. The space exposure experiments could help understand how life originated on Earth and survivability of samples to conditions on for example Mars, the Moon and in other astrophysical environments.

During the Blue Dot mission a number of logistics vehicles carried a broad range of resupply items and research payloads to ISS. The Electro Magnetic Levitator (EML) and a first batch of 18 samples arrived the ISS on ATV-5. The EML installation inside the European Drawer Rack by Alex Gerst and the subsequent on-orbit commissioning was concluded. The EML will perform container-less materials processing involving melting and solidification of electrically conductive, spherical metal alloy samples, under ultra-high vacuum and/or high gas purity conditions in order to acquire benchmark data for industrial casting processes.

Unfortunately in the Orbital-3 launch accident ESA has lost at the end of October the 2 payloads DCMIX-3 (Soret diffusion in crude oil mixtures) and GRIP (dexterous manipulation) which will need to be reproduced.

The new PK-4 payload for cold plasma research was successfully launched on Progress 57P in collaboration with Roscosmos and will be installed in Columbus in the EPM rack.

Alex Gerst and his ISS crew mates have performed a large ESA experimental programme of more than 30 experiments in human research, space biology and astrobiology, fluid physics, material sciences, space physics, technology and education/outreach. In the following just a few recent research highlights are mentioned:

Non-ISS Research in ELIPS

Parabolic Flights

The 61st ESA Parabolic Flight Campaign was successfully conducted in September with 11 experiments, 5 in Physical Sciences, 5 in Life Sciences and one exploration technology test. This was the last ESA flight campaign with the A300 aircraft which will go out of service at the end of the 2014. First test flights of the Airbus A310 which will replace the current A300 aircraft showed excellent performance and a good microgravity quality. A first joint flight campaign with CNES and DLR planned for April 2015.

Drop Tower

9 drop campaigns (97 drops) for 3 different experiments (*Slug Boiling, G-DWS, SOUND*) have been already performed in 2014; the *MICE* experiment campaign is still planned. 1 of 2 student proposals (*FELD*) has been selected within the DYT call and will be performed in November.

Concordia

The 2014 winter-over crew has performed 8 ESA experiments at the Antarctic station Concordia during the isolation phase since February until November.

For the upcoming campaign the Concordia crew members have been trained and the BDC has been performed at EAC and :envihab for 5 experiments (4 new from AO2013).

Two human research experiments from AO-2013 will be performed during this upcoming winter-over season with the British Antarctic Survey.

Research Anouncements

Two specific Announcements of Opportunities (AOs) were released on 1 October 2013:

- Bedrest AO-2013 for a long-duration (60 days) "head down" study. The foreseen countermeasures protocol that will be tested is a nutritional supplementation with a "cocktail" of anti-inflammatory, anti-oxidant substances.
- Concordia AO-2013 for new isolation experiments in Antarctica from 2015 onwards.
- Both AOs closed on 6 January 2014 and received 50 and 29 scientific proposals out of which PB-HME formally approved in May 2014 the selection of 16 and 10 proposals, respectively.

The Continuously Open Research Announcement (CORA) for Ground Based Facilities, Drop Tower and Parabolic Flights has attracted a large number of research proposals with a quick turnaround on the peer review and selection decison.

ESA has issued in spring 2014 together with NASA, JAXA and CSA the International Life Science Research Announcement (ILSRA-2014) which is jointly soliciting new life science projects on ISS for the time frame between 2016 and 2020. The AO closed on 23 May 2014 and 112 proposals led by European scientists were submitted (which is by far the majority of total of all 204 proposals). 45 of the European proposal have successfully passed the international peer review and now undergo a complementary first implementation feasibility assessment in prior to the presentation of the formal selection proposal to the Programme Board in spring 2015.

Programmatics

A proposal for complementary activities in the ELIPS-4 programme has been presented to delegations and is now up for decision at the ESA Council at Ministerial level on 2 Dec for additional subscriptions by the 15 participating countries in ELIPS period 4 in order to reduce the funding shortfall of 46% (170 MEuro). This will eventually allow to complete the full development of a variety of new ISS research payloads in due time for a continuous full scientific exploitation of the International Space Station.

Strong support recommendations for ELIPS have been provided by the European Space Science Committee (ESSC), the Human Exploration Science Advisory Committee (HESAC) to the HME Programme Board and the High Level Space Policy Committee (HiSPAC) to the ESA Director General.

FROM TOPICAL TEAMS

"ADVANCED COMPOUND MICROSCOPY FOR MICROGRAVITY RELATED RESEARCH: FROM MOLECULES TO ORGANISM MORPHOLOGY"

Progress in life sciences strongly depends on the availability of sophisticated techniques. One field of technological innovations with strong relation to research in life sciences is microscopy. The last 30 years saw a wealth of novel techniques being introduced into microscopy. Spatial resolution beyond the diffraction limits allows to see the very small approaching resolutions hitherto restricted to electron microscopy, time resolved fluorescence images and measurements can be used to show molecule interactions at well resolved sites within cells and tissues, cameras with very high sensitivity reduce phototoxicity what is of high significance in all fluorescence based methods and in micro-cinematography, interferometry provides information of changes in mass and fast high resolution 3-D imaging provides new insights in developmental biology.

Researchers at the Sasbachwalden meeting on "Scientfic evaluation and future priorities of ESA´s ELIPS 3 programme" held in April 2008 were aware of these achievements and concluded: *"Hardware development is seriously delayed, namely the development of advanced microscopy systems. This is severely hampering progress in biology… ESA is asked to increase the hardware development process based on the urgent needs of the scientists."*

Finally LSWG and FTAP adopted this proposal and established a TT on "Advanced Compound Microscopy for Microgravity related Research" in July 2012, chaired by Jürgen Bereiter-Hahn (Goethe University Frankfurt) and David Jones (Philipps University Marburg), up to 40 scientists became involved.

In addition, ESTEC offered an AO to develop a ground demonstrator of a general cell culture observation system allowing live-cell observation of adherent and non-adherent, mammalian and non-mammalian cells: General Cell Culture System (GCCS) - Optical System and Interface. Intensive contacts between members of the TT and the GCCS-group merged the ideas for the development of a bread board system.

The TT members have met twice: 1st meeting at the Buchmann Institute in Franfurt/M 12-13 Jan. 2013, 2nd meeting in Seeheim-Jugenheim 24-25 Jan. 2014 and then reported to ESA.

The first meeting was dedicated to a collection and evaluation of microscopic techniques and their possible role in gravity related research in life sciences. Furthermore the question was raised what could be the future scientific challenges to be solved using advanced microscopy. It was a general agreement that constructing new instruments has to start from the needs of science. After the first workshop an intensive discussion started via email and phone conferences (contributors were: G. Dunn, W. Grill, P. Kern, P. van Oostfeld, D. Jones, F. Wouters, P. Schiller, E. Stelzer, J. Bereiter-Hahn, P. van Loon from the TT, C. Schwarz, from ESA and D. Beghuin, W. de Vos from Lambda X). In addition a questionnaire has been sent out to TT members and other scientists known to work in space related life science research to notify their microscope technical needs. Because a microscope system will not only be used in life sciences this report is provided to the PSWG as well and asked for their comments.

A dispute started on two alternatives, whether a high–end microscope should be developed which will be used for many experiments: the samples are moved to the microscope – or this was the second alternative - a small and cheap microscope should be developed which will be used one for each experiment. The latter approach was termed "microscope farm". One of the reasons in favour of the mic farm development was the concern about statistically insufficient numbers of experiments in most projects exposing cells or organisms to altered gravity.

The planned instruments should be flexible and give the possibility to adapt the set-up in accordance with the last advancement of science and technology, e.g. those shown in a recent paper published in Nature Photonics that nicely illustrates how the hybridization between optics and computers not only generate a confocal microscope, a FSIM, a SIM but also an extra wide field microscope. If this is further expanded by non-linear optics we can expect more break-throughs in the future.

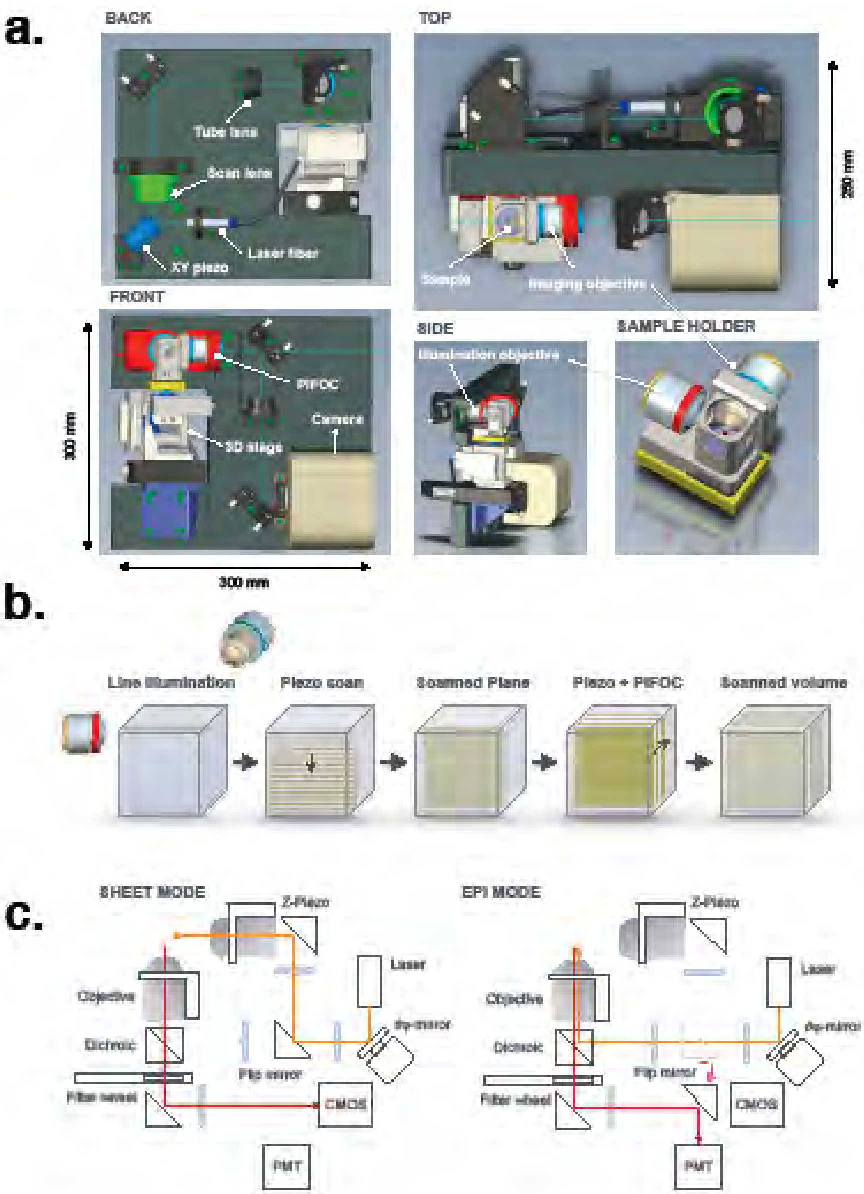
A question which should be treated independently whether a microscope farm or a single high end microscope is envisaged, was the decision which of the presently developed microscopic methods serve best the requirements of future research. Two principles were agreed to be of outmost significance LSFLM and SIM. Both systems have brilliant 3D imaging qualities. The LSFLM is the superior system for life cell imaging especially regarding the low light levels and fluorochrome bleaching. This is one of the unique points for the LSFLM. Discussing superresolution we have to consider that conditions for microgravity and for 3-D sample observation are not supporting superresolution, however, molecular interactions within nm-range may be shown via FLIM.

Starting from scientific problems we considered that prolonged exposure of humans to microgravity evokes a series of physiological and morphological changes. Reduction of cancellous bone and of immune system responsiveness or increase of ocular pressure are generally assumed to represent typical alterations. However, because of the complex environment, microgravity acts in parallel to a variety of stress factors. Whether microgravity is the key factor for these alterations still is under debate. No such an uncertainty exists for cells and organs which are "professionals" in gravity sensing as are some Protists and plant cells. The need for extended and critical evaluation becomes even more significant if we consider that most of the experiments with cell cultures done hitherto were using 2-D cell culture models. Cell behaviour in a 3D-environment differs widely from that on a flat surface. Until recent methodological restrictions by microscope developments did not allow for studying cells in 3-D cultures exposed to microgravity or hypergravity.

The ***second workshop*** therefore served a twofold goal: 1. To identify mammalian cell systems which can reasonably be hypothesized that microgravity is an important factor influencing functions, like interaction of immune cells with each other, growth of tumors or special cases of embryonic tissue or organ development.

2. If valid scientific goals have been identified, the question arises which microscope techniques (and others) are required to solve the problems in a timely manner.

Starting from **scientific questions** considered to be of significance for future gravity-related research some topics have been described which should be accessible by a new microscope system functioning under microgravity as well as on a centrifuge. These



Legend to Figure

Digitally Scanned Light-Sheet Microscope (DSLM) concept for biological space research. (a) 3D model of a compact DSLM with orthogonal illumination setup including sample holder, visualized from different angles. (b) DSLM illumination sequence: the illumination objective rapidly scans a laser line through the sample in the axial direction, thereby generating an illumination sheet. This illumination scheme is combined with a rapid displacement of the sample using a piëzo-driven three-axis motorized stage and synchronized movement of the objective by a piëzo-driven nano-positioning focus device (PIFOC). The combination of axial scanning and lateral displacement allows for sampling the complete volume; (c) Schematic illustration of the DSLM light path, equipped with a flip-mirror to allow switching between sheet illumination and CFM mode using the same equipment.

(From: Winnok H. De Vos, Didier Beghuin, Christian J. Schwarz, David B. Jones, Jack J. W. A. van Loon, Juergen Bereiter-Hahn, and Ernst H. K. Stelzer.: Invited Review Article: Advanced light microscopy for biological space research. Review of Scientific Instruments 85, 101101 (2014), with permission) topics are derived from discussions at the two workshops of the TT and from the results of a questionnaire sent to all TT members and additional scientists known to have experience in gravity-related investigations. The scientific topics include:

1 organotypic culture (difficult under space conditions): 3-D monocell and co-cultures in collagen, hydrogel;
2 determinations of substance production (e.g. antibodies, cytokines, ECM, signaling proteins);
3 cell – cell interactions and communication including cell migration, cytoskeleton dynamics;
4 lymphoid organ development (either in isolated lymph node pieces or in transparent living animals i.e. Xenopus tadpoles);
5 Cell cycle progression of immune cells;
6 Primary molecular mechanisms within cells (e.g. integrin rearrangements, actin dynamics, DNA repair, ion channels (mechanosensitive)- distribution and expression);
7 Application of the microscope in physical chemistry has also to be considered. Hereby molecular interactions and particle movements may be of major interest.

From these fields of interest **parameters** have been identified which are important to test scientific hypotheses and to describe cell and organism reactions:

1 3-D morphology-fluorescence (e.g. spheroids, lymph node pieces, organoid formation, developments in situ, e.g. tadpoles, zebra fish): confocal techniques; emphasis on light sheet microscopy;
2 gene expression, e.g. by using FPs and switching genes;
3 cytoskeleton 3D arrangement, dynamics;
4 cell migration in 3D environment;
5 cell – cell interaction;
6 cell – environment interactions (adhesion), distribution of adhesion molecules 3D environment, ECM organization;
7 mechanosensitive channel distribution and expression;
8 Ca monitoring;
9 receptor distribution and expression using fluorescence emission and interaction;
10 organelle activity, e.g. membrane potential, nucleo-cytoplasmic transport, DNA damage by a variety of available fluorescence techniques;
11 multi-well reading: e.g. ELISA reading, quantification of released substances.

Recommendations for a microscope system enabling collection of these parameters.

2D microscopy of cells in culture revealed many very important and basic processes and structures and therefore still is an important tool. However, future investigations on cellular behavior under different gravity regimes have to approach the in situ (within the body) situation as close as possible, therefore working with cells grown in 3D structures is obligatory. The resistivity of cells against radiation and any other stresses has been found to be very different whether cells are embedded in a 3D aggregate or single. In general stress resistance can be considered to be superior in 3D cultures.

On the ISS a spinning disc microscope and two fluorescence microscopes are available for the observation of 2D cell cultures and a bit thicker specimens. They will both be outfitted with spinning disks in the near future. Therefore 2-D examinations are possible (although observations cannot be made at different g-levels). What is missing, is a system which allows long time observations of complex 3D cultures at high spatial and temporal resolution. If following the trait of high end microscopy – and not for a mic-farm – the favored solution of the TT is the laser light sheet microscope which can be used for FLIM and FRAP imaging as well and operates with extremely low load of damaging photons on the specimen.

Such a system should fulfill the following **requirements**:

- It should be a highly versatile microscope frame that we can foresee to fulfill most applications.
- Very good 3-D imaging properties which at present, are provided best by LSFLM
- As low illumination needed to excite fluorescence for good imaging as possible to reduce phototoxic effects
- At minimum 2 wavelengths for fluorescence excitation – this also means two channels for image acquisition
- Compact compound microscope with some special parts (i.e. special camera) easy to mount and exchange.
- Easy to operate (also remotely!): electronic control of all variables i.e. focus, laser power, camera settings –
- Spatial resolution as provided by 0.5 to 0.75 N.A.
- Easy upgrade for FLIM (fluorescence life time imaging) in the nanosecond range and/or FRAP.
- specimen /microscope interface for small plants, organoids and spheroids, multi-well discs, (and 2-D cell cultures – facultatively), well controlled environment for specimen.
- High data transfer from microscope to ground station – better than data storage on board.
- Time for construction should be as short as possible to have a chance using the new system on ISS. Therefore the starting techniques should be quite mature.
- Any developed system should have modules that can be used in ground-based research instruments (clinostats, RPM's, centrifuges) in order to prepare for flight and for basic, stand-alone research.

Abbreviations

- FLIM fluorescence life time microscopy
- FP fluorescent protein
- FRAP fluorescence recovery after photobleaching
- FRET fluorescence resonance energy transfer
- FSIM Fluorescence structured illumination microscopy
- FTAP Future Technology Advisory Panel
- LSFLM light sheet fluorescence microscopy
- LSWG Life Science Working Group
- SIM structured illumination microscopy

MEMBER'S SECTION

SWEDISH SPACE CORPORATION

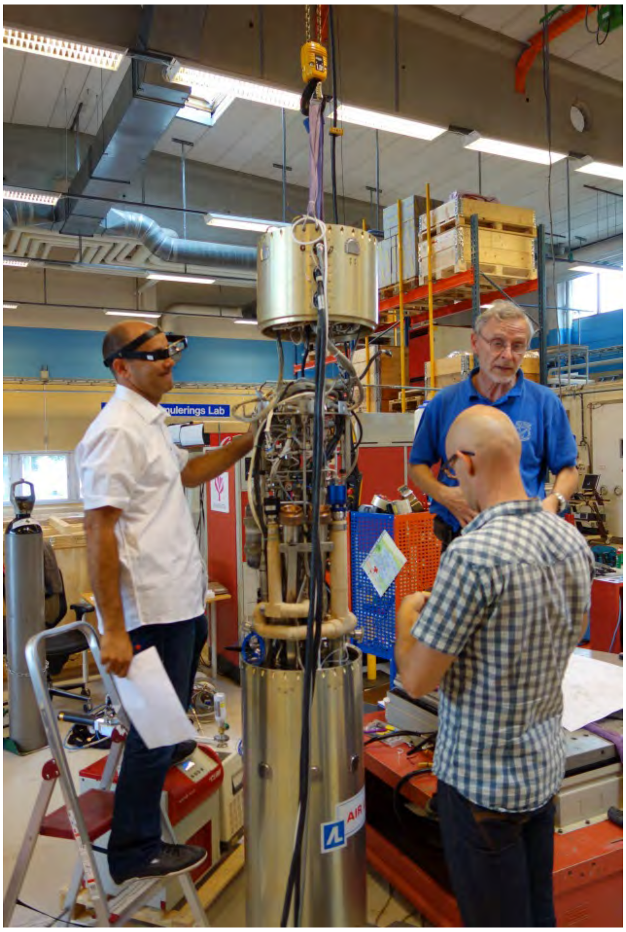
by Christian Lockowandt

Cryofenix

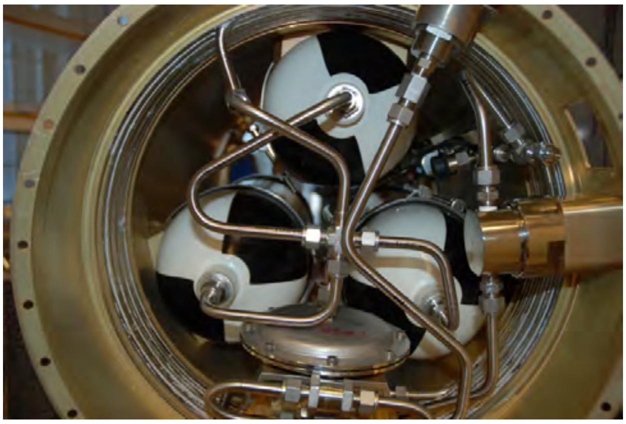
For the first time in Europe, an experiment studying the behaviour of liquid hydrogen in microgravity will be carried out in space. The experiment will complete the validation of the various simulations of the behaviour of fluids in the ballistic phase. The experiment that will fly on a sounding rocket called Cryofenix that is based on the well proven concept of the SSC microgravity rocket MASER. The experiment is developed and performed by Air Liquide Advanced Technologies. The launch of the Cryofenix rocket is planned in November 2014 from the SSC launch facility Esrange in Sweden.

The experiment will be performed to validate the behaviour of liquid hydrogen in microgravity and obtain results essential to the development of the future evolutions of

ARIANE 5. Air Liquide Advanced Technologies Project Chief, Sebastian Bianchi, said,



Integration and test of payload



Detail of thruster module

"Many preliminary studies into feasibility, safety and representativeness have assured that the Cryofenix experiment will produce relevant results. This project will complete the models we use to predict the behaviour of fluids in the tanks of a future cryogenic rocket stage that will be re-ignitable during the ballistic phase of its flight."

The rocket will provide a flight of low gravity for approximately 6 minutes for the experiment. In a normal microgravity flight efforts are made to reduce and minimize any acceleration but in this case a small acceleration will be provided during the "microgravity" period. A newly developed cold gas thruster module developed by SSC will be used in the payload to provide this precisely controlled and variable acceleration of the payload during the "microgravity" phase. This is needed to simulate the ballistic phase of the ARIANE 5 and other future cryogenic rocket stages.

The liquid hydrogen will be filled in the experiment tanks on the launcher at Esrange shortly before launch. Special modifications have been performed at the launch infrastructure at Esrange to handle liquid hydrogen. There are two experiment tanks in the payload that will be filled with approximately 22 l of liquid hydrogen and the main focus will be on investigating two Bond numbers.

The project is led by Air Liquide Advanced Technologies and performed and funded together with CNES. Air Liquide Advanced Technologies is developing the experiment and SSC is providing all other subsystems for the flight and is managing the launch and flight of the sounding rocket from Esrange.

Project logotype

STUDENT'S SECTION

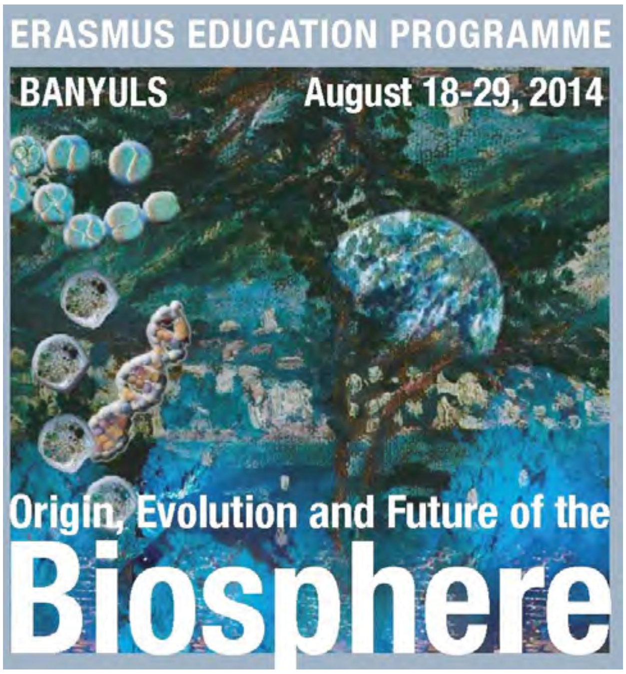
EUROPEAN SUMMER UNIVERSITY: ORIGINS OF LIFE AND LIFE IN SPACE

Jack J.W.A. van Loon (VU-Univ. Amsterdam)

Since years ELGRA supports a summer school on space and life sciences research which is organized in Banyuls-sur-Mer in France. The initial courses were supported by European Union funding but for the last years the support also came directly from various participating universities as well as from ESA and ELGRA. The course was initially organized by our former ELGRA president Prof. Gerald Perbal and after his retirement it was managed by Prof. Marie-Chistine Maurel from the Universite Pierre-et-Marie-Curie and for the last couple of episodes by Prof. Juli Peretó from Universitat de València. ELGRA first supported a number of students in 2007. In addition, various ELGRA members also lecture at these courses.

In the last course (Sept. 2014) 30 students from France, Germany, Sweden, Italy, the United Kingdom and Spain participated in Banyuls. In 2013 29 students participated. 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 life. 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 opportunity to participate in this summer school in due time.

The next course is foreseen in the summer of 2015.



Information of course content

Juli Peretó (Univ. Valentia)/ Marie-Christine Maurel (UPMC, Paris)

The course Origins, evolution and future of the Biosphere takes place in the Observatory Oceanologique of Banyuls-sur- Mer. The aim of the course is to form European students and giving them the means of a critical reading of actual knowledge concerning origins, evolution and functioning of the biosphere. The program will carry a general regard on the biosphere functioning, by being interested in the origins of life and in the training of the first ecosystems, in the possible roles of hydrothermal systems in biological evolution and in the elucidation of the metabolic ways kept in the course of evolution. Also environmental parameters such as pressure or gravity (microgravity) will be addressed. The social dimension of these scientific data will be also approached. Teachers of different disciplines participate to the course (biologists, biochemists, biophysicists, physicists).

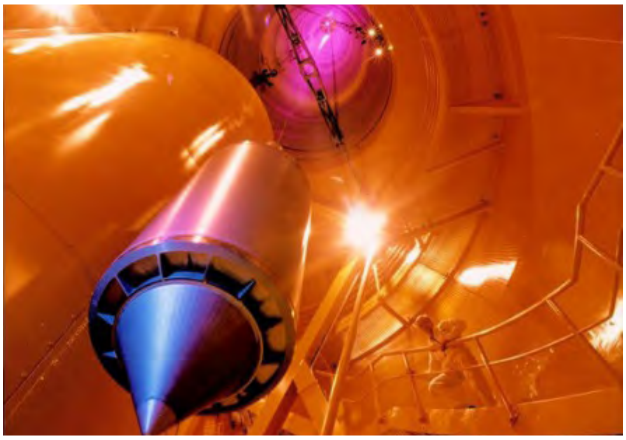
Scientific data will be introduced during lectures and the critical analysis of results of experiments will be performed during tutorial courses. By multinational groups, the students will have to work out a plan of experimentation, which will be presented at the end of the intensive program. See also: http://ipbanyuls.blogs.uv.es/

Figure: Participants of course 2014.

ELGRA AND ESA EDUCATION PROGRAMMES: SPIN YOUR THESIS! (SYT) AND DROP YOUR THESIS! (DYT)

Natacha Callen, ESA
Carole Leguy: ELGRA
Jack J.W.A. van Loon: VU-Univ.

The ESA Spin Your Thesis! (SYT) and Drop Your Thesis! (DYT) educational programmes give university students the opportunity to perform scientific or technological research in either hypergravity or microgravity conditions. Typical areas of research are biology, biochemistry, microbiology, opto-physics, general physics, material sciences, fluid sciences, geology or plasma physics.



ZARM drop tower module hoist up to the top.

The ESA Large Diameter Centrifuge (LDC).

In these SYT and DYT programmes ELGRA works closely with ESA education office. Through the selection process, ELGRA provides reviews from ELGRA members who are expert in related field of research of the student proposal. Later, the selected students are offered the support from an ELGRA mentor. ELGRA mentors are assigned to the student teams in order to advise and assist them in the preparation and realisation of their gravity related research projects.

For the Spin Your Thesis! programme the Large Diameter Centrifuge (LDC) at ESA-ESTEC, Noordwijk is used. The 8 meter diameter system can cater to experiments that require hypergravity levels up to 20 g. With up to 6 gondolas mounted on the long arms and 1 central gondola as a control experiment, this facility can provide, for example, a hypergravity environment for cells or plants, as well as physical science and technological experiments.

For the Drop Your Thesis! programme the nearly 150 meter high drop tower from ZARM in Bremen is used. In this facility, a very high quality level microgravity (10^{-6}g) for up to 9.3 s

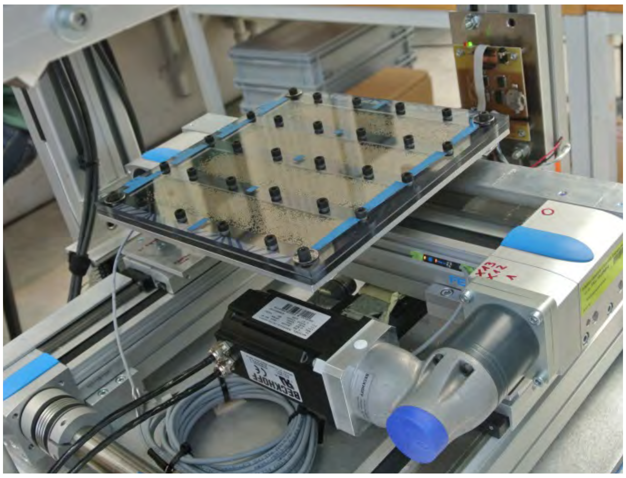
is provided to the students for their experiments.

With both the SYT and DYT programmes university students are provil ded the chance to do experimental research in facilities not usually accessible to them. They also experience the process of performing space related research i.e. work on a project like basis, provide structured documentation and reports and this all in an international setting. For both programmes a call for proposals usually opens once a year in September, which then stays open for three months. During this time, students, together with their endorsing professors from their universities, are encouraged to send in their proposals for experiments in the LDC or ZARM drop tower. In order to support their activities ESA provides some financial support to cover part of the hardware developments and travel and accommodation costs.

For the SYT programme up to four teams per year are selected. These teams will be given the opportunity to use the LDC for 2.5 days with flexible time slots. One team is selected for the DYT programme. A typical DYT campaign lasts 2 weeks in which 5 launches (in drop or catapult mode) can be performed. A student team usually consists of 2 to 4 students, and the development of the experiment, after selection, will take around 6 months. After the campaign is over, the results will need to be processed and documented within 4 months.

Their research results may also be published in papers and journals, and are often presented at the student session at the ELGRA biennial symposium or at other international conferences.

We are glad to introduce you with the selected projects which are this year once again of very high quality and very inspiring.



The DYT2013 Fall of Fame experiment set-up integrated in the capsule

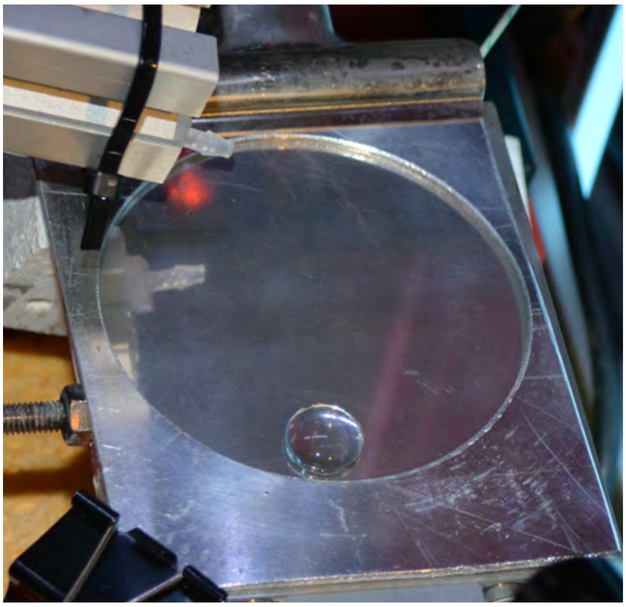
The DYT2014 FELDS experiment set-up

The 2013 DYT campaign:

The Fall of Fame team was composed of four bachelor students from the Friedrich-Alexander-University Erlangen-Nürnberg (Germany). They have investigated whether stripe formation of Amaranth grains is inhibited under reduced gravity when the normal force between particles and ground and thus friction goes to zero.

The 2014 DYT campaign

The **FELDs** team is composed of five master students from the University of Padua (Italy). They are testing a new technology to perform docking maneuvers in space. The docking system that will be tested in microgravity is tether-based. ELGRA Mentor, Guus Borst.



SYT 2013 Leidenfrost experiment set-up in LDC

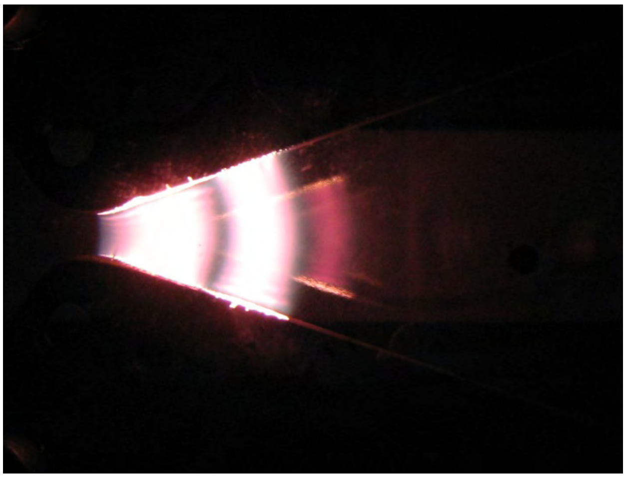
The 2013 SYT campaign

The **Hy-PHP** team was composed of a Ph.D. student and a Masters student from the University of Bergamo (Italy) interested to explore the performance of a Pulsating Heat Pipe (PHP) at various g levels. This innovative piece of technology is an effective way of removing heat from sources like consumer electronics or spacecraft. To use a PHP in spaceflight, however, will require it to work under a range of different accelerations, which can be simulated in the centrifuge. ELGRA mentor Antonio Viviani.

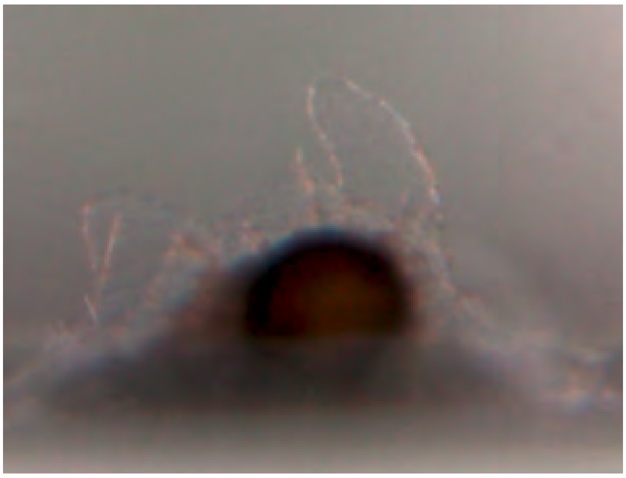
GRAVARC TNG team from Masaryk University in Brno (Czech Republic) consisted of three PhD students investigating the way an electrical discharge glides along between two electrodes. Studying such discharges at different levels of gravity is important not only for safety in electrical systems during spaceflight, but also for the design of spacecraft ion thrusters. Additionally, it helps towards understanding lightning in planetary atmospheres. ELGRA mentor Job Beckers.

The **OSTEO** team consisted of two PhD students from the Italian Institute of Technology and one Master's student from the University of Pisa (Italy). They exposed bone cells to various levels of hypergravity. Their results could help design new approaches for drug delivery and regenerative medicine. ELGRA mentor Jennifer Ngo-Anh.

The **Spin Leidenfrost** team composed of two PhD students from the University of Liege (Belgium), used the centrifuge to



SYT 2013 GRAVARC TNG team showing glide arc in helium atmosphere at 18 g level.



A sponge gemmules from SYT2014 Sponges in Space team with its typical, tent pole like, spicules at 20 times its own weight.

investigate the role gravity plays in the Leidenfrost effect. The experiment, which required a droplet to be placed on the hot surface, while the centrifuge was turning, proved a little tricky to set up but soon the results were flowing in. ELGRA mentor Anne-Laure Biance.

The 2014 SYT campaign

The AngioGravity team is composed of three Master students from the University of Porto and one PhD candidate from the MIT Portugal Program. (Portugal). This project focuses on understanding angiogenesis, the formation of new blood vessels, under hypergravity conditions for tissue engineering applications. ELGRA mentor Kim van der Heiden.

SYT2014 Glacier team set-up in the LDC exposed to various gravity levels.

Sponges in Space: This team is composed of two Master students and one PhD candidate from the University of Amsterdam (The Netherlands). The team is studying the energy demands of developing sponges by influencing the physical constraints i.e. gravity, during a specific stage of germination. The findings could help to improve culture methods for sponges and their use in biotechnological purposes such as drug development. ELGRA mentor Jack van Loon.

Transformers: The team is composed of four PhD students from the Istituto Italiano di Tecnologia (Italy). They are exploring hypergravity as a physical stimulus enhancing gene delivery for regenerative medicine purposes. The expected results may help overcoming limitations inherent to currently available methodologies in the delivery of genes useful for the treatment of skeletal muscle conditions. ELGRA mentor Jennifer Ngo-Anh.

Glacier: The team of two master students from the University of Amsterdam (The Netherlands) aims to model the influence of gravity on glacier flow dynamics. The knowledge that they will obtain could contribute to new interpretations or even to reconstruction of landscape formation on Mars, where the ice deformed large parts of the surface.

For more information

- http://www.esa.int/Education
- http://www.elgra.org

During the last ELGRA Symposium held at the Vatican in September 2013, thanks to the initiative of Francisco Javier Medina, Carole Leguy and Andrew Winnard, all the students in the Symposium were invited to attend a special meeting to discuss the idea of forming a student ELGRA group.

The concept took hold immediately and caught the attention of the students present, and thus the first discussions on the objectives and development of such an organization took place at that very meeting, with much vigor and enthusiasm.

It was clear that ELGRA would benefit from having a stronger student base, and that there should be a platform at the student level for all gravity-related research in Europe. This association would thus serve as the nexus of discussions, information, news and opportunities for all students within the scientific community. With this mission in mind, SELGRA (Student ELGRA) was established.

SELGRA's management committee is currently formed by:

- ***Anna Garcia-Sabaté*** (BarcelonaTech, Spain) – President
- ***Miguel*** Ángel ***Valbuena Crespo*** (CIB-CSIC, Spain) Vice-president
- ***Oliver Schüler*** (DLR and University of Münster, Germany) – MC Member
- ***Lars Krause*** (DLR and Rheinische Friedrich-Wilhelms-Universität Bonn, Germany) – MC Member
- ***Andrew Winnard*** (Northumbria University, UK) – UKSBA Liaison
- ***Carole Leguy*** (DLR and Simon Fraser University, Germany and Canada) – ELGRA Liaison

Since inception, SELGRA has grown steadily, in both membership and organizational structure. SELGRA has established a collaboration with the UK Space Biomedicine Association (UKSBA), designed logos, a webpage, and increased its presence in social networks. Moreover, 3 projects have been set in motion: outreach

Figure 1 Attendees to the dinner to discuss the creation of a student ELGRA group

presentations, conference grants and Open Space.

Outreach presentations is a project to encourage SELGRA members who have participated in gravity-related research to do presentations about microgravity and hypergravity research, how ELGRA is involved in it and what are SELGRA students researching. The aim of these presentations is to reach out to students (from primary school to masters) and possibly motivating them to follow science careers.

Conference grants is a program that offers students the opportunity to present their work (in microgravity or hypergravity) in a conference of their choice, SELGRA will then sponsor the student's conference fee travel and accommodation expenses. Sponsored students are selected competitively and priority is given to those students whose abstract has already been accepted for oral or poster presentation at the conference.

Open space is a project that opens the doors of space research institutions to young people who have limited access to science in general. The aim is to encourage and support them to pursue scientific studies and careers in science. The first Open Space event is focused on students with visual impairments.

SELGRA is continuously working to reach out to future scientists and to improve and create new and exciting projects that will benefit students in the scientific community. On behalf of SELGRA, we hope that you can be a part of it going forward.

SELGRA MEMBERS WANT TO GERMINATE AND GROW PLANTS ON MARS!

Miguel Ferreira & Miguel Valbuena

A team composed of student members of ELGRA was selected as a finalist of Mars One's Payload University Competition. The team is now in the final ten from which only one will be selected by public voting to be sent to Mars in 2018.

The first Seed on Mars

The project's name is Seed and its aim is to prove the concept that it is possible to germinate and grow plants on Mars. In order to do that, the team wants to provide earth-like conditions inside a chamber on the surface of Mars. Besides the social impact of growing the first life form on Mars, the possible scientific outcomes of this experiment could contribute to a better understanding of plant growth on Mars and possibly contribute for the development of life support systems.

The Seed Team is composed by students of the University of Porto (Daniel Carvalho, Guilherme Aresta, Miguel Ferreira and Teresa Araújo), MIT Portugal (Raquel Almeida), and, University of Madrid (Miguel Valbuena).

You can find and vote for the team on Mars One's website: http://community.mars-one.com/projects/seed1 as well as on its Facebook - facebook.com/seedmarsone - and Twitter - @SeedMarsOne pages.

AN INSPIRING SPIN FOR BIOENGINEERING IN PORTUGAL!

Carole Leguy, Miguel Valbuena and Miguel Ferreira

Following a very successful Spin Your Thesis project from ESA Education Office, Daniel Carvalho, Miguel Ferreira, Guilherme Aresta and Raquel Almeida brought their enthusiasm about gravitational research to their university in Porto. Within the *6th Symposium on Bioengineering* that was held at the University of Porto on November 21st and 22nd, they have beautifully orchestrated a 3-hour session on Bioengineering in Space. Especially for this session, Dr. Jason Hatton, Dr. Jonathan Scott and Timothy Irawan have kindly accepted to present their work at ESA ESTEC and EAC centers via videoconference sessions for the enjoyment of the 400 participants.

At ELGRA, we are very proud to have supported this event, fully organized by students, with the role of gold sponsor. Many attendants were curious about ELGRA and SELGRA, and have collected our newly designed mission and logo stickers offered at our stand. We would like to particularly thank Dr. Natacha Callens from ESA Education Office for sending the conference organizers promotion material that has been used for our stand. Last but not least, we sincerely congratulate the whole organizing team of the *6th Symposium on Bioengineering* and are very glad to see that interest about gravity research is growing within the bioengineering community over Europe.

Miguel Valbuena, Daniel Carvalho and Carole Leguy promoting SELGRA/ ESA stand. Bottom: Miguel Ferreira, organizer of the Bioengineering and Space session with the whole student organizing team (right).

ROOTS ON-BOARD THE INTERNATIONAL SPACE STATION!

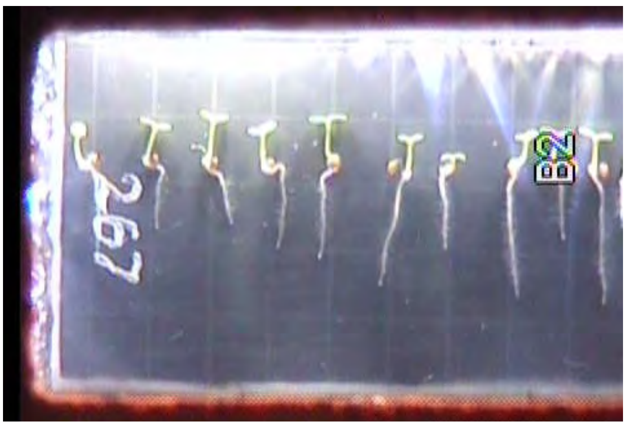
Miguel Valbuena

Miguel Valbuena, Vice-president of SELGRA, has recently prepared a spatial experiment called Seedling Growth (SG). This international project ESA-NASA will reveal the mechanisms of phototropism and gravitropism responses in plants (*Arabidopsis thaliana*) and the synergic effects between them when plants are grown under real microgravity conditions in the context of space exploration.

Dragon spacecraft (SpaceX CRS4) launched 21st September 2014 from Cape Canaveral (USA) with the material that the PhD student had prepared one month before, the second part of the Seedling Growth (SG2). The seedlings that germinated during November were frozen until coming back to the lab on Earth for genomic analyzes.

"The results we expect with this series of Space Research will provide keys to define the growth conditions of the plants that will be used by astronauts in future space stays or even in spaceflights to Mars that are already planned. Additionally, they will lead to increase agriculture efficiency and sustainability on Earth", says Javier Medina, Researcher at Centro de Investigaciones Biológicas (CSIC) and European leader of the Seedling Growth Project."

Miguel Valbuena selecting the seeds for the Seedling Growth 2 in NASA complex ARC (California).



Control samples of a mutant of Arabidopsis thaliana growing in the ISS.

STUDENT'S PRESENTATION

The Student Session of the Vatican City Symposium consisted of six oral communications, three of Life Sciences and three of Physical Sciences, previously selected from the total of 18 applications received, based on the contents of two-page abstracts sent by applicants. The presenters were: Anna Garcia Sabaté, Gurunath Gandikota, Thomas Triller, Lars Krause, Miguel Valbuena, Oliver Schueler. Student communications not selected for oral presentation were presented as posters in their corresponding subject sessions.

Among the student oral presentations, the attendants voted for election of the best presentations in Life and Physical Sciences, respectively. A total of 41 votes were recorded for two LS presentations and 35 for PS. The winners of the Student Contest were:

- Lars Krause and Oliver Schueler (Life Sciences)
- Anna Garcia Sabaté (Physical Sciences).

ACTIN MEDIATED STATOLITH DISPLACEMENT IN GRAVITROPIC CHARA RHIZOIDS UNDER ALTERED GRAVITATIONAL STIMULATION: SUITABILITY OF 2D- AND 3D CLINOROTATION FOR SIMULATION OF MICROGRAVITY

Lars Krause[1], Markus Braun[2, 3], Ruth Hemmersbach[1]
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Gravity-depended statolith positioning in Chara rhizoids were investigated under altered gravity conditions on the Random Positioning Machine (RPM) by using this device in different operational modes (2D clinorotation and 3D clinorotation in real random mode). The objective of this study was to evaluate different techniques which are applied to simulate microgravity. A comparison of actin-dependent statolith displacement kinetics in Chara rhizoids during the different RPM operation modes with data from real microgravity conditions from Texus and Maxus missions allowed an assessment of the simulation quality. Displacement distance and velocity of statoliths correlated with the rotational speed of the RPM. Both, but necessarily fast 2D clinorotation and 3D rotation in real random mode induced in Chara rhizoids a displacement of the statoliths away from the tip with a comparable kinetic as in real microgravity. Slower rotational speeds in the 2D clinorotation and 3D real random mode caused less displacement of statoliths and different displacement kinetics. As a consequence, with respect to the displacement of statoliths in a unicellular system, the 2D clinorotation is more preferable than the 3D real random mode.

In view to the displacement of statoliths in Chara rhizoids on a 3D clinostat, the results are matching with Hoson's (Hoson et al. 1997) observations and extend them with respect to displacement kinetics. Furthermore, the results show that every alteration of gravity amount and direction affects the movement of statoliths. Therefore it was possible to show qualitative differences between the different RPM modes based on displacement kinetics and displacement distance of statoliths. The results show, that the rotational speed of a clinostat or an RPM has to be carefully selected to achieve a qualitative microgravity simulation. Beside the rotational speed, the selection of RPM operational mode has also to be considered. Although no significant differences in statolith displacement distance were observed between fast 2D clinorotation and 3D real random mode, the displacement kinetics were slightly different. These differences might be influenced by stronger vibrations during the respective operation mode. The additional rotational axis in 3D real random mode caused more intense vibration patterns. Vibration maxima appeared irregular in context to changing rotation directions. In contrast to this operation mode, the 2D clinorotation caused weaker vibration maxima and a more regular vibration pattern through the whole measured frequency spectrum. The differentiation between 2D mode performed with the inner frame and 2D mode performed with the outer frame showed also different vibration patterns. The inner frame caused lesser vibrations probable through a smaller mechanical slackness and is therefore more preferable.

To conclude these observations, the 2D clinorotation with the inner frame is more preferable in view to a nearly stimulation-free environment and a qualitative good simulation. The additional rotation axis in 3D real random mode has no further advantage toward the 2D clinorotation with respect to the selected experimental parameters.

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ALTERATIONS IN THE PROTEIN EXPRESSION PATTERN INDUCED BY DIFFERENT GRAVITATIONAL STIMULI IN ROOTS OF ARABIDOPSIS THALIANA

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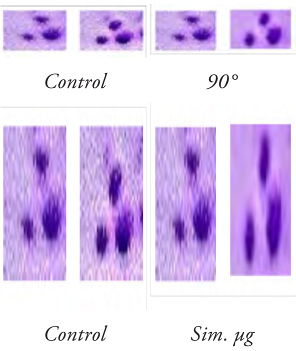
Plants will be an essential part of future Life Support Systems, which enable long duration human spaceflight and colonisation of other planets. For this reason we have to understand plant's gravitational response towards a deviation from the vertical (e.g 90° alteration) and modifications/ behavioural changes under microgravity.

The concrete objective of our work was to identify proteins, putative key proteins of the graviresponse, whose expression patterns were altered in *Arabidopisis thaliana* roots of 7 days old Col-0 wildtype seedlings after 30 minutes of simulated microgravity (Sim. µg) and 90° treatments. Total protein extracts out of whole *Arabidopsis* roots were used for a quantitative protein analysis basing on 2D SDS-PAGE ([1]).

The resulting data comprised a lot of new insights in the field of plant's response to changes of the gravity vector.

After a 90° gravistimulus for 30 minutes, the total protein expression pattern was not as strongly effected compared to clinorotation treatment. Only four proteins exhibited an increased concentration. They have functions in the heat shock response, defense against biotic stresses and probably auxin transport/ binding. No downregulations of proteins were observed.

The highly restricted response to a 90° stimulus totally reflects our hypothesis, because the deviation from the vertical is a common stress to the plant since first land plants evolved and for sure plants possess a highly regulated program to cope with changes of the gravity vector.



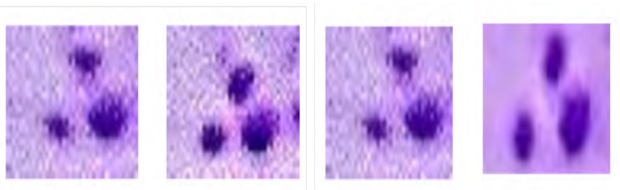


Figure 1: Sections of 2D SDS- PAGE gels after Coomassie staining. The treated samples (90° and Sim. µg) clearly exhibit upregulations of two out of three stress-induced proteins (red arrows).

Interestingly, almost the same proteins were upregulated after 30 minutes of clinorotation treatment, too (Fig.1). This overlap of altered protein expression between a lack of gravity and a proper gravitational response is currently undescribed.

In contrast to the response to 90° stimulation, simulated microgravity treatment induced an intensive decrease in total protein expression. Interestingly, an increase of random degradation of proteins and/or transcriptional/ translational inhibition might occur. Eight proteins exhibited a clear and reproducible downregulation. Those proteins have a function in the carbohydrate cycle, cell wall biosynthesis and transcriptional and translational regulation.

Our data clearly demonstrate several alterations of the proteome after 30 minutes of simulated microgravity treatment, which could cause severe problems for plant's physiology while growing in space. Less changes were observed for the response to 30 minutes of a 90° stimulus. With the help of those insights and future experiments, we are able to prepare plants by breeding or genetic modification to grow, germinate and reproduce themselves in space with similar effectivity to earth.

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THE EFFECTS OF HYPERGRAVITY AND ACOUSTIC FIELDS ON RISING BUBBLES

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[1] L.A. Crum. "Bjerknes forces on bubbles in a stationary sound field", *The Journal of the Acoustical Society of America,* vol. 57, no. 6, p. 1363, 1975

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It is very common to find air bubbles rising in fluids in many different situations, from simple daily activities (*e.g.* bubbles rising in a glass of beer) to more complex applications (*e.g.* fuel tanks). Some of the applications where we encounter rising bubbles undergo different gravity conditions during their lifetime (either microgravity or higher gravity levels due to high accelerations). Different methods have been tested to control the behavior of bubbles, among which acoustic fields have been proven as good candidates to efficiently control bubble dynamics[1-3].

We have conducted a series of experiments to study the effects of acoustic fields on rising bubbles in a hypergravity environment. The experiments were carried out in the frame of the ESA's "Spin Your Thesis! 2012" campaign. The main objectives of the experiments were to study the detachment of bubbles from an injector and the dynamics of rising bubbles. To this end, an experiment was designed and built to be able to work at gravity levels from 1g_0 to 20g_0 (g_0 = 9.81 m/s2).

Our experiment consisted of the injection of bubbles (1ml/min by means of a syringe pump) into a cubical cell. Two acoustic fields (one at a time) were applied to the test cell. Oneof the acoustic waves was set at a frequency of 53 kHz and transverse to the direction of gravity. The second field was set at 60 kHz and parallel to the axis of gravity. During each gravity level we explored different acoustic amplitudes by changing the voltage output from the function generator. Reference tests (Figure 1) were performed at each gravity level in order to compare results with and without acoustic fields.

Figure 1. *Reference test at 2g0 (overlay of the bubble paths during 1s).*

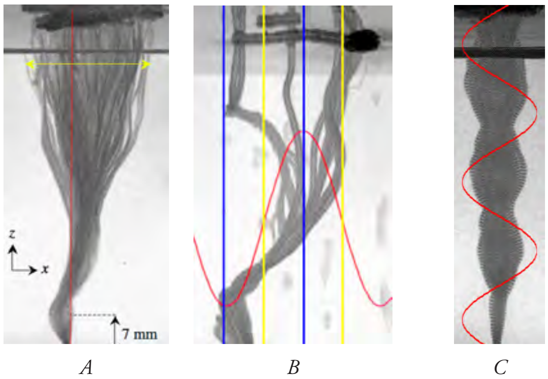

Figure 2. *Pixels of minimum intensity during 1s. A: 15g0 transverse field 4V. B: 2g0 transverse field 6V. C: 10g0 axial field 4V.*

The applied acoustic fields generated different effects on bubble dynamics. First of all, we observed a change in bubble directionof movement right after injection. With respect to the axis of the nozzle, injected bubbles followed a straight path, right deviation, left deviation or downwards. Another effect observed upon injection involves the size of the injected bubbles. At the lowest driving voltage bubble size did not change, whilebubbles had different detachment sizes as the voltage increased.

Regarding the rising trajectories,different behaviors were analyzed. Although bubbles initially deviated either to the right or to the left of the nozzle axis, they coalesced with the free surface at evenly spread points in both directions, as shown in Figure 2a. We also observed a relation between the applied standing wave and the final trajectories of the bubbles (Figure 2b). When the bubble trajectories during one second are overlapped, the obtained pattern shows an oscillatory behavior, especially when applying the axial acoustic field.

Finally, three other effects where observed in a few cases: levitation of bubbles (motionless bubbles in the same position for approximately 300ms), interaction between bubbles due to the secondary Bjerknes force, and cavitation of bubbles which follow highly deviated trajectories compared to those of the injected bubbles.

ELGRA MEDALS

ELGRA MEDALIST LIFE SCIENCES

MARIANNE COGOLI

(born 4.3.1943) got her Ph.D. in organic chemistry at the University of Zürich, Switzerland, in 1971. After 2 years of research assistance in the Department of Organic Chemistry at the University of Zürich, she attended a one-year Postgraduate Course in Experimental Medicine and Biology at the University of Zürich. From 1974-75 she was Visiting Scientist at the Weizmann Institute of Science (Department of Biochemistry), Rehovot, Israel. Back in Switzerland she worked for 6 years as Research Assistant in the Institute of Biochemistry, University of Zürich followed by 5 years in the laboratory of Medical Oncology, University-Hospital, Zürich where she gained experience in cell biology and immunology.

In January 1986 Marianne Cogoli joined the Space Biology Group at the Swiss Federal Institute of Technology (ETH Zürich) headed by her husband Augusto Cogoli. She was Investigator team member of 9 experiments performed on 5 different Spacelab /shuttle missions (Spacelab 1, Spacelab SLS-1, IML-1, IML-2 (coordinator and responsible for execution) and STS-107 and 5 experiments on Sounding Rockets (Maser 3, Maser 4, Maxus 1B and Maxus 2) which all were under here responsibility. Furthermore she was Principal Investigator for 1 experiment on Maser 9 and 1 flown in Kubik BION1 on ISS. For many experiments outlined above she was involved in the development, manufacture and testing of the space qualified hardware. The major scientific interest and experience of Marianne Cogoli in Space Biology/Biotechnology are related to the adaptation of the immune system and mammalian cells to changes of the gravitational environment. Due to her great experience in space biology, she was consultant to ESA and to several major aerospace companies. She was manager of two scientific studies on Biolab for the Columbus Attached Laboratory and the Columbus Free Flying Laboratory of ESA and of the science team for the Biolab studies. In 2000 ESA appointed one of the European User Support Centers to the ETH Zürich. The center, called BIOTESC (Biotechnology space Support Center), is a support center for Biolab and responsible center for Kubik and was headed until 2007 by Marianne Cogoli. Marianne Cogoli is author and co-author of 39 publications in peer reviewed journals and 27 in proceedings, 25 resp 26 in the field of space biology / biotechnology and other space related activities. In 2004 Marianne Cogoli founded together with her husband an ETH spin-off company - Zero-g LifeTec GmbH. Today she is still executive director of this company.

From 1995-2005 Marianne Cogoli was member of the ELGRA Management Committee, 1997-1999 as Vice-President and 1999-2003 as President. 2001-2008 she was Swiss delegate to the Programme Advisory Committee for Esrange Andoya special projects and from 2004-2007 member of the Swiss commission on space activities.

ELGRA MEDALIST PHYSICAL SCIENCES

DANIEL BEYSENS

(born 11.08.1945) is Director of Researches at the Commissariat à l'Energie Atomique at Grenoble (France) and at the Ecole Supérieure de Physique et Chimie Industrielle - ParisTech. After having obtained an engineering diploma in Optics at the Institut d'Optique (Paris) in 1969, he received his PhD (supervised by P. Bergé) in 1973. His current interests are centered on phase transition in fluids, especially in non-classical conditions: constrained on a surface (dew or breath figures) or in space conditions (weightlessness and vibrations). With the goal to improve the management of fluids in space, the investigations emphasize the near and supercritical conditions in order to get benefit of their universal behaviour: studying one fluid corresponds to study all fluids.

He is author or co-author of nearly 400 publications and 8 books in the above fields of research. The French Physical Society gave him the Ancel Prize of Condensed Matter Physics in 1985, he was decorated in 1995 as a Knight of Palmes Académiques for outstanding data in education and research, he shared in 2000 the Grand Prix of the French Academy of science for the discovery of a new thermalization process in space, received in 2007 the Prize of Innovative Technologies for the Environment, bestowed by ADEME. In 2008 he was given the Emergence award from the French Ministry of Research and in 2012 he obtained the Loyalty award from the SDEWES Organization.

Daniel Beysens was Director of Laboratory at CEA-Saclay from 1991 to 1995 and Director of Institute at CEA-Grenoble between 1995 and 1999. Going back to basic research since then, he is since 2000 the Director of a joint laboratory based at ESPCI-ParisTech, CEA-Grenoble and CNRS ICMCB-Bordeaux. He is since 1999 the President - founder of the OPUR International Organization for Dew Utilization. He initiated and coordinated 6 sounding rockets experiments aiming at validating very fine density matching by partial deuteration and thermalization of fluids near the critical point. He showed that only two universal growth laws hold for phase separating fluids. Using sounding rockets, MIR station (8 experiments in Alice and Alice2) and Space Shuttle (CPF in IML1 and IML2), he revealed with his team a new thermalization process, the so-called "piston effect". This effect exhibits spectacular and paradoxical behavior as thermalization critical speeding up instead of critical down in closed samples, (apparent) violation of the 2nd thermodynamic law… He is co-PI in recent experiments conducted in the ISS with DECLIC, aiming at clarifying the origin of the boiling crisis in heat exchangers and the behavior in space of supercritical water. In addition, Daniel Beysens originated and organized experiments in hydrogen and oxygen under partial or complete compensation of gravity by using superconductive magnetic levitators. Using such levitators with MiniTexus and Maxus sounding rockets to study the effect of vibrations, he showed that vibrations can induce flows and order interfaces in a way that correspond to the effect of an artificial gravity.

Daniel Beysens was President of ELGRA between 2003-2007 and member of its Management Committee between 2007 and 2011.

CALENDAR OF EVENTS

ARTES 1 Final Presentations Days
14-15 January 2015,ESA-ESTEC, The Netherlands

PERASPERA Workshop
11-12 February 2015, ESA-ESTEC, The Netherlands

ADM-Aeolus Science and CAL/VAL Workshop
10-13 February 2015, Frascati, Italy

8th European Symposium on Aerothermodynamics for Space Vehicles
2 - 6 March 2015, IST Congress Centre, Lisbon, Portugal

Earth Observation for the Oil and Gas Industry: Professional Training Course Offshore Applications
11 - 12 March 2015, Frascati,Italy

Workshop on Ball bearings design and calculations in space mechanisms / Mechanisms' Final Presentation Days
11-13 March 2015, ESA-ESTEC, The Netherlands

Workshop on Simulation for European Space Programmes (SESP)
24-26 March 2015, ESA-ESTEC, The Netherlands

6th International Workshop on Microwave Filters
23rd – 25th March 2015, CNES, Toulouse, France

FRINGE2015 WORKSHOP
23-27 March 2015, ESA-ESRIN, Frascati,Italy

4th IAA Planetary Defense Conference Protecting our planet from impacts by asteroids and comets
13-17 April, 2015, ESA-ESRIN, Frascati,Italy

Alert Workshop 2015
14 April 2015, ESA-ESTEC, Noordwijk, The Netherlands

ASTRA 2015
11-13 May, ESA-ESTEC, The Netherlands

TRISMAC 2015 The Contribution of Safety and Mission Assurance to Cost-Effective Missions
18 to 20 May 2015 ESA-ESRIN Frascati, Italy

2nd SMOS Science Conference
18-22 May 2015, ESA-ESAC (near Madrid), Spain

Sentinel-3 for Science Workshop
2-5 June 2015, ESA-ESRIN, Frascati, Italy
22nd ESA PAC Symposium
7-12 June 2015, Tromsø, Norway

The Extremes of Black Hole Accretion
8-10 June 2015, ESA-ESAC (near Madrid), Spain

ESAW 2015
16-17 June 2015, ESA-ESOC, Darmstadt, Germany

16th International Science Team Meeting (GHRSST XVI)
24 July 2015, ESA-ESTEC, Noordwijk, The Netherlandss

ESMATS 2015: 16th European Space Mechanisms and Tribology Symposium
23 - 25 September 2015, Bilbao, Spain

Software Product Assurance Workshop
8-10 September 2014, ESRIN, Italy

Exploring the Universe with JWST
12-16 October 2015,ESA - ESTEC, the Netherlands,

31st Meeting of the American Society for Gravitational and Space Research (ASGSR)
11-14th November 2015 Alexandria, VA U.S.A.

2015 IAA Humans in Space Symposium
June 29 - July 03, 2015
Prague, Czech Republic

ELGRA

EUROPEAN LOW GRAVITY RESEARCH ASSOCIATION

INTERNATIONAL BIENNIAL SYMPOSYUM & GENERAL ASSEMBLY

CHANDRIS HOTEL, CORFU ISLAND GREECE 29TH SEPTEMBER – 01ST OCTOBER 2015

SCIENTIFIC/ORGANIZING COMMITTEE

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- Valentina Shevtsova — President
- Monica Monici — Vice-President
- Floris Wuyts — Gen. Secretary
- Kurt Kemmerle — Treasurer
- Carole Leguy — Member
- Ricard Gonzalez-Cinca — Member

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WELCOME

The European Low gravity Research Association (ELGRA) is pleased to invite you to the Symposium and General Assembly, which will be held in Corfu Island, Greece, 29 Sept- 01 Oct 2015. The symposium will last 4 days, with plenary lectures, oral and poster sessions.

For more information about the event, please consult the ELGRA website (**www.elgra.org**).

Do not hesitate to contact the local organizers by phone **(0030 2310 997772)** or e-mail **(karapant@chem.auth.gr)**

VENUE: CORFU ISLAND

Corfu or Kerkyra in Greek, is the second largest of the Ionian Islands, and, including its small satellite islands, forms the edge of the northwestern frontier of Greece. Magnificent, verdant Corfu, was Homer's 'beautiful and rich land'. Mountains dominate the northern half where the coastlines can be steep and dramatic and where the island's interior is a rolling expanse of peaceful countryside. South of Corfu Town the island narrows and flattens.

Throughout its history, the island was desired for its geographical location, abundant wood, food and water, making the island a vital port between Greece and Italy. In the beautifully preserved Old Town of Corfu, a UNESCO world heritage site, Renaissance,

Baroque and Classical "repertoire" came to be successfully applied to local artistic traditions. Palaces, fortresses, austere public buildings of the Venetian rule uniquely blend with lines of drying washing in tiny alleyways and small secluded squares. Strolling through a complex of narrow cobbled streets with stairways and vaulted passages, the so-called "kantoúnia", will make you feel as if you've travelled to Genoa or Naples. Corfu, unlike the rest of Greece, never fell under the Ottoman oppression. Due to the successive dominations of the Venetians, the French and the British over the centuries, the island has primarily become part of the Western rather the Levantine world. Their culture wielded strong influence in the city: it was here that the first Greek University (the Ionian Academy), the first Philharmonic Orchestra and the First School of Fine Arts were founded.

With the passage of time the island may have changed, but we can still feel the spirit of a distant glorious past. Its rich multi-cultural heritage, its historic monuments, its stunning natural landscape, its crystal clear seas, and its excellent weather all year round explain why Corfu is one of the most cosmopolitan Mediterranean destinations weaving a powerful spell on its visitors.

Social Program

Welcome Reception

The welcome reception is a key networking event among the delegates of the ELGRA2015 Symposium. Participants will have the opportunity to catch up and mingle with fellow colleagues in a relaxed and cozy atmosphere.

GALA DINNER

All registered attendees are cordially invited to the ELGRA2015 Gala Dinner. The ELGRA2015 symposium Dinner offers a unique opportunity for business conversation under the stars, in a magnificent scenery. Let yourself enjoy the culinary delights accompanied by excellent drinks!

CALL FOR ABSTRACTS

Traditionally, the ELGRA Symposium is a forum for scientific and technological reports in gravity dependent and space related research. Abstracts in the fields of life sciences, biotechnology, physiology, physical and material sciences, fluid physics, and other (micro-)gravity related topics are welcome. Abstracts may be submitted via the symposia link on the website **www.elgra.org**

TOPICS

Life Sciences

- The human body and long lasting missions
- Adaptation of cells and biological tissues to long-term conditions of altered gravity
- Psychological and behavioural aspects in long lasting missions
- Life support systems
- Moon and Mars environments
- Countermeasures
- Soft matter mechanics of living cells
- From science to health

Physical Sciences

- Material sciences
- Fluid physics
- Plasma physics

Others

- Ethical aspects in space exploration
- New opportunities from commercial suborbital flights
- Artificial gravity and simulation
- Dust in space
- From Science to Philosophy

STUDENT CONTEST

As every Symposium, ELGRA will establish a program to support student attendance and organize a student contest. More information will be provided, in due time, on the ELGRA web site: **www.elgra.org**

ATTENTION

Information for abstract submission, social program, registration and hotel reservation will be communicated starting from February. Please consult the web site www.elgra.org.

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EUROPEAN LOW GRAVITY RESEARCH ASSOCIATION ELGRA

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Represented by . . . .

Main science area ❑ (PS) Physical Science — Additional details . . . .

❑ (LS) Life Sciences . . . .

❑ (TE) Technology . . . .

Date and Place	Signature
. . . .	. . . .

TO BE COMPLETED BY GENERAL AND STUDENT MEMBERS

Name . . . . Surname . . . .

Professional Status . . . .

Field of activity . . . .

Mailing address . . . . Tel. . . . .

. . . . Fax . . . .

. . . . e-mail . . . .

Main science area ❑ (PS) Physical Science — Science discipline (e.g. material sci., plant physiology, cell biology)

❑ (LS) Life Sciences . . . .

❑ (TE) Technology — Additional details . . . .

Date and Place	Signature
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