3 PhD Positions (M/F) in Aerospace Life Sciences

Start
December 1, 2016

Duration
3 Years

Research Area
Space and Flight Physiology, Gravitational Biology, Radiation Biology and Astrobiology

DLR is the national aeronautics and space research center of the Federal Republic of Germany. Approx. 8000 employees conduct extensive research and development work in aeronautics, space, energy, transport and security. DLR’s research portfolio ranges from fundamental research to the development of products for tomorrow. If you strive to conduct excellent research in an inspiring and appreciative environment, start your mission with us.

Job Specification

The DLR offers a comprehensive and interdisciplinary training for doctoral students from different fields. Project language is English.

The scientific training is provided in cooperation with several universities in a superb and vibrant research environment with state of the art facilities and cutting edge research projects. Students will learn to develop integrated concepts to solve health issues in aviation and human spaceflight and in related disease patterns on Earth, and to further explore the requirements for life in extreme environments, enabling a better understanding of the ecosystem Earth and the search for life on other planets in unmanned and manned missions. Prospective students can choose one out of several challenging research projects.

We offer

- a PhD position paid according to TVöD (E13/2)
- a top-level research environment
- a periodic research report system
- efficient supervision by a team of two supervisors and a mentor
- an interdisciplinary training program
- intensive courses in soft skills
- Cologne – a lively city with a vibrant cultural scene, successful scientific centers of innovation and dynamic business activities

We expect

- a degree in any Life Science related to the research topics (e.g. biology, microbiology, physiology, neuroscience, and psychology or related fields)
- graduation with outstanding marks and a Diploma or Master degree that qualifies for starting a PhD study in Germany. Candidates who are about to earn their degree are welcome to apply.
- fluently spoken and written English is essential
- advanced laboratory experience / clinical study experience (dependent on research topic)
• strong interest in Aerospace Life Sciences
• high motivation and dedication to science
• ability to work creatively in a multidisciplinary team

Your application includes
• a letter of motivation
• a CV with certificates
• two letters of recommendation (e.g. from your master thesis supervisor)

Application Deadline  September 30th 2016

Points of Contact
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Your benefits
Look forward to a fulfilling job with an employer who appreciates your commitment and supports your personal and professional development. Our unique infrastructure offers you a working environment in which you have unparalleled scope to develop your creative ideas and accomplish your professional objectives. We are striving to increase the proportion of female employees and therefore particularly welcome applications from women. Disabled applicants with equivalent qualifications will be given preferential treatment.
Research Area: Space Psychology & Physiology

Project Title: Embedded testing as a new approach of astronaut's cognitive functions and motivation monitoring using the 6df system

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Keywords: Reaction-Time, Audio-Visual Stimuli, Response Control

The hand control of objects in weightlessness requires the consideration of six degrees of freedom. For comparison, driving a car needs the control of two degrees of freedom: direction (turn on vertical, here y-axis) and speed (along x-axis). In the open space no linkage exists between turns of an object around its own axes and the objects track in space. This requirement is unusual under terrestrial conditions. Man is not prepared by usual educational development (including flying or diving). The control of any object under these conditions requires a higher degree of complexity in perception, cognition and motor multitasking. Manzey et al. (1998a, b) demonstrated that deficits in certain periods of the flight (initial phase) are already visible in an unstable tracking with 2 degrees of freedom. A more sophisticated monitoring of tracking and control skills of astronauts with increasing degrees of difficulty would provide better understanding of space flight's short and long-term effects on mental performance and motor control. A task type with a perceptible relationship to real challenges of the mission will maintain the motivation of the subjects for the repeated measures over a long period. On the one hand this characterizes the task type itself as an excellent model for psychological research with numerous clearly distinguishable factors. On the other hand the practical relevance of the topic became evident in research of Salnitski et al. (2001a, b). The reliability of skills (docking) trained only on simulators but never in reality practiced (“artificial skills”) decreases even in well trained astronauts after a longer than three month period of space flight without training. Hand controlled docking was required, if the automatic docking failed due to missing sensory inputs (measures of distance, relatively speed etc.). Finally, when running a hand controlled docking the astronauts usually do it the first and lonely time in their life in reality. Assuming an increasing duration and complexity of space stations or long-term missions as to Mars the role of hand controlled moving and docking in space will grow exponentially. Taking into consideration that docking a spacecraft is hardly to learn by trial and error, as demonstrated by data of the SFINCSS study, an autonomous computerized learning program would be a helpful mean for the training, refreshment and maintenance of this important space skill.

However, also beginners will be educated more effectively if the development of the psychologically fundamental abilities is supported by a theory based training and this training was tested in terrestrial long-term isolation studies (Johannes et al. 2004).

The project proposes the development and testing of a diagnostic methodology appropriate for the selected clientele of astronauts. The method should provide a parallel assessment of cognitive functions as provided in PRET (CSA) or in future work sample based embedded assessments.

Johannes B, Salnitski VP, Goeters KM, Maschke P, Stelling D. Learning with simulation only - artificial skills. Proceedings of the 23st Annual Gravitational Physiology Meeting, Moscow, Russia, June 2004


The fundamental force of gravity, unique due to its stability throughout evolution has shaped all life on Earth. Consequently, biological systems have developed mechanisms to perceive gravity and use this cue for spatial orientation (directed movement and/or growth) and have adapted to gravity regarding a variety of physiological issues. There are strong indications that gravisensation is a characteristic of eukaryotic organisms in general and consequently of single cells in vivo and in vitro. Microgravity (weightlessness)-related problems such as dysfunctioning of the immune system and degradation of muscles and bones might be associated, at least to some degree, to gravity-dependent alterations on the cellular level.

In the frame of your thesis, you will expose different cell types in vitro to our unique platforms (clinostats and centrifuges) to alter the influence of gravity, including a variety of applications ranging from simulated microgravity to hypergravity. If an opportunity arises, possibly you might even perform an experiment in real microgravity (e.g., on parabolic flights or sounding rockets). Live-cell imaging during exposure to both micro- and hypergravity will allow insights to cell intrinsic mechanisms and adaptations, such as ion transports (e.g., calcium-sensitive fluorescent imaging), visualization of alterations in cytoskeletal components. Furthermore, the identification of subsequent steps, especially the activation of signaling molecules by various biochemical assays and different "Omics"-technologies at DNA, RNA and protein levels will be a major topic during your work.

Consequently, your thesis will contribute to a more detailed understanding how environmental factors trigger changes in cellular events responsible for fundamental processes in the functionality of individual (mammalian) cells in vitro.

**Fig.** Platforms on ground and in space to elucidate the question, how single cells perceive and adapt to the influence of different gravity conditions.
Halophilic archaea thrive in high saline environments such as solar salterns or the Dead Sea, and due to the recent discovery of liquid salt brines on Mars, are prime candidates for extant life on Mars. To counterbalance changes in external osmotic pressure, halophilic archaea have evolved the “salt-in” strategy, where $K^+$ ions are pumped into the cytoplasm while $Na^+$ ions are excluded. However, the recent isolation of *Halococcus hamelinensis* from Shark Bay stromatolites, Western Australia (Fig. 1), changed that dogma significantly as this organism utilizes osmolytes such as glycine betaine or trehalose, to adapt to changes in external osmotic pressure, a mechanism not observed in other halophilic archaea.

This raises the intriguing question, if other halophilic archaea would benefit from the presence of osmolytes as well and if their survival and resistance against detrimental environmental conditions such as radiation or a simulated travel to outer space would increase. However, very little is known about the mechanisms of uptake and/or synthesis of osmolytes in *Hcc. hamelinensis* or in other halophilic archaea (Fig. 2). This research project is directly aimed to investigate and elucidate this novel strategy of osmoprotection in detail. Besides classical microbiological investigations such as growth, survival, and resistance studies in the presence or absence of osmoprotectants, a transcriptomics analysis is anticipated to uncover novel molecular constituents responsible for the production and transportation of osmolytes. This project will add new pieces to the emerging picture of the versatility of halophilic archaea in dealing with external and internal osmotic stress.

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**Fig. 1:** Modern stromatolites from Shark Bay

**Fig. 2:** Halophilic archaea
Research Area: Astrobiology

Project Title: Investigation of radiation effects and oxidative stress in hyperthermophiles, model organisms with repair systems related to bacteria and to higher organisms

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Early Earth was dominated by harsh, hostile environmental conditions but life has been able to emerge, propagate and inhabit our planet since ~3.8 Ga ago. Based on a hot origin, it is assumed that early life forms may have thrived in environments like present day deep-sea hydrothermal vents, terrestrial hot springs and hyper salinic brines. Due to the ability of hyper-/thermophilic Bacteria and Archaea to live in these extreme habitats on Earth it can be hypothesised, that these organisms can also outlast other harsh conditions, e.g. those prevailing in space or on Mars.

We could demonstrate in earlier studies that one archaeal hyperthermophilic representative, *Ignicoccus hospitalis*, possess a unique resistance to ionizing radiation up to 20 kGy. The active very fast repair of radiation induced DNA damage can be investigated via PCR-based RAPD technique (randomly amplified polymorphic DNA). Due to the fact that *I. hospitalis* is able to withstand these high radiation doses the next step is to identify the genes which are involved in damage repair. In the genome of *I. hospitalis* only a few repair genes have been found, some of them are coding for proteins related to bacterial repair enzymes, others are related to eukaryotic repair enzymes. They turned out to be only slight upregulated during repair (qRT-PCR). So far, there is no complete repair machinery detected. Further studies should be focused on the more detailed characterisation and analysis of the repair processes. This can be achieved on the transcriptome level by use of a commercial microarray system available for *Ignicoccus* to find out which genes are active during repair after irradiation. Subsequently, on the proteom level repair associated proteins can be identified and characterised (n-terminal sequencing and mass spectroscopy).

On Mars the availability of different chemical compounds that can be used as nutrients in form of electron donor and acceptor pairs is limited. The Phoenix lander and the Curiosity rover detected significant amounts of perchlorate ions in Martian soil. Therefore, the examination of the perchlorate metabolizing archaeon *Archeoglobus fulgidus* as well as phylogenetically deep-branching bacterium *Hydrogenothermus marinus* to survive and grow in the presence of perchlorate is of high interest. These microorganisms were able to tolerate high concentrations of perchlorate without any changes in their growth pattern. After cultivation in the presence of 400 mmol/l of perchlorate *H. marinus* showed significant changes in cell morphology. This organism is normally growing as single motile short rods; treated with perchlorate long chains of still living were built. The underlying molecular mechanisms and changes are completely unknown and should be analysed further.

In summary, hyper-/thermophiles exhibit unexpected high tolerances against cell damaging treatments. The molecular basis for this is not yet fully understood. Due to the position of Archaea in the tree of life between Bacteria and eukaryotes, i.e. higher organisms, Archaea can be seen as less complex models for eukaryotic systems. Expected results of new or so far unidentified repair systems could contribute to improve the health of human exposed to radiation e.g. in space.

Fig. 1: *Archeoglobus fulgidus* (Syst Appl Microb. 10:172-173 (1988))

Fig. 2: *Ignicoccus hospitalis*; Scale bar 1 μm (PNAS 105:7625-7626 (2008))
Since human space exploration began, microorganisms have traveled with us and are ubiquitous throughout the spacecraft. A major risk for astronauts during prolonged space flight is (a bacterial) infection as a result of the combined effects of microgravity, situational and confinement stress, alterations in food intake, altered circadian rhythm, and radiation that can significantly impair the immune system and the body’s defense systems. Previous studies have demonstrated that bacteria and fungi, including potential pathogens, were commonly isolated in the air, water and on surfaces aboard the Mir Space Station and the International Space Station (ISS). Here, it is important that timely information about the concentration of potential pathogenic bacteria or fungi in the ISS are made available, since those microorganisms present a threat to the integrity of the health of the astronauts manning the space station and the components of the space station itself. Fungal strains have been detected on the ISS multiple times as actively growing molds on the environmental surfaces or responsible microorganisms deteriorating the components of ISS hardware. The abundance of the fungal molds in indoor environments was reported to be associated with invasive infections and allergies. Therefore, a high number of fungal isolates from the ISS locations confirmed a need for continuous monitoring of the ISS for fungal populations. Aspergillus niger was found to be one of the predominant isolate, and although it does not have the potential to cause disease at the same rate as other Aspergillus species (A. fumigatus, A. flavus), it was correlated with pulmonary and ear infections. Aspergillus species are repeatedly isolated in indoor microbiomes. The detection of multiple isolates of A. niger is consistent with its frequent presence in built environments including ISS surfaces. However, its survival capability, proliferation, and molecular alteration in response to ISS microgravity conditions need to be studied further. On the other hand, A. niger is known for production of many beneficial substances. The potential for production of novel beneficial secondary metabolites under microgravity conditions could also be of interests in diverse biotechnological and pharmaceutical fields.

Aim of this PhD thesis to perform systematic investigations on the survival capability, proliferation, and molecular alteration of A. niger in response to spaceflight relevant conditions such as microgravity or intensive UV and ionizing radiation exposure. The major goal is to evaluate the microbial and medical risks potentially originating from the fungal model system and know spaceflight contaminant. Within this PhD thesis an integrative approach using common microbiological, molecular biological and genetic methods (such as different ~omics) will be applied.
The department of Cardiovascular Aviation and Space Medicine studies acute and chronic effects of environmental factors on the human cardiovascular system. We apply state-of-the-art methodology to elucidate functional and structural changes of heart and vasculature in highly controlled, complex experimental human investigations including high altitude, real- and simulated weightlessness, and artificial gravity. Gender, age, early stage cardiovascular diseases as well as genetic and epigenetic factors modulate individual cardiovascular responses to the environment. To better understand these interactions, we investigate individuals with defined genetic variants or rare autonomic nervous system disorders.

In particular, we are interested in autonomic nervous system mechanisms regulating cardiovascular function. Increased sympathetic activity is a major contributor to cardiovascular diseases and an independent risk factor. Changes in autonomic cardiovascular control during short- and long-term weightlessness may predispose to post flight cardiovascular disturbances. We develop new approaches of measurements of muscle sympathetic nerve activity by microneurography to improve cardiovascular monitoring and therapy.

For your thesis you will learn methods to study the autonomic nervous system and especially the technical principles of microneurography. You might also participate in data acquisition and data analysis during experimental clinical studies or, if an opportunity arises, in an experiment during simulated (bedrest study) or real weightlessness (parabolic flight). With your thesis you can contribute to the improvement of the acquisition hardware, enhance the capabilities of currently available biosignal analysis tools, and provide deeper insight into autonomic cardiovascular control mechanisms.

Figure: Microneurography of the right peroneal nerve (left), parabolic flight experiment (middle), and a head down tilt experiment combined with lower body negative pressure (right).