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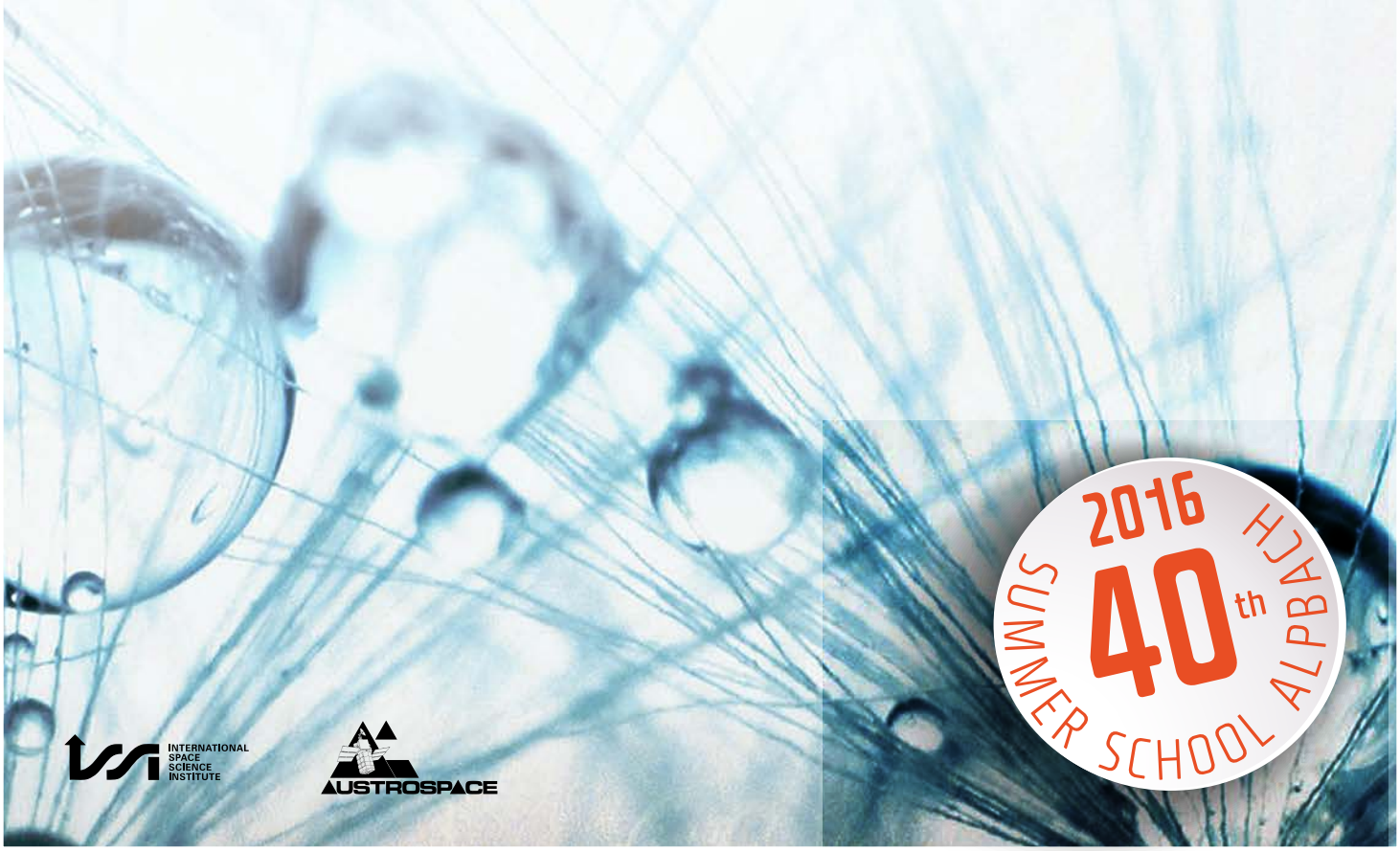
Research Promotion Agency

The Summer School Alpbach – A Research and Education Lab for Space Science and Technology

On the occasion of its 40th edition



INTERNATIONAL SPACE SCIENCE INSTITUTE

AUSTROSPACE

Content

IMPRINT
The Summer School Alpbach is organised by the Austrian Research Promotion Agency (FFG) and co-sponsored by the European Space Agency (ESA) and the national space authorities of its member and cooperating states. A traditional partner is the International Space Science Institute (ISSI). It is also supported by Austrospace, the association of Austrian space industries and research institutions.

www.summerschoolalpbach.at

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Combining Tradition, Science and Technology

Jörg Leichtfried

Austrian Federal Minister for Transport, Innovation and Technology

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Over the past decades Austria has developed into a respected aerospace location. As part of its portfolio, the Federal Ministry of Transport, Innovation and Technology invests around EUR 70 million in the space sector annually, the majority of which is allocated to programmes and projects run by the European Space Agency (ESA). Over 100 research institutions and companies and more than 1,000 employees are active in this field, generating an annual turnover of around EUR 125 million. More than 1,000 scientific publications are evidence of Austria's innovative capacity in this sector.

Austrian institutes and companies play an important role in many ESA missions such as the new Galileo satellite navigation system, the Rosetta mission, the Copernicus Earth observation programme, and many earlier missions. Austrian contributions range from control systems, measuring equipment, thermal insulation for satellites and systems for ground stations or the evaluation and application of satellite data for scientific and commercial purposes.

The Space Summer School Alpbach plays a major role in Austria's space activities. With some 4,000 participants to date, both lecturers and students, it has provided an important impetus for training young scientists, and has acted as a springboard to a career in the space sector for many of them. At the same time the Summer School has given rise to new research projects and satellite missions. Consequently, the Summer School is, and has been, both an educational event and the perfect environment in which to develop, discuss and try out new ideas. Thanks to its unique format, the Summer School also contributes to strengthening Austria's reputation as a location for aerospace activities.

The uniquely innovative spirit of Alpbach

Jan Wörner

Director General of the European Space Agency, ESA

© ESA Philippe Sebirot

The Alpbach Summer School is more than just a nice place to stay and learn. It is an institution that lies at the heart of European space-related activities and plays an important role in advancing the European spirit as students from all over Europe come together to develop new ideas in one or other space subject. In so doing, they are taking part in a highly enriching form of interaction beyond national borders and the simple expression of synergy, 1+1 › 2 becomes reality.

In addition to this important interaction, its role in preserving the peace in Europe and its uniquely innovative spirit, a further aspect of the Summer School seems important to me: we are currently facing a series of very challenging situations in the form of climate change, economic crisis, terrorist attacks and migration. The existence of these crucial challenges and the vast scope of the internet pose some risks to the development of our society, which can at times be expressed in frustration boiling over and an over-concentration on individual advantage. The Alpbach Summer School undoubtedly does a great deal to counter this through the fascinating topics it addresses while also bringing about intensive cooperation among very diverse young people. If the Alpbach Summer School did not already exist, I would strongly argue for it to be established as soon as possible. In my view, we should also consider the ideas and results produced by the students when developing the future programmes of ESA. Let us make every effort to incorporate this perspective in the Summer School programme.

I thank all those who make the Alpbach Summer School a reality and I am looking forward to interacting with the students.

Strengthening the Austrian Aerospace Cluster

Henrietta Egerth and Klaus Pseiner

Managing Directors of the Austrian Research Promotion Agency (FFG)

© FFG Astrid Knie

The Austrian Research Promotion Agency (FFG), through its Aeronautics and Space Agency (ALR), functions as the "docking station" to the international aerospace industry for Austrian business and science. Its aim is to strengthen the international standing of Austrian business in these key technologies, and to develop a sustainable Austrian aerospace cluster.

The FFG is using a variety of means to achieve these goals. It implements national aerospace policies, and represents Austria on the corresponding international committees. It manages Austria's space programme, supports the involvement of Austrian scientists in both international and bilateral collaborations, and drives the organisation and development of international networks. Many of these activities take place in cooperation with the European Space Agency (ESA).

ESA is also one of the partners organising the Space Summer School in Alpbach. Since 1975 the FFG, and its predecessor organisation the ASA, has hosted this unique training event for junior scientists. Here, for a period of ten days and under the guidance of international experts, participants learn about the basic principles of complete satellite missions based on current challenges and issues.

Consequently, the Summer School Alpbach is an important constituent in the FFG's portfolio for the development of human resources in research. It supports the international networking of national research and the transfer of technology, and strengthens Austria as a space research location. It also contributes towards more firmly anchoring space as a subject in universities, research institutions and business.

The Summer School Alpbach is organised in close cooperation with the European Space Agency and its member states. Partners include the International Space Science Institute (ISSI) and Austrospace, the Association of Austrian Space Industries. Special thanks are owed to the many international experts who work with the students in their role as lecturers and tutors.

Developing a whole satellite mission in just ten days

Michaela Gitsch

Director of the Summer School Alpbach

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The Summer School Alpbach offers an intensive advanced training and working experience for European graduates, post-graduate students, young scientists and engineers in the field of space science and space technology. 60 students in four teams are conceiving innovative satellite missions concentrating on current topics of European interest. Until now, almost 4000 participants among them Nobel prize winners and other distinguished scientists, leading space experts and astronauts attended the Summer School as students, tutors or lecturers. For many of the participants, the Summer School Alpbach was a first step in a distinguished space career.

The purpose of the Summer School is to foster the practical application of knowledge derived from lectures, to develop organisational and team-work skills and to encourage creativity. Participants attend stimulating lectures on various aspects of space science and technology and work intensely within a smaller group to define and design a space mission, all under the supervision of noted scientific and engineering experts within the field. Teams compete to execute the best project, judged by an independent jury. The teams themselves are responsible for the selection of the subject of the project and for the team structure and working methods.

But the Summer School Alpbach is much more than just another summer course. The selected topics are always inspired by ESA's programmes and plans and are discussed within the Alpbach programme committee with representatives from ESA, CNES, DLR and are chosen in line with the ESA Science and Earth Observation programmes. Current and future ESA missions provide a realistic framework for Alpbach students to identify and develop new ideas and mission proposals. The missions developed in Alpbach have attracted the attention of ESA many times and a variety of papers and posters have been published during the past years, providing fruitful ideas for European space science and technology. And the Summer School Alpbach has become very popular: The enthusiasm from the academic communities in Europe has also steadily increased over the years.

Programme and goals

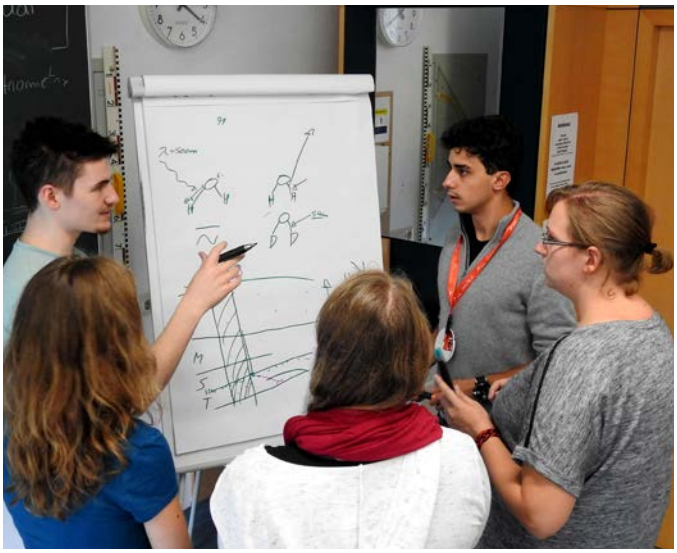
The student teams define the scientific objectives of a space mission and provide a preliminary end-to-end design of spacecraft, scientific instruments as well as mission and science operations that will meet their stated objectives. The teams are responsible for selecting and researching the problem to be addressed by their space mission, for building a strong spirit of cooperation among team members to meet difficult deadlines, and for developing their own working style. They also need to balance scientific objectives and requirements with the realistic constraints of mission-design, spacecraft-design, and mission cost.

Four teams are guided by experts who act as tutors for these workshops. The lecturers also participate in the workshops and thus establish a close relationship with the students in providing assistance in the definition of the missions to be designed. The results of each workshop team are presented to an international jury.

To get the students started they have many lectures on scientific and technical topics given by experts in the field. On top of that, the teams have a large team of tutors to support and help them throughout the summer school. Each team has a science and an engineering tutor assigned directly to the team. Their task is essentially to help and guide them along during the workshop. The tutors should not do the work for the students, but provide information and support. This support can be as simple as providing a literature reference or pointing out an expert to ask, but can go as far as lending a shoulder to silently cry on or in rare cases cracking the symbolical whip when things go really awry. In the words of a former head tutor: "Keep them happy and productive!"

Apart from shaping a formal team structure, it takes usually some effort to bring scientists and engineers together, since at this stage of their careers they are to a large extent still trapped inside their respective worlds and not really used to talk to each other. Because of the complex nature of the space mission they set out to design, this requires an interdisciplinary effort. A close cooperation of engineers and scientists is the only way to cope with the challenge. This is possibly one of the most important lessons of the Alpbach Summer School.

In the early days of the Summer School proceedings were published by ESA containing lecture material. With the start of the workshop activities the results of the mission studies of the students (a power point presentation and a report) were published on the website of the Summer School Alpbach as well as on the ESA Education website. During recent years a variety of scientific papers and posters had been published which is an excellent advertisement for the very high standard that's achieved by the students in Alpbach.



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Students at work

Post Alpbach is an add-on to the Summer School Alpbach, introduced in 2009 by FFG to carry on with one of the Alpbach missions which was found best suited by the Alpbach Jury. All Alpbach students are invited to apply. 15 of the Alpbach students are being selected each year and provided with an ESA grant to attend the workshop, with the possibility of eventually presenting a paper at a scientific congress and/or in a scientific journal.

© Leopoldina Markus Scholz

Wolfgang Baumjohann,
Director Space Research Institute Graz, Summer School Vice-Director

Forty years ago, I had just finished my physics diploma (about seismic waves) and started my PhD in space physics. If I only had known about the existence of the summer school, I might have been one of its first students (and would have learned a lot). As it turned out, my first contact with the summer school, 30 years ago, was as a lecturer. During all these years I have seen the Summer School evolve. Improving both the settings and the curriculum, together with top European scientists and engineers as lecturers and tutors, is what has made the Alpbach summer school so successful and now a fixed point in European space education. Every year, there are twice as many applicants as places for students and the ones selected suddenly find themselves working day and night for ten days. However, few complain of the hard work, there is always a lot of praise from the students. They like the challenge and the hands-on experience, the chance to successfully develop their own space mission. Some teams have been so successful that their mission concepts are mirrored in actual missions planned by ESA or national agencies.

Max Kowatsch,
President, AUSTROSPACE

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Since the first summer course in 1963, this outstanding opportunity for advanced training in space research has brought together enthusiastic graduates and post-graduate students from around the world in the inspiring environment of the Alpbach village.

AUSTROSPACE, the association of Austrian space industries, has been pleased to co-sponsor the summer school Alpbach for more than 10 years, considering its program as a very valuable contribution to the curriculum of potential high achievers in academia and the space industry. We are convinced that there will be no lack of fascinating challenges for the next generations of space researchers, and we look forward to continuing the support of this highly appreciated initiative in the future.

> *"To get the same quality of work from an industrial contractor would have needed several months and millions of dollar"* *Roger Bonnet*

The history of the Summer School

The concept of the Summer School is unique, best practice and an indispensable pillar of team-oriented space education and training. Through all the years a continuous stream of Summer School graduates found their way into this flourishing Austrian and European space environment.

Years before the first Austrian-developed equipment for scientific experiments flew into space aboard a sounding rocket in 1969, the predecessor of the Summer School started off in 1963 in the village of Erwin Schrödinger. It was at an early time of space activities in Europe and the first time that such a summer course was held on the subject of space physics. The idea to organise Summer Schools in Alpbach for European students was conceived in 1963 by Johannes Ortner. The first two Summer Schools in Alpbach were organised in the framework of the Preparatory Commission (COPERS) of the European Space Research Organisation (ESRO). It was the first time, in 1963 and 1965, that such summer courses were held in Europe on the subject of space physics. Thanks to an invitation from the Austrian Government, these lectures were given in the College House of Alpbach, Tyrol.

The 1970s were fruitful times on both the national and European level. The Austrian Space Agency was founded in 1972 and ESA in 1975. Austrian space activities were boosted by the activities of the Space Research Institute of the Austrian Academy of Sciences in Graz, founded in 1970. Austria's ambitions and further development of space activities quickly resulted in close cooperation with ESA. In 1981 Austria joined the Agency as an associated member, followed by full membership in 1987. Since that time Austrian research institutes and companies have been actively involved in the development of space missions, providing instruments as well as components of satellites and launcher systems, and developing useful space-based applications.

In 1974 Johannes Ortner created an annual Summer School in Alpbach to train Austrian specialists in different subjects of space research. The first Austrian Alpbach Summer Schools were jointly organised by the Austrian Space Agency, the European Space Agency (ESA) and partners in Germany, Norway and Switzerland, then later also with France, the Netherlands, Sweden and finally with all member and cooperating states of ESA. Austrospace, the association of Austrian space industries and research institutions, came on board as co-sponsor in 2004. The International Space Science Institute (ISSI) joined the effort in 2006 and has contributed tremendously to the harmonization of the lecture programme by providing a Scientific Coordinator.

Starting with the late George Scoon and Robin Laurence as pionieering tutors in 1995, the tutorial leadership has greatly contributed to the raising of the standards. The Summer School had the privilege to engage outstanding Head Tutors in Alpbach during the years, namely, Eamonn Daly, Martin Turner (t), André Balogh and Peter Falkner.

© Böglerhof

The Duftner Family, Hotel Böglerhof

40 years of Summer School Alpbach and Hotel Böglerhof is a long-standing and happy relationship. It is a great pleasure and an honour for us to see, over the years, students themselves become teachers, guests from the early days become regulars and even friends with whom we always enjoy a good discussion. The Summer School is an excellent training ground for the European space research and technology sector. The participants develop and present solutions together, creating a culture that is simply exemplary.

No.	Year	Topic
1	1963	Solar-Terrestrial Relations
2	1965	Electromagnetic Radiation in Space
3	1975	Remote Sensing of the Earth
4	1976	Practical Application of Remote Sensing
5	1977	Satellite Meteorology
6	1978	Manned Space Activities
7	1979	Space Astronomy and Astrophysics
8	1980	Research under Microgravity
9	1981	The Solar System and its Exploration
10	1983	Remote Sensing
11	1984	Utilisation of Platforms in Space (cancelled)
12	1986	Space Astronomy and Solar System Exploration
13	1987	Space Science and Fundamental Physics
14	1989	Remote Sensing and the Earth's Environment
15	1991	Global Environment: Processes and Monitoring from Space
16	1992	Infrared Astronomy and Cosmology
17	1993	Comparative Planetology
18	1994	Solar Terrestrial Relations
19	1995	Horizon 2000 Plus
20	1996	Mission to the Moon (Science of and from the Moon)
21	1997	Fundamental Physics in Space
22	1998	Our Solid and Liquid Planet
23	1999	Mars
24	2000	Extragalactic Astronomy and Cosmology from Space
25	2001	Satellite Navigation Systems for Science and Application
26	2002	Space Weather: Physics, Impacts and Predictions
27	2003	Living and Working in Space: from ISS to Moon and Mars
28	2004	The Birth, Life and Death of Stars
29	2005	Dark Energy and Dark Matter in the Universe
30	2006	Monitoring of Natural Hazards by use of Space
31	2007	Astrobiology: Life detection in and from space
32	2008	Sample Return from Moon, Asteroids & Comets
33	2009	Exoplanets: Discovering and Characterizing Earth Type Planets
34	2010	New Space Missions for Understanding Climate Change
35	2011	Star Formation Across the Universe
36	2012	Exploration of the Giant Planets and their systems
37	2013	Space Weather: Science, Missions and Systems
38	2014	Space Missions for Geophysics of the Terrestrial Planets
39	2015	Quantum Physics and Fundamental Physics in Space
40	2016	Satellite Observations of the Global Water Cyle

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Johannes Ortner, Founder of the Summer School Alpbach

In the early sixties the idea came to my mind of organising summer courses for European students in Alpbach, Austria. I had known this place from the European Forum Alpbach which was created after the 2nd World War to promote the creation of a joint Europe. Alpbach was an ideal meeting place: it was a most beautiful remote Tyrolean village where participants could be staying close together for a certain period of time without the possibility to escape.

Markus Bischofer, Mayor of Alpbach

© Gemeinde Alpbach

Some 40 years ago now, here in Alpbach, on a sunny plateau in the Alpbach valley, professors and students gathered for the first Summer School Alpbach (ASA and ESA) and found the village held a special charm that has kept them coming back ever since. Maybe it was and of course still is something to do with the Alpine scenery, or the ideal location for developing projects or the opportunities to learn in what has become known as the "village of thinkers". In my capacity as mayor of Alpbach, I wish the Summer School all the very best for the future.

The Alpbach Miracle

Roger Bonnet

President of the Summer School Jury, ESA Director of Science (1983-2001), ISSI Executive Director (2003-2013)

© Wu Ji

At each step in the preparation of the School, a miracle occurs. It starts with the elaboration of the program in the course of the one-day first meeting of the Program Committee where every year there are new members because there are no two successive Schools on the same topic; some of them are familiar to me, some others are unknown.

The second miracle occurs in the first days of the School when the sixty selected students are confronted to their future team colleagues and to their respective tutors, those who during the next ten days will help them in their work. The teams are formed out of a random selection of 15 students, each team being responsible for formulating one of the four space missions that should be produced at the end of the School. Most of them, when they arrive in Alpbach, do not know much of the subject, don't know their tutors and don't know their team colleagues. Out of these unknowns, they have to create, in less than ten days, the concept of a mission at a level that I would call a pre-phase A, while attending the daily scientific and technical lectures that provide them the main elements from which to develop their mission.

All these years, the creativity of the teams has always impressed me very much. The Jury has of course the delicate task of judging the accomplishments and the respective merits of each proposed mission concept. Usually, Juries would select a "winner" out of four competitors. In Alpbach, this would leave one team happy while the three others would be disappointed. In the Summer School, where all teams work equally hard with great motovation, it is important that all students leave proud of their work and achievements and motivated by their experience in their future careers. I was not happy that the Jury should only select one "best" project from the four on offer and this is why we introduced the "Oscar Approach".

This way, each team would be judged in four different categories: one Oscar each for the best science case, the best technical end engineering approach, the best presentation of the team's work and the best competitive and original mission. Of course, it is not infrequent that a single team would get two Oscars. But there are other criteria by which to reward success; these can be decided by the Jury and its Chairman, as well as by the Head Tutor of the Summer School. A particularly good example of such an extra Oscar might reward a team who had to overcome the greatest challenges of organising themselselves into an effective project team. This is also part of the Alpbach tradition: by the customary miracle, the teams generally develop excellent mission proposals, but sometimes their struggles to achieve this are harder – paralleling the typical, real-life struggles to a successful space mission.

© Josef Bletzacher

Josef Bletzacher,
Headmaster NMS Alpbach

For the organisers of the Summer School Alpbach, the event's 40th anniversary is undoubtedly a confirmation of their innovative engagement over a significantly long period of time. For the village of Alpbach and parts of its population, this learning opportunity provided by the European space science sector has over the past forty years developed into a well-established institution.

In this spirit, I wish the Summer School organisers and participants in the decades many successful and happy "landings" in Alpbach, productive conferences and many lasting and positive memories of Alpbach.

Georg Hechenblaikner,
Alpbach Tourismus GmbH,
Congress Centre Alpbach

© Hannes Senfter

Alpbach is a very special place. Awards for "Most Beautiful Floral Village in Europe" or "Austria's Most Beautiful Village" bear witness to the unique character of this Tyrolean mountain village. Alpbach is, however, also known as "The Village of Thinkers". Alpbach gained this reputation thanks to the conference and meeting participants, the many Nobel Prize winners, world class scientists, philosophers, business leaders or politicians who have been regular visitors here. The Summer School Alpbach has indeed played an important role. This year's 40th anniversary bears testimony to the longstanding association between the organisers, participants, speakers and the people of Alpbach.

What makes the Summer School special

André Balogh

UK/ISSI, Scientific Coordinator of the Summer School Alpbach

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The choice of a different topic every year reaches a different community of young scientists and engineers. This is possible because, over the past decades, space systems revolutionised a very broad range of sciences and introduced applications that are now part of everyday life. This means that not only the students are all new every year, but also that for many of the teaching staff it is often their first experience of the Summer School.

The format of the Summer School has evolved over the 40 years as the organisers have always been open to suggestions for improvements. It has to be said, however, that the underlying stability of the Summer School format and the very careful preparations each year have enabled the new arrivals to dive straight into the deep end and start swimming!

One of the most remarkable features of the Summer School is the way the students bond. The sixty students, who don't know each other on arrival, fit together very quickly, in no more than a day, in the four teams to which they have been assigned. This is an achievement that is transparent to the students, but is made possible by the thoughtful pre-selection of the teams. The teams, despite the diversity of the students, quickly form very efficient project-oriented structures that lead to what is always an amazing experience of the finished project presentation only ten days after arrival in Alpbach.

In in the two short weeks of the Summer School a strong community is formed each year. The end result, imaginative and well-thought out proposals for future space missions always impress very strongly the experts of the Summer School Jury and all the Summer School participants. The Summer School Alpbach has a Europe-wide, indeed worldwide reputation.

© Michel A. Iakob

The opening of the 40th Alpbach Summer School in Summer 2016. On this occasion EURISY awarded the Hubert Curien Prize to the organisers of Alpbach Summer School. In the picture (from left to right): Peter Falkner (ESA, Head Tutor), André Balogh, (ISSI/ Imperial College London, Scientific Coordinator of the Summer School Alpbach), Ambassador Peter Jankowitsch, Michaela Gitsch (FFG), Johannes Ortner (Founder of the Summer School), Dominique Tilmans (EURISY President), Andreas Geisler (FFG), Jan Wörner (ESA Director General), Wolfgang Baumjohann (Director, Space Research Institute OeAW), Pascale Ehrenfreund (Chair of the DLR Executive Board), Klaus Pseiner (Managing Director of the Austrian Research Promotion Agency FFG, Vice Chairman of the ESA Council), Stephaan de Mey (EURISY Secretary General).

Earth Observation – Monitoring the Earth for mutual benefit

Earth Observations from space provide essential information to forecasting the weather, assessing environmental hazards, managing natural resources, and improving our understanding of climate. The need for understanding environmental dynamics is even more urgent nowadays than ever.

In recent years, Earth observation has become technologically increasingly sophisticated. Comprehensive, long-term measurements made by satellites allow us to monitor a wide range of parameters about the Earth system, regularly and repeatedly over many years. Policy makers, the general public, the administration, the industry and research circles are highly dependent on up-to-date information on the state of the environment.

Earth observations can be applied to a wide variety of possible uses, such as forecasting weather, tracking biodiversity and wildlife trends, measuring land-use change (such as deforestation), monitoring and responding to natural disasters, including fires, floods, earthquakes and tsunamis, managing natural resources, such as energy, freshwater and agriculture, addressing emerging diseases, predicting, adapting to and mitigating climate change and monitoring migration.

The history of Earth observation by satellites started in 1972 when NASA launched Landsat 1 to monitor Earth's land areas. Landsat images depicted large areas of the Earth's surface in several regions of the electromagnetic spectrum, including both the visible and the near-infrared, and at spatial resolutions useful for many practical applications, such as assessing land cover and use.

In the seventies Europe also turned to this issue. Consequently the topic of the third Summer School Alpbach 1975, was "Remote Sensing of the Earth" and the topic of the Summer School 1977 was "Satellite Meteorology". The Summer School programme promised "a tremendous improvement in our ability to observe such physical physical processes and the behaviour of the atmosphere" for the future. – Expectations were high and reality proved even better.

In November 1977 Europe's 1st geostationary weather satellite, Meteosat 1, was launched. In 1983 the Alpbach Summer School again picked up the topic "Remote Sensing", 1989 it was "Remote Sensing and the Earth's Environment" and in 1991 "Global Environment: Processes and Monitoring from Space". During these years, ESA's first remote sensing satellite ERS-1 was in the design phase. Finally in 1991 the satellite ERS-1 was launched, which carried a comprehensive payload including an imaging synthetic aperture radar, a radar altimeter and other powerful instruments to measure ocean surface temperature and winds at sea. ERS-2, which overlapped with ERS-1, was launched in 1995 with an additional sensor for atmospheric ozone research. At their time of launch the two ERS satellites were the most sophisticated Earth observation spacecraft ever developed and launched by Europe.

In the following years, ESA's Earth Observation programme developed a rich menu of missions to assess aspects of climate change. Copernicus – the new name for the Global Monitoring for Environment and Security programme – startet in 1998. It is the most ambitious Earth observation programme to date, consisting of 30 satellites and in situ sensors. It will provide accurate, timely and easily accessible information to improve the management of the environment, understand and mitigate the effects of climate change and ensure civil security.

Earth Observation remained an important topic for the Alpbach Summer School, when an earthquake triggered a series of lethal tsunamis in 2004. In 2006 the Alpbach Summer School addressed the challenge with the topic "Monitoring Natural Hazards by use of Space", followed by the topic "New space missions for understanding climate change" in 2010. In 2016 the Alpbach Summer School adressed the topic "Satellite Observation of the Global Water Cycle". Students were expected to propose missions that will provide new observations on the different facets of the water cycle.

© ESA

Copernicus is the worlds largest single Earth observation programme and a joint initiative of the European Union (EU), the European Space Agency (ESA), the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), and their member states. Seven Sentinel missions provide data to Copernicus, including radar and super-spectral imaging for land, ocean and atmospheric monitoring. Each Sentinel mission is based on a constellation of two satellites.

Josef Aschbacher

Josef Aschbacher was appointed as ESA Director of Earth Observation in June 2016. Earth Observation is the largest item and accounts for approximately one third of ESA's budget, 1.6 Billion Euro in 2016.

© ESA

I have a very close connection to Alpbach and its Summer School, in many ways. First, I was born and raised near Alpbach, in a similarly small and charming Austrian mountain village, only a 30 minutes car drive away. Second, during my university studies I was passionate about physics, in particular the theories of relativity, the uncertainty principle and quantum mechanics discovered in the early-mid twentieth century by Einstein, Heisenberg and Schrödinger. Erwin Schrödinger, a Nobel-prize winning Austrian physicist in quantum theory, is buried in Alpbach. And third, the Alpbach Summer School severely shaped my professional career. Let me explain.

I was studying meteorology and geophysics at the nearby University of Innsbruck and specialised in remote sensing. During my MSc and PhD studies my professors, Hans-Jürgen Bolle and Helmut Rott, brought me along at several Summer Schools to listen to the fascinating lectures by some of the best experts in their field. Meeting and exchanging ideas with students from many different countries and cultures, who are all eager to learn the latest about space, was a fascination in itself.

In 1989, the last year of my PhD studies, I was looking for a job. And there was no better place than to try my luck at the Alpbach Summer School. I had the fortune of meeting Luigi Fusco from ESA, who was giving lectures there. Although I knew his name well through my work on some ESA projects I was working on, I met him face-to-face for the first time in Alpbach. Asking quite directly whether there are any job openings at ESA, he offered me, on the spot, to apply for a Young Graduate Traineeship at ESA ESRIN. The plan was to get acquainted with ESA for one year and afterwards move to Bangkok, Thailand, to teach radar remote sensing and image processing at the Asian Institute of Technology as well as representing ESA's interests in SE-Asia.

A few months later, even before my official university graduation ceremony, I already moved to Frascati and got fully immersed in a completely new world: an international environment, working in my dream discipline of space, struggling with English as working language and adapting to a new culture in Italy. One year later I moved to Bangkok, worked there for three years, moved to Ispra, Italy, to work for the European Commission for seven years, moved to Paris to work at ESA HQ and, after another seven years, moved again to Frascati to work at ESA ESRIN, where I am still posted today.

Throughout my 25 years working abroad now, I regularly returned to the Alpbach Summer School, as lecturer, tutor and jury member.

© FFG

Few months before Europe's 1st geostationary weather satellite was launched, Alpbach Summer School was dedicated to "satellite meteorology".

Discovering new worlds

Human spaceflight is one of the great achievements of the modern age and technology. Since the first manned venture into space in 1961, more than 500 men and women have flown in space. Twelve men explored the surface of the moon.

© NASA

ISS

As long as human beings fly into space the practical expense, costs and difficulty of maintaining the human body in space is discussed. Especially in comparison to the relative ease of operating a machine in space, it has been argued that space science can be done most effectively and efficiently through the use of robotic probes.

Nevertheless, different manned spaceflight missions have been carried out. After the Apollo program, which accomplished landing the first humans on the Moon from 1969 to 1972, the United States developed the Space Shuttle program. The Space Shuttle was a partially reusable low Earth orbital spacecraft system. Five complete Shuttle systems were built and used on a total of 135 missions from 1981 to 2011.

While the Space Shuttle program was conducted by NASA, the Spacelab was developed in collaboration by NASA and ESRO (the predecessor of ESA), starting in 1973. Spacelab was a reusable laboratory used on certain spaceflights flown by the Space Shuttle.

In 1996 the Summer School again addressed the question of human spaceflight. Experts and students focused on the Moon's rich potential as a scientific outpost and natural Space Station. There were two issues: science of the Moon, including geophysical, geochemical and geological research on the Moon as a planetary body, leading to a better understanding of the origin of the Earth-Moon-system. And science from the Moon, taking advantage of the stable lunar surface, its atmosphere-free sky and, on the far side, its radio-quiet environment. The participants of the Summer School were challenged to build build a small lunar orbiter. The LunarSat Proposal was the answer of the Alpbach participants to this challenge, later published in Lunar and Planetary Science. Another student group presented a concept of a lunar rover "Mondwalze SCOUT".

In 1999, the Summer School headed towards to Mars. The students were set the task of defining a future Mars exploration mission. Having studied a variety of possible missions to Mars, the students proposed the use of an airship or Zeppelin, as a highly versatile vehicle for exploring the Red Planet. The novel idea of using a Zeppelin provides for three dimensional steering and a choice between sojourning at an interesting spot, and travelling for surveying the lanscape or to visit another location. The work of the students led to an article issued in the ESA Bulletin in 1999.

In 1998 the first components of the International Space Station were launched. The ISS is one of the most complex and expensive engineering projects ever undertaken. It is a joint project among five participating space agencies. In 2003 the Alpbach Summer School addressed the topic "Working and living in Space: from ISS to Moon and Mars". The partcipation of two astronauts, Claude Nicollier (ESA) and Chiaki Mukai (NASA) in the Summer School brought first hand experience of living and working in space to the students.

The work of the students culminated in the design of four space missions, one of them was an early manned mission to Mars: project M3: Building Orbiting Stations Around Mars: This project was subsequently submitted to ESA's Aurora Student Design Contest and was selected to be among the finalists of the contest and was presented at the Aurora Academia Workshop in September 2003.

What makes a space mission a good one? In reality and for the Alpbach students

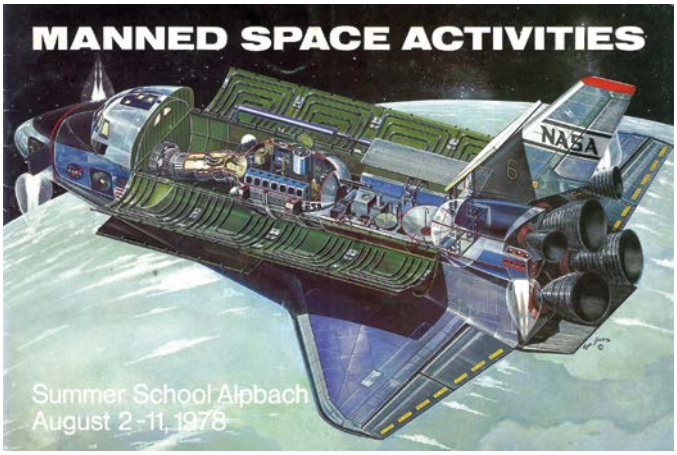
Roger Bonnet

Chairman of the Jury

© Wu Ji

A good space science mission is one that aims at breaking through the barriers of scientific knowledge. It is one that calls upon the best brains on Earth so that it opens its development and exploitation to international cooperation. It is one that its architects are ready to fight for, from the first concept through its development onto its operations in orbit. One they are proud of, that they will defend against competitors, that will enthuse the community that it serves and possibly others. A good application mission is one that offers better or new services to its users and possibly at a cheaper price. For each one of these two categories, a good space mission is one that rests on both innovation and conservatism in the search for competitiveness, be it in scientific research or in commercial activities; innovation because new technologies and techniques generally open the way to new or better observations and to better and cheaper services yet unreached; conservatism because some of the critical systems or subsystems that enter into the development of the mission may not afford innovation and should rather rely on well proven reliability, as they may represent potential single-point failures possibly leading to the loss of the full mission. It is also one for the development of which its managers take due account of the lessons learnt from similar missions, those that have failed as well as those that have fully succeeded, and one that is affordable in the limits imposed by budget and schedule constraints.

For the Alpbach students, the requirements to make a space mission a good one should consider all of the above as elements that the Jury will evaluate, emphasizing the need to identify clear objectives, and to rest on techniques adapted to these. Of course, a good space mission should be the fruit of imagination in all domains, scientific or technical. A mission that may surprise the Jury by its originality, and convince its members that something new has been created, that the responsible team is able to describe, and explain what its objectives are and how to fulfill these, and to clarify all remaining obscure points that the Jury may raise in the course of presentation, is a good or even an excellent Alpbach mission. However, above all, remembering that the Alpbach Summer School is indeed a School, a good Alpbach space mission is one that would allow the students to learn. To learn how to build a space machine responding to its fundamental objectives within realistic limits in the respect of the constraints that all professional managers are confronted to: budgetary, calendar, and reliability. To learn how to work together in a team spirit, extracting the best of all students involved. One that will allow these new talents to sooner or later become part of the space community, remembering the Alpbach summer school experience as a unique opportunity, rich of promises to make their first steps in space!



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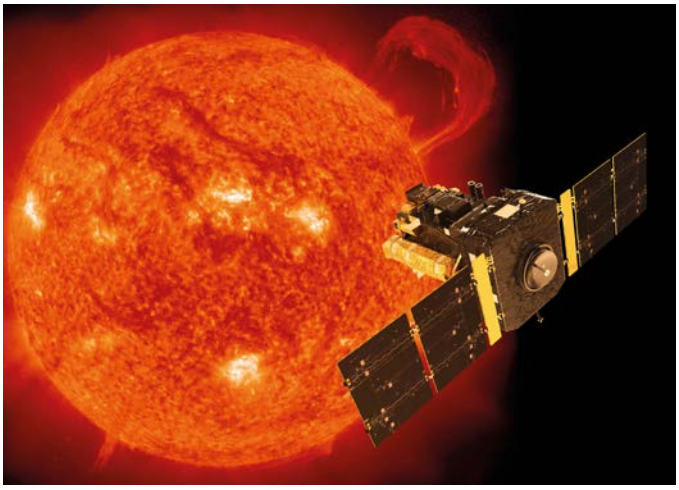
The topic of the Alpbach Summer School 1978 was "Manned space activities" and it was dedicated to the development, integration and operation of experiments and payloads for the Spacelab. Six special areas of Spacelab utilisation had been chosen: space plasma physics, astrophysics, material sciences, Earth observation, life sciences and technology.

Our Solar System – A special long-distance Relationship

During the last millennia humankind created many myths and legends in the attempt to understand our solar system and the solar-terrestrial relations. People in the ancient world believed Earth to be stationary at the centre of the universe. It took hundreds of years until Nicolaus Copernicus developed a mathematically predictive heliocentric system. But only modern space technology made it possible to uncover the secrets behind our solar system step-by-step.



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SOHO (SOlar Heliospheric Observatory) is a space-based observatory, viewing and investigating the Sun from its deep core, through its outer atmosphere – the corona – and the domain of the solar wind, out to a distance ten times beyond the Earth's orbit.

Only one year after NASA launched its first robotic space probe, Mariner 2, to perform measurements of the temperature of Venus, the interplanetary magnetic field and the solar wind, the first Summer School in Alpbach started in July 1963. The topic was "Introduction to Solar-Terrestrial Relations", a theme relevant to the very first ESRO scientific satellite project (ESRO was the predecessor of ESA). This event became a great success and therefore ESRO after its creation in 1964 organised the second summer school on "Electromagnetic Radiation in Space" in 1965 again in Alpbach.

It was a long way from the early-1960s until all planets in the Solar System have been visited by spacecraft launched from Earth. The Alpbach Summer School reconsidered the issue several times and from different perspectives. In 1981 The Alpbach Summer School was devoted to "The Solar System and its Exploration". One of the main questions was the interaction of the solar wind with planetary environments, the planets, moons, rings and other solid bodies in the solar system.

The topic of the Summer School 1986 was "Space Astronomy and Solar System Exploration". The programme was based on the ESA's science programme "European Space Science Horizon 2000" which was approved by ESA in 1985. The Summer School focused in particular on four main themes: the early universe, formation of stars and planetary systems, from solar physics to stellar physics, space and plasma physics. The Horizon 2000 Programme lasted 20 years, from 1985 to 2005. It was succeeded by the Horizon 2000+ Programme from 2005-2015, leading to the current Cosmic Vision Programme that will run until 2025.

The topic of the Summer School 1994 was "Solar-Terrestrial Relations". It highlighted the related space missions Ulysses, SOHO and CLUSTER. There were three main subjects: First, solar physics, in particular helio-seismology, the solar interior, solar atmosphere including photosphere, chromosphere, corona, also solar activities and magnetic fields. Second, the interplanetary medium, in particular the solar wind and interplanetary plasma processes. Third, the magnetosphere, its structure and dynamics, boundary and acceleration processes, auroral phenomena, and the interaction of the magnetosphere with the ionosphere and the upper atmosphere.

SOHO, the Solar and Heliospheric Observatory, was a cooperative effort between NASA and the European Space Agency. It was launched into space in 1995 and revolutionized our study of the sun especially in heliophysics – the study of how the sun's influence spreads out in all directions, able to dramatically affect the space environment near Earth and throughout the solar system. SOHO has studied more than 20.000 coronal mass ejections to date, pinpointing their sources on the Earth-facing hemisphere of the Sun, and determining their speed and direction to provide up to three days' warning – sufficient to take action on Earth.

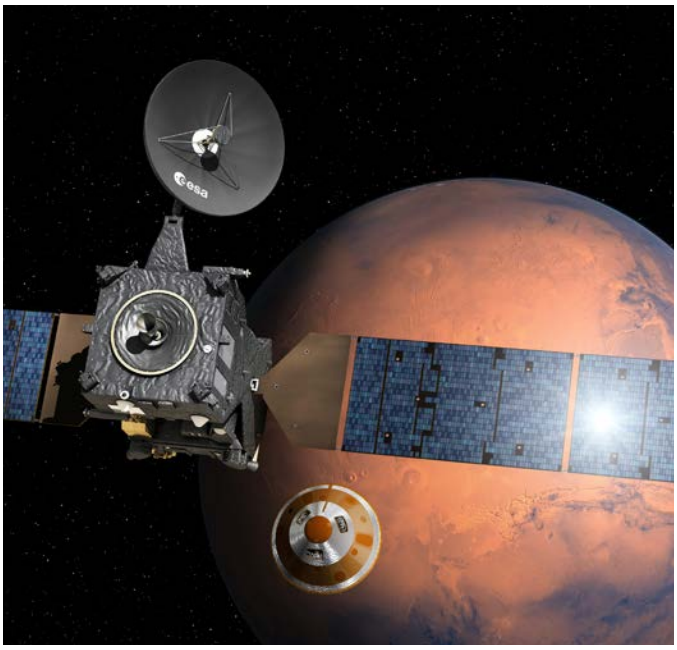
Cluster was a constellation of four spacecraft flying in formation around Earth. They relayed the most detailed infor-

mation ever about how the solar wind affects our planet in three dimensions. Due to the fact that the solar wind can damage communications satellites and power stations on Earth, these informations are of great significance for business and infrastructure.

In 1998 the Summer School was dedicated to "Our Solid and Liquid Planet" and thus directly linked to the objectives of the Earth Explorer Programme of the European Space Agency. The Summer School focused on two particular areas, namely the use of remote sensing for understanding the global energy and water cycle and the dynamics of the solid earth. Both topics were of great relevance to the work of the Intergovernmental Panel on Climate Change (IPCC) and programmes such as the World Climate Research Programme (WCRP).

In 1999, the students were set the task of defining a future Mars Exploration Mission. Having studied a variety of possible missions to Mars, the students proposed the use of an airship, or "Zeppelin", as a highly versatile vehicle for exploring the Red Planet. The novel idea of using a Zeppelin should provide for three-dimensional steering and a choice between sojourning at an interesting spot, and travelling for surveying the landscape or to visit another location. The Zeppelin could have also been useful for studying the Mars dichotomy. ESA launched Mars Express in 2003 – unfortunately without the Zeppelin.

In 2002 and 2013, the space weather again was the topic of the Summer School. Corresponding to the conclusion of the OECD, to improve the current geomagnetic storm warning and alert system, the students developed satelli-



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Establishing if life ever existed on Mars is one of the outstanding scientific questions of our time. To address this important goal, the European Space Agency (ESA) has established the ExoMars programme to investigate the Martian environment and to demonstrate new technologies paving the way for a future Mars sample return mission in the 2020's.

te missions for monitoring Coronal Mass Ejections (CMEs) and Corotating Interaction Regions (CIRs) in 2013. All four Summer School concept proposals 2013 were presented during the European Space Weather Week 2014 and a paper was published by EDP Sciences 2015.

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ESA's science programme and in particular the exploration of the solar system was the topic of the Alpbach Summer School in 1986.

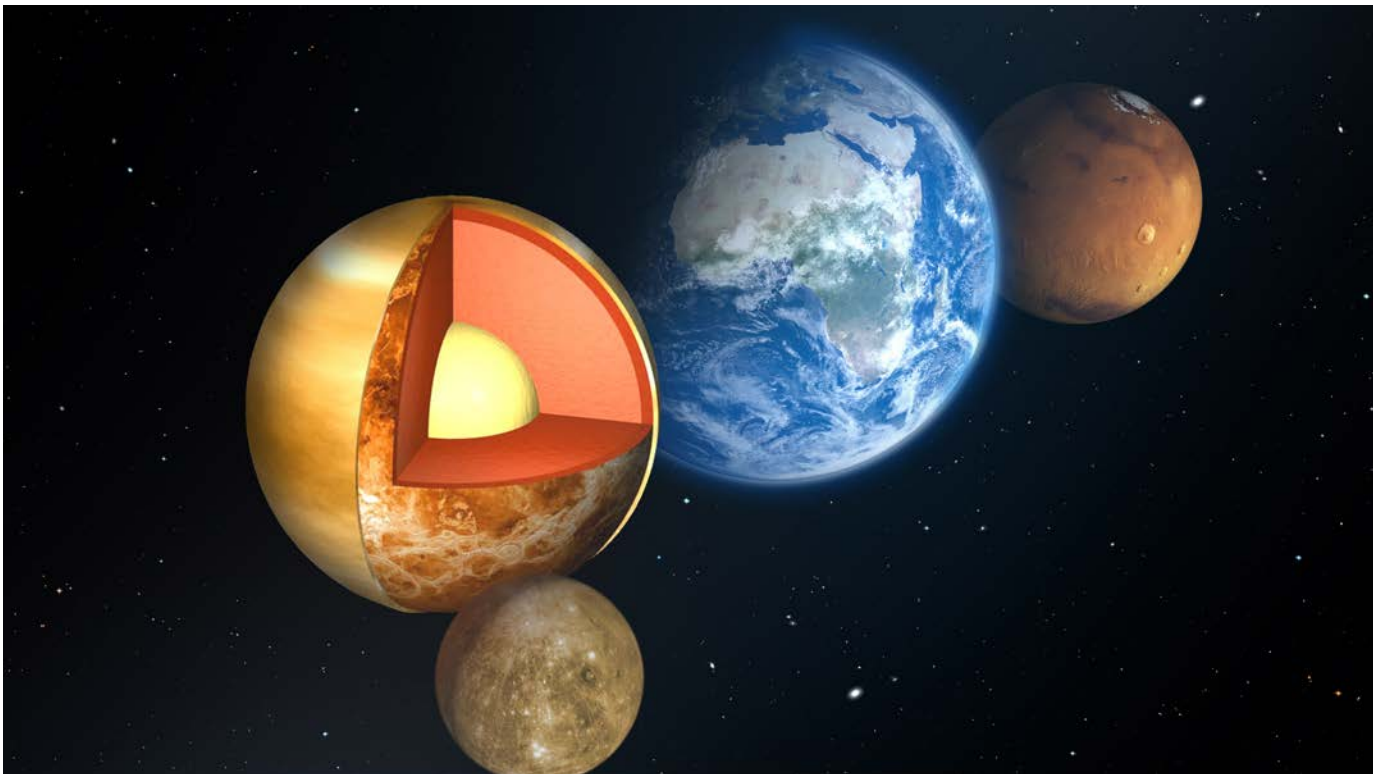
Alpbach: Space Science in focus

Basic research issues dominated many of the 40 Summer Schools. Successful projects and interesting missions indicate the high qualitfy of the work acomplished by the students participating in the Alpbach Summer School.

In the early days of the Summer School proceedings were published by ESA containing lecture material. With the start of the workshop activities the results of the mission studies of the students (a power point presentation and a report) were published on the website of the Summer School Alpbach as well as on the ESA Education website and archived at FFG to serve as reference material for students and Alpbach Alumnis. During recent years a variety of scientific papers and posters had been published which is an excellent advertisement for the very high standard that's achieved by the students in Alpbach.

Examples of such papers:

- The HADES mission concept – astrobiological survey of Jupiter's icy moon Europa, International Journal of Astrobiology 8 (4) : 321–329 (2009) Printed in the United Kingdom, Cambridge University Press 2009
- The 2014 Alpbach missions were presented at EGU 2015.
- A session at the European Planetary Science Congress 2015 "MT11 Alpbach Mission Studies" was organised to present the missions of the Summer School Alpbach 2014 within the programme group "MT = Missions, Techniques and Industry"
- Article on the Summer School Alpbach 2015 results in International Astronomical Union Divison D Bulletin no. 7, October 2015
- Summer School Alpbach 2015: A pilgrimage to Erwin Schrödinger's grave: Quantum Physics and Fundamental Physics in Space, article published in Europhysics News (magazine of the European Physical Society), Volume 47, Number 1 in February 2016.
- 2015: GLINT mission: Gravitational-wave Laser Interferometry Triangle paper submitted to journal of Experimental Astrophysics to be published in 2016.



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The topic of the Summer School 2014 was "Space Missions for Geophysics of the Terrestrial Planets".

Past topics and their context

André Balogh

UK/ISSI, Scientific Coordinator of the Summer School Alpbach

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From the mid-1990s, ESA's programmes accelerated, as missions in the Horizon 2000 programme became operational. The topic of 1995 was "Horizon 2000+", the follow up to Horizon 2000 – the Summer School looked at both the future Mercury mission (now BepiColombo) and the astrometry cornerstone of the programme, GAIA. "Mission to the Moon" (1996) was prompted by both the then forthcoming ESA lunar mission SMART-1 and the enduring interest in mission proposals to the Moon.

In 1998, "Our solid and liquid planet" reflected in part the initiation at the time of the Cryostat mission aiming to determine the thickness of the Earth's continental ice sheets and marine ice cover. The "Extragalactic astronomy and cosmology from space" Summer School (2000) addressed for the first time cosmological objectives, at a time when ESA's Planck mission was being developed – Planck was to bring major discoveries about the Big Bang and its immediate aftermath. The topic "Dark matter" (2005) was the first look at a topic in ESA's Cosmic vision long term science programme and is now covered by the Euclid mission.

The following three topics, "Astrobiology" (2007), "Sample Return from Moon, Asteroids & Comets" (2008) and "Exoplanets: discovering and characterizing Earth type planets" (2009) addressed different aspects of the search for life and habitabily beyond the Earth and what primitive objects can teach us about the origin of our solar system. ESA missions related to these topics included Rosetta, Exomars, Corot and CHEOPS-1, the first small (S-class) mission in the Cosmic Vision programme.

The topic "Star formation across the universe" (2011) used ESA's Herschel mission (one of the cornerstones of Horizon 2000) as a guide to envisage follow-up missions.

The astounding success of the NASA-led Cassini mission to Saturn and the landing of the Huygens probe on Saturn's moon Titan and advanced plans for ESA's large (L-class) mission to Jupiter (JUICE) led to the topic of the "Exploration of the Giant Planets and their systems" (2012). The always ambitious Summer School students proposed missions to Uranus and Neptune!

Mankind's ever increasing reliance on space infrastructure is at risk from space weather events triggered by giant solar eruptions. In 2013, the Summer School's topic, "Space weather: science, missions and systems" inspired the students to formulate four imaginative missions to monitor the Sun and the propagation of eruptive events from the Sun to the Earth. The following year, in 2014, the topic "Space Missions for Geophysics of the Terrestrial Planets" led to all four teams to identify Venus as the most important and most neglected planet and to propose missions to explore the geophysics of the Earth's "evil twin".

The topic in 2015, "Quantum Physics and Fundamental Physics in Space", presented a great challenge. Both the science and the technical requirements on missions in this topic are extreme, as has been discovered by space agencies attempting to launch such missions (the gravity wave telescope LISA is a good example). Remarkably, the students met the challenges, by showing a good theoretical understanding of the objectives and putting forward imaginative yet believable mission concepts.

Post Alpbach projects and publications 2010-2015

Post Alpbach is an add-on to the Summer School Alpbach, introduced in 2009 by FFG to carry on with one of the Alpbach missions which was found best suited for additional work by the Alpbach Jury. All Alpbach students are invited to apply. 15 of the Alpbach students are being selected each year and provided with an ESA grant to attend the workshop, with the possibility of eventually presenting a paper at a scientific congress and/or in a scientific journal.

» 2010: AVALON (Atmospheric water Vapour from an Active Limb-soundingObserving Network)

A mission for better understanding climate change proposing new observations such as direct radiative forcing from water vapour and aerosols, indirect radiative forcing from aerosols through the formation of cirrus clouds and contrails and troposphere-stratosphere exchange mechanisms

Result: AVALON presentation at the American Geophysical Union Meeting in December 2011

» 2011: THESEUS (T-Tauri & HErbig Ae/Be stars Study with Echelle Uv Spectrograph): Studying the adolescent phases of star formation

THESEUS is a proposed space based mission to study pre-main sequence T-Tauri and Herbig Ae/Be stars. The mission shall gain knowledge of a short but critical period in stellar formation and to reveal current unknowns involving turbulence, magnetic fields, and angular momentum

Result: Article published in the ESA Bulletin

» 2012: Uranus Study MUSE – Mission to the Uranian System: Unveiling the evolution and formation of icy giants

In the study the rationale, selection, and conceptual design for a mission to investigate the Uranian system, as an archetype for ice giants, is presented. A structured analysis of science questions relating to the Uranian system is performed, categorized by the themes atmosphere, interior, moons and rings, and magnetosphere.

Result: Paper published in ELSEVIER Advances in Space Research, Volume 55, Issue 9, 1 May 2015, Pages 2190–2216: MUSE – Mission to the Uranian system: Unveiling the evolution and formation of ice giants

» 2013: Carrington Mission for CME Detection to improve space weather forecast

A concept for a space weather forecast mission.

Result: presented as poster at the EGU General Assembly 2014, held 27 April - 2 May, 2014 in Vienna, Austria, id.12232

» 2014: Hesperos Mission

Study of an L-class mission to Venus to study the difference between Venus and Earth by focussing on the tectonics and internal structure and composition of Venus by means of an orbiter and a balloon

Result: The Hesperos Mission, a follow-up of EvolvE and Aphrodite from the Summer School Alpbach 2014 was presented at the European Geophysical Union (EGU) Congress in April 2015

» 2015: The Janos Mission

This experiment was designed to examine the effect of gravity on quantum systems. The basis of the experiment is a single-photon interferometer, distributed between an Earth orbiter and a ground station. The photons are split in a superposition to explore how gravity acts on them, as compared to a classical system, aiming at confirming or refuting the hypothesis that there is a fundamental effect of gravity on quantum systems.

Result: Paper to be published in the European Physical Journal (EPJ) – Quantum Technology: Thematic Series on Space Applications of Quantum Technology

A steep learning curve: From fundamental science questions to a full space mission in just 10 days

Rupert Ursin

Senior group leader at the Institute for Quantum Optics and Quantum Information – Vienna, Austrian Academy of Sciences.

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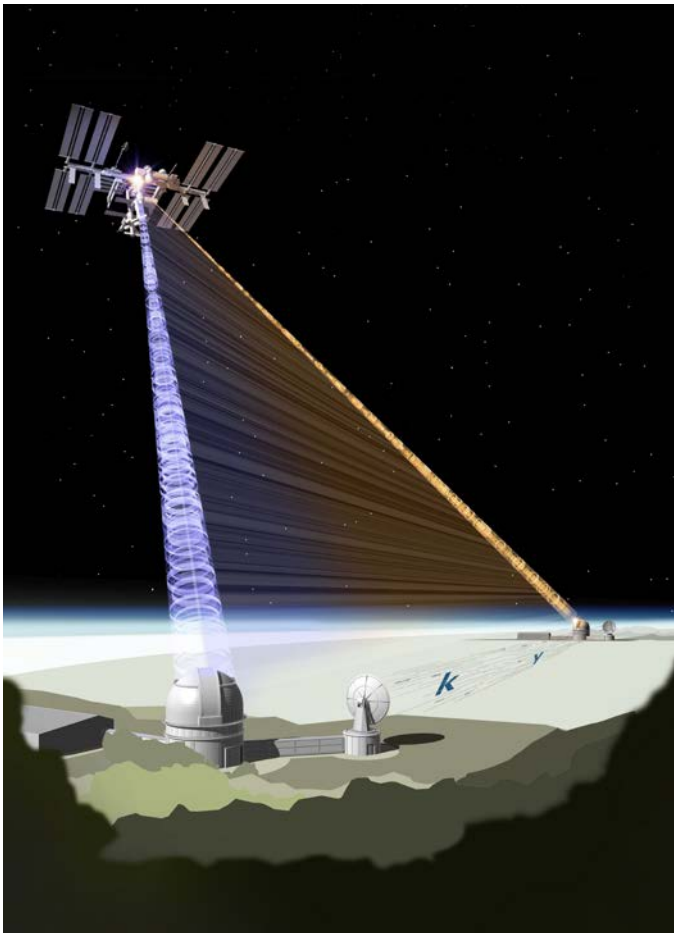
When I was invited by FFG to teach at the 2015 Summer School on quantum physics in space, I was not expecting to witness this miracle-in-progress. The topic of the Summer School was "Quantum physics and fundamental physics in space", a departure from more classical space science and application topics. To convey just the fundamentals of quantum physics in no more than 10 days is already quite a challenge. But to have students develop their own ideas for a fully-fledged space mission, and to then put those ideas into practice – well, that is something else entirely. So it will not surprise you when I tell you that at the outset, I did not expect us to succeed. In fact, I had braced myself for failure.

To my great astonishment, those young people proved me wrong. Not only did the participants manage to truly come up with their own ideas for quantum physics experiments in a space environment. Throughout the days (and a large portion of the nights), the students, who had split into teams of scientists and engineers – but still closely collaborated and really negotiated with each other – developed scenarios and identified the best possible solutions for a full mission outline with all necessary details. Watching the development of the projects proved to be a truly remarkable and inspiring experience for me. The questions that were asked, the ideas that were developed as the young participants delved deeply into the subject matter, were extraordinary. The results, however, are amazing.



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Alpbach Summer School 2015: 60 students had to find out how satellite missions could help to develop and enrich quantum physics research and if future satellite missions could benefit from quantum physics.

Get ahead in Space Research and Industry

Europe's space industry currently has a total of approximately 39.000 employees. About 2000 staff members work in ESA's various locations. The space sector offers divers career opportunities, involving engineers, mathematicians and physicists, as well as biologists and medical professionals.

Prospective space scientists must have a strong academic background in science, especially in physics. Experience with computers and the basics of engineering and electronics are also needed. According to the different needs there are various training pathways available. However, the Alpbach Summer School is unique. Since 1975, it has been training students and young scientists in different aspects of space science and space technology through lectures, discussions and, most importantly, the collaborative development of actual space missions.

One of the most important achievements of the Alpbach Summer School remains the fact that over four decades it has sent more than 2000 young scientists and engineers on their way towards key positions in European and international science and technology, in European and UN space organisations as well as in the space industries of many countries, thus offering an ideal recruiting base.

Encouraging Carreers in Space

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Bettina Böhm
ESA Head of Human Resources

ESA is Europe's gateway to space. ESA guides the development of Europe's space capability and carry out pioneering research in all areas of space activity. What does Mercury's surface look like? What is a comet made of? How does climate change influence life on Earth? The European Space Agency (ESA) aims to find the answers to these and many more exciting questions about our Universe.

ESA is continuously on the look-out for new talented people from the following fields of expertise: Aerospace and mechanical engineering, Communications and electrical engineering, Software engineering, Physics, Astronomy/astrophysics, Mathematics, Biology/medicine, Law and Business administration. The Young Graduate Trainee and Postdoctoral Research Fellowship programmes of ESA have been designed to help recruit the best qualified young people for Europe's space programme. ESA offeres training possibilities such as the Young Graduate Trainee (YGT), a 1 year programme wich gives an opportunity to gain valuable experience in the development and operations of space missions, or the Postdoctoral Research Fellowship programme which offers young scientists and engineers the possibility of carrying out research in a variety of disciplines related to space science, space applications or space technology.

By choosing a career in Space, young talents are able to work on fascinating projects that would not be possible for individual companies or countries and join a world-class industry and contribute to outstanding scientific discoveries. Students and graduates of universities or equivalent who have qualified in science, technology, engineering or mathematics are highly encouraged to join the space community. The Space Industry is a prime example of what can be achieved by working together – a model for multicultural and international cooperation.

The Concurrent Design Facility (CDF) is a state-of-the-art facility equipped with a network of computers, multimedia devices and software tools, which allows a team of experts from several disciplines to apply the concurrent enginee-

Summer School Alpbach means real project life

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Peter Falkner (ESA) , André Balogh (ISSI), Eamonn Daly (ESA)

The Alpbach Summer School provides young Engineers and Scientists the possibility to experience the pressure of completing the definition of a real space project. First class tutors and lecturers support the students and carefully watch over their project work. Participants are aware that at the end of the Summer School the result of the team work has to be presented to a high ranking Jury and to the audience that includes the competing teams, lecturers and tutors.

Each team is assigned two tutors, one with a scientific expertise in the topic of the Summer School, one in space engineering. In addition, roving tutors, with scientific and engineering expertise support all the teams. The tasks of the tutors are coordinated by the Head Tutor who oversees the project work and leads the daily review of the progress of the teams. This intense coordination, on top of the very high staff-to-student ratio (about 20 tutors and lecturers at any time for the 60 students) ensures that the support for the students to complete their projects is up to the challenges of the Summer School. In addition to technical competence, management skills have to be deployed, given the complexity of multi-skilled teams in an international environment to run a multidisciplinary project in such a short time.

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ring method to the design of future space missions. It facilitates a fast and effective interaction of all disciplines involved, ensuring consistent and high-quality results in a much shorter time.

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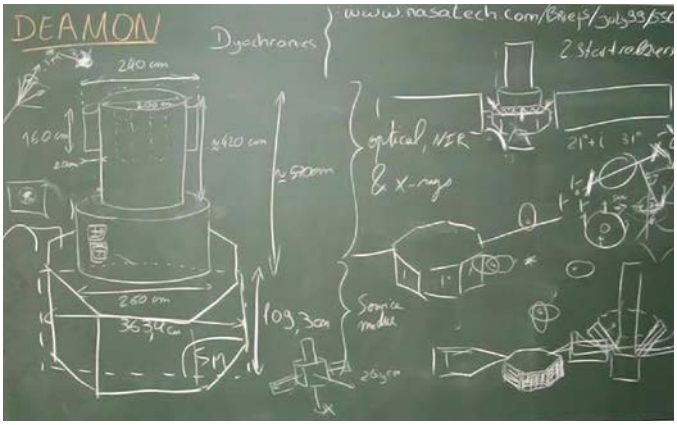
2006 – Team work impression with tutor



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2005 – Development of the DEAMON Mission

The expectation is that the teams develop their own new ideas of how to make progress in the field of the Summer School topic, avoiding mission concepts which have been studied or implemented elsewhere and to think ahead for the next steps to be undertaken.

Many of the problems arising during the projects are hard even for the experts in the field and challenge not only the students but the entire Summer School team. This creates what we call the Alpbach experience. The students leave the school with much knowledge and experience gained and, very importantly, with a network of new colleagues and participating professionals from space agencies, institutes and universities, supported by a dedicated alumni social network.

Fit for the Future

As has been discussed intensively, in order to remain competitive, Europe will be facing a triple challenge in the years to come: to keep and expand its own resources (skill-levels and workforce numbers), to develop new skills to satisfy the need of emerging sectors and to attract talent from third countries.

Low cost approaches or budgeting plans, primary drive towards innovation, combining currently available "cheap-off-the-shelf" (COTS) technologies in an innovative manner providing a new and highly capable system at lower costs will presumably have an impact on the European space policy and industry. Also the use of launch systems that were developed by private funding as well as small satellite missions and Cubesats as well as full electric powered missions will leave their marks.

These challenges will also have an influence on the Summer School's mission designs. Open to innovative approaches and topics as it has been for decades it will certainly develop further along the evolution of European space science and industry.

In the future more of the tutors might come from the non-space field. Reflecting the increasing international collaboration in space key note lectures by non-European experts might also be an attractive option. The students will come from even more states than before as new countries join the European Space Agency. Although the high share of female students is already remarkable (close to 40%) gender balance will be aspired to.

The tools for designing and calculating missions will be more sophisticated. One can expect that Alpbach students in the near future will build upon modelling software and integrated simulation tools of missions that are interlinked with other institutions. Discussions on future Post Alpbach workshops already focus on the alignment with the newly established ESA Academy. A combination of both the Summer School and ESA academy will even strengthen their profile. In general the closer integration with universities is a further point at the agenda of the Summer School. As is the case already for the ESA Academy Concurrent Design Facility Trainings in preparation for the Summer School might be of relevance.

In the years to come students efforts might not only be in the form of presentations, reports and publications, but e.g. also in the form of 3D printed models that enrich with haptic experience as well as videos. Financial support for publications will be a helpful tool for teams that spread after the Summer School and Post Alpbach.

In conclusion the concept of the Summer School is unique, best practice and an indispensable pillar of European team oriented space education and training. It will play its role for the years to come.

The Alpbach Summer School: an Austrian Contribution to Space Learning and Education in Europe

© Carina Ott

Peter Jankowitsch, Chair of FFG Advisory Board on Aeronautics and Space and President of the International Academy of Astronautics (IAA)

Over the past forty years a unique institution has left its mark on Europe's academic space community, providing continously a one of its kind breeding and training ground for the best and most ambitious among new, future generations of space scientists and engineers as well as other future actors of an ever growing internmational space commmunity, the Alpach Summer School.

The Alpbach Summer School has thus since its early beginnings in 1963 succeeded extremely well to offer its own unique blend of in-depth teaching and practical exercise of many aspects of state of the art space science and technology, a distinguishing feature not found in other places. To guide this effort it has introduced curriculae of a most varied nature, alternating between subjects that are more science oriented and others closer to space applications. It has always aimed to appeal to the creative talents of its participants who came from many, not only European, countries thus offering a unique mix of academic cultures and traditions. Projects developed by the Alpbach Summer School students have often attracted the attention of international space organisations like ESA and their resesarch programmes.

The Alpbach Summer School must finally also be seen as a part of Austria's strong commitment to international cooperation and dialogue in space. Without being a major player in international space affairs she has offered valuable contributions for the good conduct of UN and European space organisations such as the UN Committee on the Peaceful Uses of Outer Space, ESA, EURISY and others. Not the least of these contributions is the Alpbach Summer School with its continuing impact on space education in Europe.

Prominent Graduates

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Alexander Gerst, Summer School student in 2006, became ESA astronaut in 2009

Alexander Gerst was selected as an ESA astronaut in May 2009. He joined ESA in September 2009 and completed Astronaut Basic Training in November 2010. In September 2011, Alex was assigned to fly to the International Space Station on a six-month mission. He served as a flight engineer for Expeditions 40 and 41. He was launched on a Soyuz spacecraft from the Baikonur Cosmodrome in Kazakhstan in May 2014, returning to Earth in November 2014. His comprehensive research programme included a wide variety of European and international science experiments.

Alexander Gerst graduated from the Technical High School in Öhringen, Germany, in 1995. In 2003 he received a diploma in geophysics from the University of Karlsruhe, Germany, and a master's degree in Earth sciences from the Victoria University of Wellington, New Zealand. In 2010 Alex graduated with a Doctorate in Natural Sciences at the Institute of Geophysics of the University of Hamburg, Germany. His dissertation was on geophysics and volcanic eruption dynamics.

© Cornell University

Lisa Kaltenegger, Summer School student in 1997, Professor at Cornell University

Lisa Kaltenegger is an Austrian astronomer with expertise in the modeling and characterization of exoplanets and the search for life. She holds a Ph.D. in Astrophysics from Karl Franzens Univerity Graz since 2005. On July 1, 2014, she was appointed Associate Professor of Astronomy at Cornell University and is Director of the Carl Sagan Institute.

Previously, she held a joint position at the Max Planck Institute for Astronomy in Heidelberg where she was the Emmy Noether Research Group Leader for the "Super-Earths and Life" group, and at the Harvard-Smithsonian Center for Astrophysics in Cambridge, MA. She was appointed Lecturer in 2008 at Harvard University and 2011 at University of Heidelberg.

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Pascale Ehrenfreund, Summer School student in 1987, Chairwoman of the board of DLR since 2015

In 1987 I was studying molecular biology and astronomy, and attended the summer school in Alpbach on the topic of fundamental physics. Many participants of the Alpbach summer school 1987 are now in leading positions in space research institutes, companies or at ESO and ESA.

After Alpbach I decided to move to Paris to the laboratory of Alain Leger and Louis d'Hendecourt. I completed my PhD in 1990 and I received an ESA external postdoc fellowship to work at Leiden Observatory on laboratory simulations of ices and organics in the interstellar medium. With a CNES fellowship I continued to work in Verrieres le Buisson, France for the Cassini-Huygens mission. I returned to Leiden to work in the field of astrochemistry and on the interpretation of the first data of the Infrared Space Observatory ISO. I also started to work on observational stellar and interstellar astronomy.

In 2000 I founded my own research group around the new discipline "astrobiology". With various positions as professor in astrobiology in the Netherlands and the US, and in collaboration with the NASA Astrobiology Institute NAI, I have been involved in many exciting research topics. I returned to the Alpbach summer school on the topic of astrobiology in 2007 where I was a lecturer and Jury Member.

The next three topic proposals for Alpbach

2017: The Dusty Universe

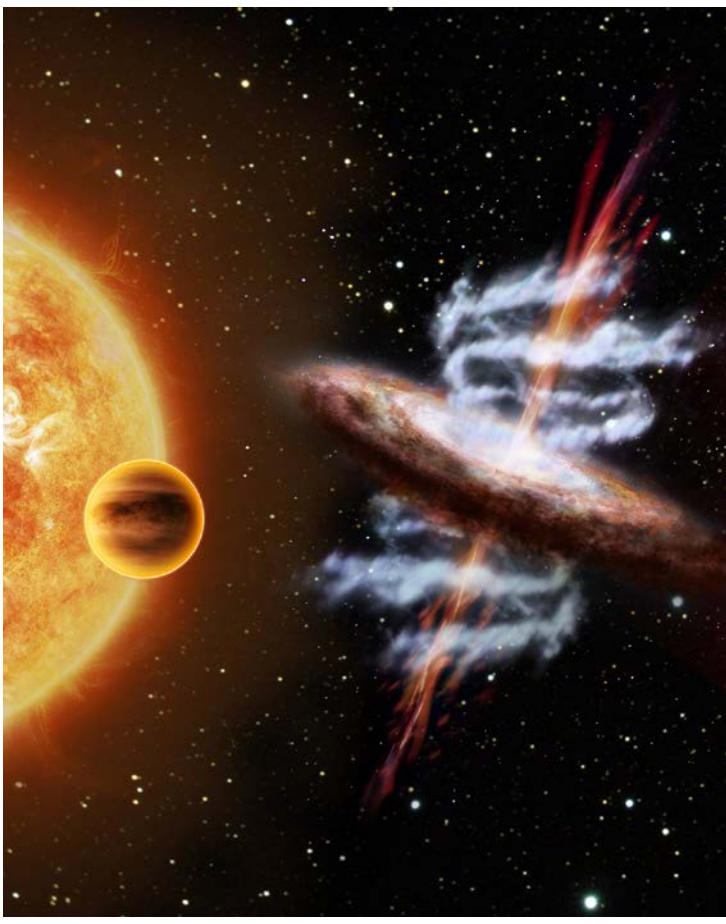
Cosmic dust particles form an important component of the universe. Observing dust particles is best done in infrared light. Space missions that concentrated on the infrared part of the spectrum (for example ESA's infrared Space Observatory and Herschel missions, NASA's Spitzer mission) have discovered new and important features of dust in interstellar space and beyond. This topic is rich in future observational possibilities, using imaginative concepts that the students in Alpbach will be invited to develop.

2018: Large Scale Structure Astrophysics (galaxy formation/ evolution)

A fundamental and remarkable feature of the Universe is the presence of large scale structures such as galaxies and galaxy clusters. Understanding their formation and evolution is crucial to understanding the evolution of the Universe from the Big Bang. Both ground-based and space-based observatories have increased enormously the available observations, yet there are opportunities for both small- and large-scale space missions to address specific questions, in different spectral ranges and with different resolution capabilities. Following a series of lectures, students will identify scientific objectives related to open questions in the formation and evolution of large-scale astrophysical structures.

2019: Comparative Plasma Physics in the Universe

Large parts of the Universe are filled with plasma, a highly ionised form of matter. The plasma environments are always highly dynamic, from the Earth's magnetosphere to the scale of supernovae and their environments. Ionised matter is threaded by magnetic fields, producing complex interaction processes and phenomena such as shock waves and elementary particles accelerated to high energies. Observations of cosmic plasmas can be made both in situ (in the solar system) and remotely. Observational objectives that span the scales can lead to targeted space missions that will bring advances in understanding the behaviour and coupling processes of plasma at several astrophysical scales.



Support for Space Science and Technology in Austria

The Aeronautics and space Agency (ALR) of FFG (Austrian research promotion Agency) is the docking station to the international space world for Austrian science and industry.

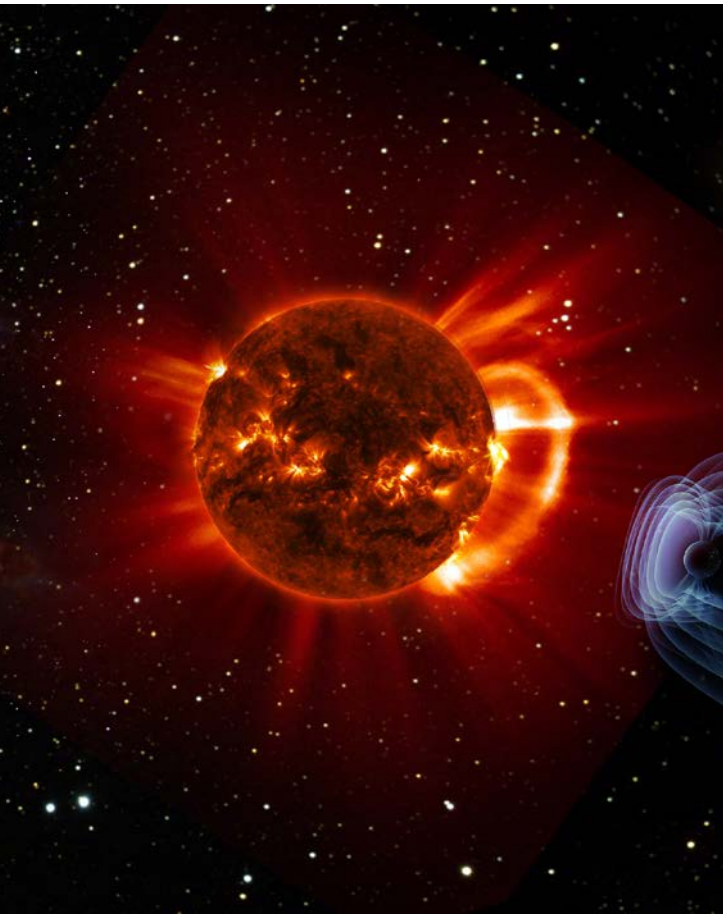
On behalf of the Federal Ministry for Transport, Innovation and Technology, the Agency implements the national space policy and represents Austria on an international level, in particular in the bodies of the European Space Agency (ESA).

The Agency's core objectives lie in the international positioning and networking of Austrian industry, economy and science, and in securing Austria's competitiveness at the international level. It is a central contact point for coordination activities in the area of space and represents Austria in EU bodies, ESA and EUMETSAT.

Importantly, the Aeronautics and Space Agency manages the participation in bilateral and international aerospace programmes and aims at developing and strengthening the Austrian aeronautics and space cluster. Education and outreach are also important tasks, which are fulfilled through special initiatives that aim at fostering children's interest in technical and scientific topics via space technology and research.

The Austrian Space Applications Programme (ASAP) is managed by the FFG and has been running since 2002. It is a bottom-up research and development funding programme in support of and complementary to bilateral and European programmes (ESA and EU) in the three areas of technology development, space science and application of space technology. It is aimed at strengthening the position of Austrian industry, promoting ideal use of space technology and supports international and bilateral cooperation in space.

www.ffg.at/en/space



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Exoplanets, plasma physics and the X-ray Universe are the topics chosen by ESA to be considered for the fourth medium-class mission in its Cosmic Vision science programme, for launch in 2025.

Following the recommendation by a peer review committee, ESA decided that three candidate concepts submitted to its 'M4' mission call will be studied further: the Atmospheric Remote-Sensing Infrared Exoplanet Large-survey (Ariel), the Turbulence Heating ObserveR (Thor) and the X-ray Imaging Polarimetry Explorer (Xipe).

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The Summer School Team 2016

2016 40th SUMMER SCHOOL ALPBACH

INTERNATIONAL SPACE SCIENCE INSTITUTE

AUSTROSPACE

The Summer School Alpbach – A Research and Education Lab for Space Science and Technology

On the occasion of its 40th edition

The Summer School Alpbach is organised by the Austrian Research Promotion Agency (FFG) and co-sponsored by the European Space Agency (ESA) and the national space authorities of its member and cooperating states. A traditional partner is the International Space Science Institute (ISSI). It is also supported by Austrospace, the association of Austrian space industries and research institutions.

www.summerschoolalpbach.at