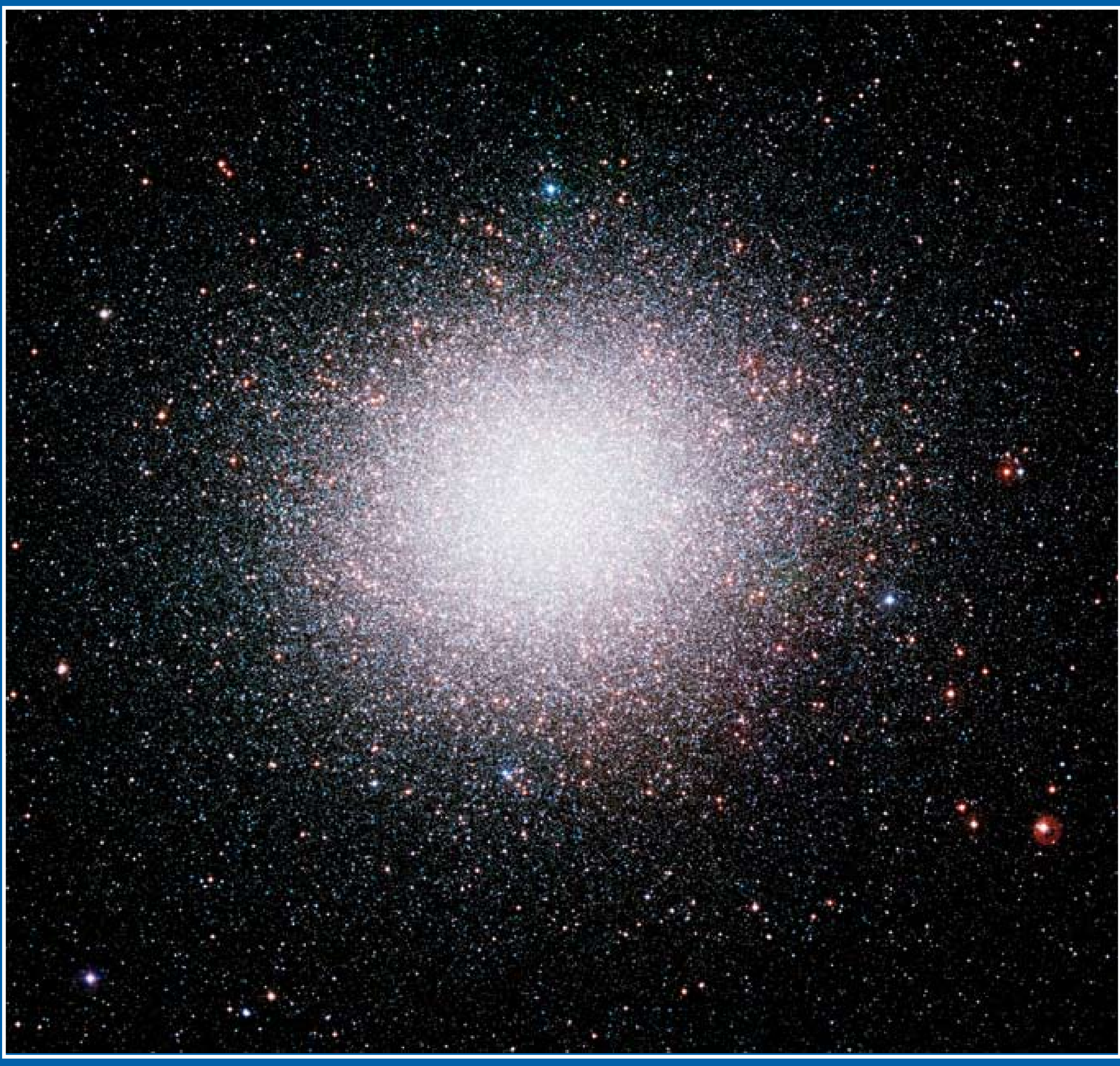
THE INTERNATIONAL YEAR OF ASTRONOMY (IYA2009) & ASTRONOMY IN SWITZERLAND



COVER PICTURE

The globular cluster Omega Centauri, with as many as ten million stars and located 17'000 light-years away, is seen in all its splendour in this image captured with the WFI camera and the 2.2m telescope at ESO La Silla Observatory. The image shows only the central part of the cluster. (ESO/EIS)

SOLAR PHYSICS AND RADIATION, EARTH CLIMATE

The Sun in ultraviolet (304 Å), in January 8, 2002. The very strong solar activity produces tremendous gas ejections.

(SATELLITE SOHO, ESA)

THE INTERNATIONAL YEAR OF ASTRONOMY (IYA2009)

Catherine Cesarsky
President of the International Astronomical Union

The *International Astronomical Union* (IAU) launched 2009 as the International Year of Astronomy (IYA2009) under the theme, "*The Universe, Yours to* Discover". IYA2009 marks the 400th anniversary of the first astronomical observation through a telescope by Galileo Galilei. It will be a global celebration of astronomy and its contributions to society and culture, with a strong emphasis on education, public engagement and the involvement of young people, with events at national, regional and global levels throughout the whole of 2009. UNESCO has endorsed the IYA2009 and the United Nations proclaimed the year 2009 as *the International Year of Astronomy* on 20 December 2007.

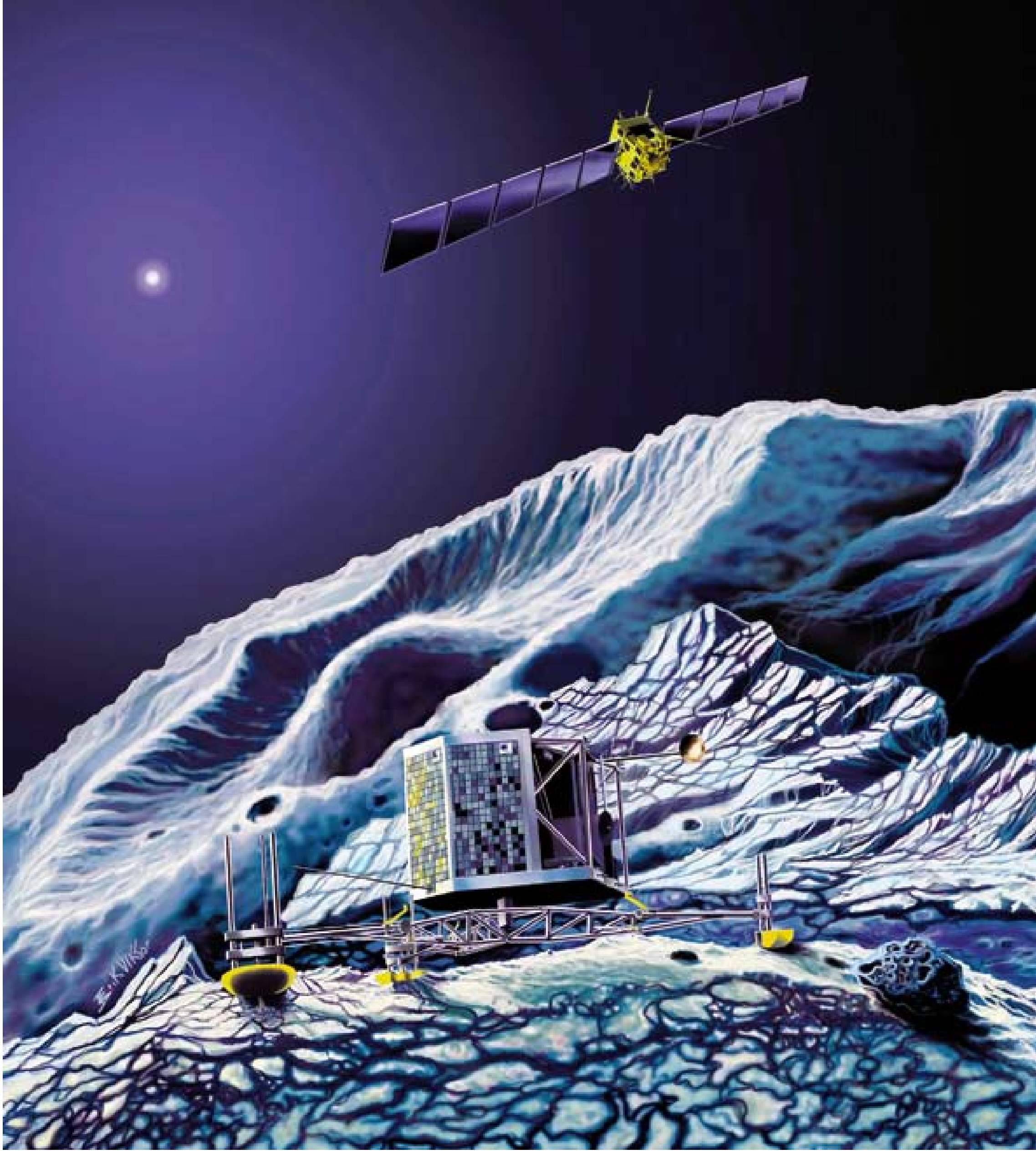
Astronomy is one of the oldest fundamental sciences. It continues to make a profound impact on our culture and is a powerful expression of the human intellect. Huge progress has been made in the last few decades. One hundred years ago we barely knew of the existence of our own Milky Way. Today we know that many billions of galaxies make up our Universe and that it originated approximatively 13.7 billion years ago. One hundred years ago we had no means of knowing whether there were other solar systems in the Universe. Today we know of more than 300 planets around other stars in our Galaxy and we are moving towards an understanding of how life might have first appeared. One hundred years ago we studied the sky using only optical telescopes and photographic plates. Today we observe the Universe from Earth and from space, from radio waves to gamma rays, using cutting edge technology. Media and public interest in astronomy have never been higher and major discoveries are frontpage news throughout the world. The IYA2009 will meet public demand for both information and involvement.

There are outstanding opportunities for everyone to participate in the IAU2009 events. Some of the events are planned at the global level, which will be supported by thousands of additional national and regional activities.

The IAU, UNESCO and Organisational Associates wish everyone a year rich in astronomical experiences as we all celebrate the International Year of Astronomy 2009!

FUNDAMENTAL ASTRONOMY

The dark spot marking the totality zone on Earth during a solar eclipse, seen from space by the astronauts inboard MIR orbital station, on August 11, 1999. (MIR 27, CNES)



SPACE MISSIONS AND INSTRUMENTATION, SOLAR SYSTEM

Launched in March 2004, the space probe ROSETTA will reach the comet Churyumov Gerasimenko in August 2014. The ROSETTA lander will make the first controlled touchdown on a comet nucleus (artist's view).

(ESA)

IYA2009 AND SWITZERLAND

Mauro Dell'Ambrogio
State Secretary for Education and Research

The *State Secretariat for Education and Research* SER within the Federal Department of Home Affairs is the federal government's specialised agency for national and international matters concerning general and university education, research and space. The SER is responsible for drawing up and implementing policy in the area of science, research, university and space policy in Switzerland.

In the area of science and research, the SER is responsible for Swiss membership in international research organisations and Switzerland's participation in European and international research programmes and cooperation projects. The SER covers all related financial obligations. Swiss efforts to involve its research community in international cooperation programmes began in 1953 with the considerable support the country gave to the founding of the *European Laboratory* *for Particle Physics*, CERN, in Geneva. Since then this involvement has constantly increased.

International research organisations – as the *European Southern Observatory* ESO – drive major scientific and technological discoveries. By signing international agreements for membership with international research organisations, the Swiss Confederation helps to ensure that Swiss researchers are part of multilateral research cooperation efforts. The international realm is important to Swiss researchers enabling them to gain access to otherwise cost-prohibitive infrastructures that would be required for such fields as astronomy, high energy physics or

SOLAR SYSTEM

The comet Hale-Bopp on March 30, 1997, with the queues of gas (blue) and dust (brown).

(MANUEL JUNG, SAS)

particle physics, and aerospace. Since 1982, Swiss astronomers successfully participate in ESO, the European Organisation for Astronomy.

Astronomy is one of the oldest and most widely recognised sciences, originating with the simple fascination and wonder of the night sky. Over the centuries, astronomy and astrophysics have evolved into a physical science where theories are rigorously tested against precise observations. Observations of the Universe are also used to refine, and sometimes revolutionise, ideas about fundamental physics.

The International Year of Astronomy 2009 (IYA2009) is a global celebration of astronomy and its contributions to society and culture, highlighted by the 400th anniversary of the first use of an astronomical telescope by Galileo Galilei. Initiated by the International Astronomical Union and UNESCO, it was approved as an *International Year* by the United Nations at the end of 2007. Switzerland substantially contributed to this last step.

The IYA2009 is a global effort to stimulate worldwide public interest, especially among young people, in astronomy, astrophysics and science under the central theme *The Universe, Yours to Discover.* IYA2009 events and activities are promoting a greater appreciation of the inspirational aspects of astronomy to help the citizens of the world rediscover their place in the Universe.

Everyone should realise the impact of astronomy and other fundamental sciences on our daily lives, and understand how scientific knowledge can contribute to a more equitable and peaceful society. IYA2009 activities take place locally, nationally, regionally, internationally and globally. Switzerland is a full member and participant to all these many programmes and activities in 2009 which will establish collaborations between professional and amateur astronomers, science centres, educators, science media communicators and the general public.

I'm convinced that the huge preparatory work executed so far will make the IYA2009 an outstanding and enjoyable event to commemorate the 400th anniversary of the first use of an astronomical telescope by Galileo Galilei. I wish the International Year all the attention, visibility and success it deserves.

FROM GALILEO TO IYA2009

Gilbert Burki & Pierre Dubath
Université de Genève
Swiss Organizing Committee for IYA2009

"*After it had been notified to me that this doctrine was contrary to Holy Scripture, I wrote and printed a book in which I explain [...] that the Sun is the centre of the world and immovable, and that the Earth is not the centre and moves*". Galileo was 70 years old when he had to utter these words before being sentenced to life imprisonment by the Holy Office on June 22, 1633. It was the unfortunate outcome of a long battle between Galileo Galilei, a proponent of the heliocentric, Copernican vision of the solar system, and the highest authorities of the Catholic Church. The forced abjuration and the sentence handed down against him, in addition to his exceptional discoveries, were to help to make Galileo Galilei a scientist of incomparable stature through the quality of his observations and the intelligence of his interpretations, but also through his determination to get "truth" to triumph.

The year 1609 was emblematic in Galileo Galilei's busy life because it marked the beginning of his astronomical observation work, which forms the basis of his scientific fame and the source of his troubles. In the space of a few months Galileo Galilei was to construct his own astronomical telescopes[1], conduct numerous observations and derive from them the interpretations that were to revolutionize our knowledge of the cosmos. The choice of the year 2009 as the International Year of Astronomy therefore marks the 400th anniversary of the beginning of the vision of the cosmos that uses instruments other than the naked eye alone. The very many and important astronomical discoveries that have succeeded one another over the last four centuries, based largely on technological progress, evidently show that the months of astronomical fever that Galileo Galilei experienced at the end of 1609 and during the following years were the point of departure of a major scientific and philosophical revolution.

The work of Galileo Galilei, which is impressive in terms of its richness and depth, extends well beyond his pioneering work in observational astronomy. He was not yet 20 years old (he was born in 1564) when he discovered isochronism of the oscillations of the pendulum (1583). Over the next 25 years he discovered, invented or perfected the hydrostatic scales, the pulsometer (pulse measurement), the cycloid (mathematical curve), the proportional compass (the precursor of the slide rule),

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1 *The instruments constructed by Galileo Galilei consisted of two lenses, the objective and the eyepiece, and bear the generic name of "refracting telescope". The invention of the telescope, formed of two mirrors ("reflecting telescope"), is generally attributed to Isaac Newton in 1671.*

the water pump, the thermoscope (the first thermometer) and magnet armatures; he studied the laws of mechanics, how bodies fall and move; in December 1604 he participated in the observation with the naked eye of a nova (new star) the sudden appearance of which testified to the fact that the skies are not unchanging.

Over these years, which he spent mainly in Padova (1592-1610), Galileo Galilei perfected his technical skill by building or perfecting these different instruments. This technological ingenuity was to be crowned by the success of the construction of the astronomical telescopes, which Galileo Galilei undertook as of the month of May 1609. The principle of the magnifying glass, consisting of a thick-glass lens, had been known since the 11th century and the first spectacles for the long-sighted had existed since the end of the 13th century. As for the first instrument made of two lenses, the objective and the eyepiece, which makes it possible to magnify a distant object, it is said to have been built for the first time in 1590 by an Italian craftsman and then reproduced by opticians in the Netherlands. Galileo Galilei became aware of the existence of such an instrument during the spring of 1609. Although we do not know whether he was lucky enough to handle one, he immediately took a keen interest in this telescope and began to build a series of them, making successive improvements to the magnification and quality of the images. Galileo Galilei had not studied the laws of geometric optics, knowledge of which

FORMATION AND EVOLUTION OF PLANETS

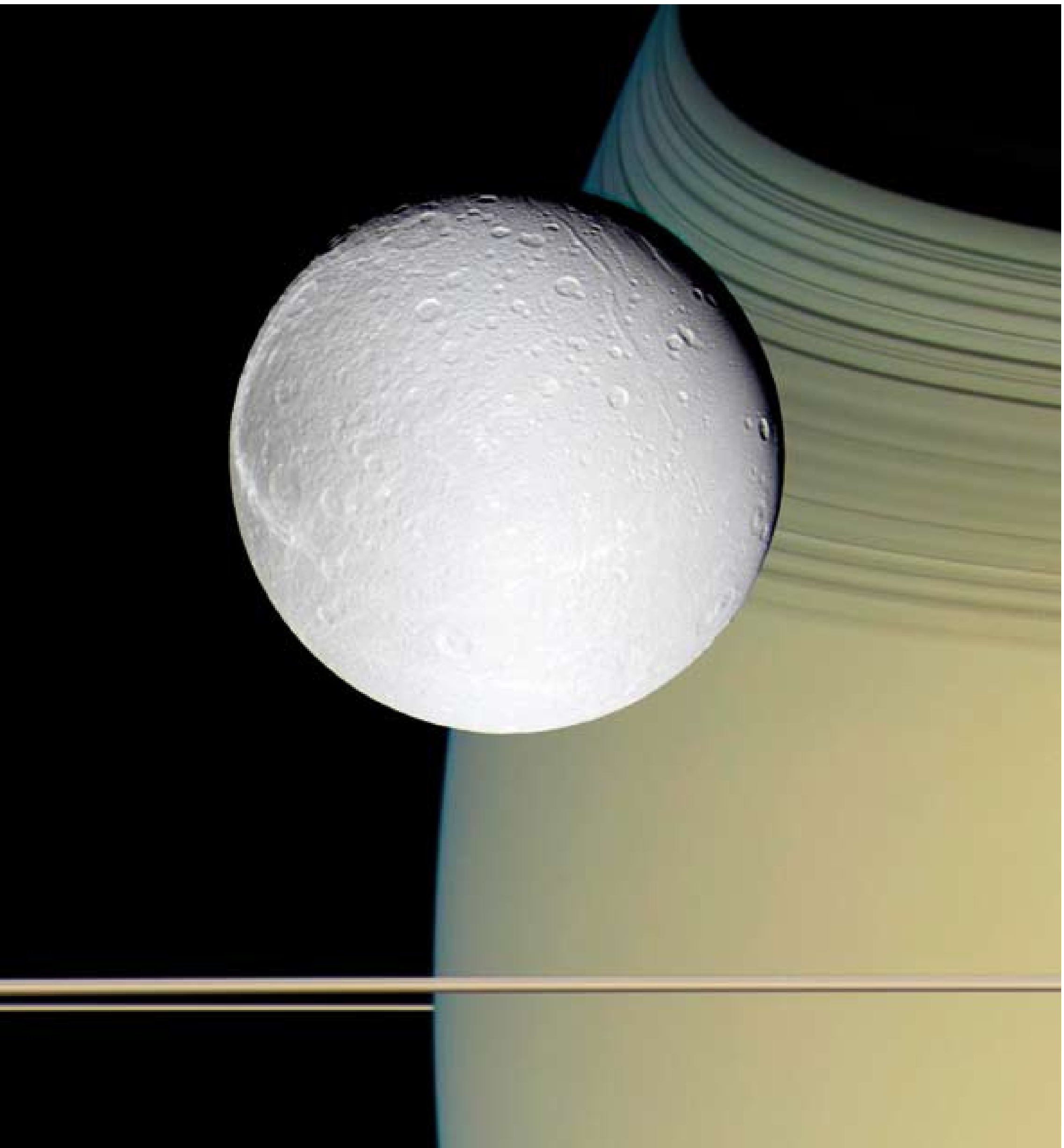
Image of the Moon craters seen near the terminator, the line which separates the brightly sunlit portion from the rest of the disk, obtained from Sternenberg (Zürcher Oberland).

(JAN DE LIGNIE, SAS)

was quite recent (Della Porta, 1593; Kepler, 1604). He thus succeeded intuitively and by means of successive tests in developing telescopes of good enough quality to conduct his astronomical observations.

Galileo Galilei began his astronomical observations in September 1609. At the end of the same year he was already able to announce his first results: the Moon has a shape similar to that of the Earth, with mountains in particular, and the mysterious Milky Way is produced from the luminous accumulation of many faint stars. On January 7, 1610 he discovered the satellites of Jupiter: three at first and then the fourth on January 13. And above all by observing Jupiter night after night, he observed that these "new celestial bodies" move in relation to the planet. In all likelihood it was on January 15 that the idea was born that these bodies might be satellites of Jupiter.

On July 25, 1610 he discovered that Saturn has a strange appearance, with two luminous patches on either side of the planet. Fifty years later Charles Huygens



PLANETARY SCIENCE

The space probe Cassini has taken this remarkable view of Dione, one of the sixty satellites of the planet Saturn partly shown in the foreground. The rings themselves can be seen slicing across the bottom of this image, with their shadow on the surface of the planet.

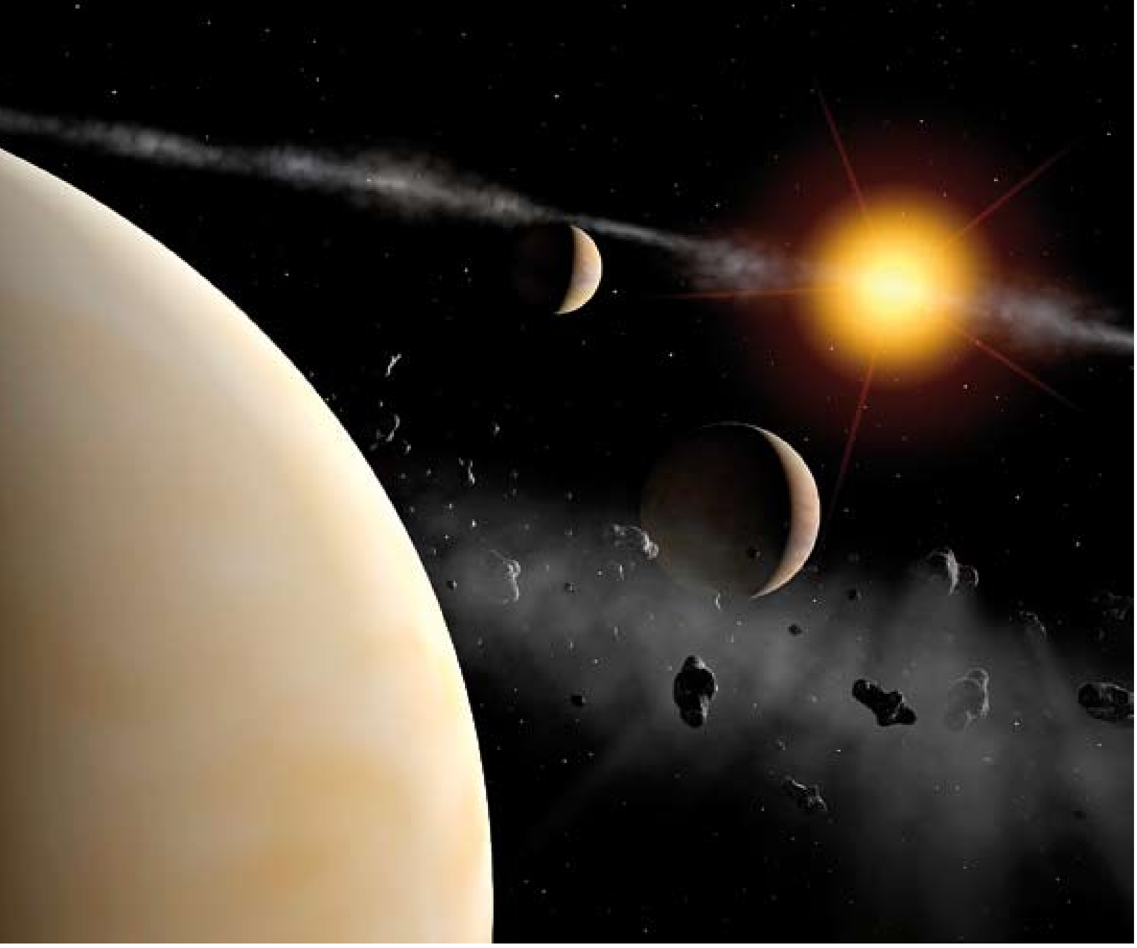
(CASSINI IMAGING TEAM, SSI, JPL, ESA, NASA) was to discover, thanks to his more powerful instruments, that Galileo Galilei had seen a "bad" image of Saturn's rings. In August 1610 Galileo Galilei discovered some dark spots on the surface of the Sun. In September of the same year he observed for the first time the phases of the planet Venus, which are similar to the phases of the Moon. Only one year had elapsed since his first astronomical observations... Such a succession of discoveries, all of which call into question the ideas (or prejudices) about the bodies being studied – the Moon, Milky Way, Saturn, Sun, Venus –, and moreover about the conception of the world, has no equivalent in the whole history of science. If one adds that Galileo Galilei in addition published his discoveries in the Sidereus Nuncius (The Sidereal Messenger) in March 1610 and that he moved house from Padova to Firenze in July, one can imagine that he had quite a full year!

These are Galileo Galilei's most famous astronomical observations. He made other discoveries, of course, since he devoted hundreds of hours to observing the sky. For example, he probably observed Neptune in September 1612 when the eighth planet, which was officially discovered by Johann Galle in 1846, was located in the same field as the satellites of Jupiter! As with the Milky Way, he also observed the nebulae, finding that some of them are formed of a myriad of stars.

The observations of Galileo Galilei that are mentioned here have all had consequences that affect the foundations of our vision of the cosmos. With the discovery of the lunar mountains, of which Galileo Galilei even measured the height, and that of the sunspots and their movement, it was the perfection of the "supra-lunar" world (including the Moon) that was called into question since this world was no longer formed only of perfect geometric shapes (spheres). With the explanation of the Milky Way and the discovery of the nebulae, the complexity of our world expanded. With the satellites of Jupiter, it was the discovery of new bodies in the solar system, which, moreover, do not orbit around the Earth. With Saturn's strange shape, it was again the sphericity of the planets that was called into question. The phases of Venus provided proof that this planet orbits around the Sun and not around the Earth; for Galileo Galilei it was further proof of the accuracy of the heliocentric, Copernican model.

These discoveries of Galileo Galilei result from some very simple observations which can easily be reproduced today using inexpensive instruments – a pair of binoculars or a small telescope. The International Year of Astronomy invites you to re-experience Galileo Galilei's excitement by repeating his historic discoveries[2]. Four centuries on these observations that revolutionized astronomy and our vision of the world are still just as interesting and are often the point of departure to further astronomical wonders.

2 *Caution, you must never look directly at the Sun, particularly not through a magnifying instrument, as you run the risk of causing serious permanent damage to your eyes.*



EXTRASOLAR PLANETS

A planetary system, called Neptune's Trident, has been discovered around the star HD 69890 (artist's view). The masses of the three extrasolar planets are 10, 12 and 18 times the Earth mass, thus near the mass of Neptune (17 times the Earth mass).

(ESO)

THE ASTRONOMICAL HERITAGE

Daniel Pfenniger
Université de Genève
MAP Platform of the Swiss Academy of Natural Sciences

The relationship of our modern society with the cosmos is a paradoxical one. Never before has the knowledge about the Universe accumulated by science been as great, but never has the abundance of artificial lighting distanced us as much from the daily, direct relationship that our ancestors had with the starry sky. Nowadays city-dwellers are deprived of this immediate contact with the stars and many of them have never seen the Milky Way. On the other hand, they can travel virtually through space by means of computers fed with astronomical data, allowing them to perceive the Universe as never before. Yet it is indubitable that down through the ages the familiarity of the grandiose spectacle that the sky represents has greatly influenced all cultures and civilizations. In this context it is useful to recall all the things that we owe to this cosmic environment, which at first sight is so distant and yet so closely associated with everything that defines us.

The natural heritage

Today we know that the Earth and the Universe were formed 4.54 and 13.7 billion years ago respectively, according to the laws of known physics. Astrophysicists can describe the physical conditions that prevailed a fraction of a second after the Big Bang and, knowing how the stars function, they can from there explain, for example, the proportions of the different atoms of which we are made up.

It is also understood that gravitation is responsible for the appearance of the multitude of very different celestial bodies such as the galaxies, stars or planets. Gravitation has the ability to make thermal differences increase, furthering the collapse of cosmic gas clouds. A thermal difference maintained for billions of years between the sun's radiation (6000° K) and the rest of the Universe (currently at 3° K) was essential to produce the prodigious complexity of the chemical and biological structures on the surface of the Earth, something which is impossible for systems close to a thermal equilibrium. In contrast, the latter, see their entropy and disorder increase inescapably. It is thus not directly solar energy that allowed life to fructify, but the permanent contact with very hot and very cold temperatures provided by our cosmic environment. Following a long evolutionary sequence that increased the sophistication of living beings, and following countless abortive attempts at evolution that were disrupted by major disastrous events such as the impacts of asteroids, our current state is the result of this chaotic history in which both stable and random cosmic factors have played a determining role.

Following billions of years of adaptation, living beings have closely synchronized their biological rhythms with the daily, monthly and seasonal cycles that result from the movements of the Earth and the Moon. It is also through adaptation that plant photosynthesis and the sensitivity of the eyes have been optimized to make the best use of the solar spectrum. We thus have the ability to perceive

INSTRUMENTATION

The design and construction of new instrumentation is essential for the future discoveries. This picture shows the setting of the Differential Delay Lines (DDL) for PRIMA, one of the instruments of the Very Large Telescope Interferometer (VLTI).

(UNIGE)

stars similar to the Sun, but we remain blind to other important components of the cosmos such as interstellar gas clouds, microwave radiation coming from the Big Bang or the enigmatic dark matter.

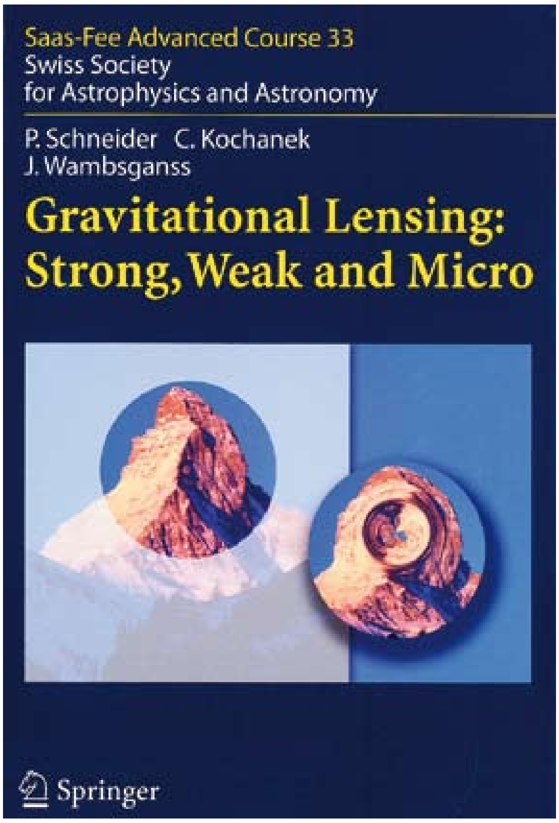
The cultural heritage

The spectacle of the starry sky crossed by the Milky Way, the perfect circularity of the Sun, the crescent of the Moon, not forgetting the rare but spectacular events such as eclipses and comets, have never failed to impress human beings and have fuelled their imagination since time immemorial. The ideas of transcendence and perfection have been associated with the sky, which is unreachable and enigmatic, in contrast to the immediate terrestrial phenomena, which are transitory and irregular. The cosmic rhythms, which appeared to be unchanging for centuries, were able to suggest the idea of infinite time, eternity. The constellations, as irregular and unchanging figures, have stimulated the imagination and had mythological figures associated with them. The Sun, Moon and planets have regularly been linked with the principal divinities. Thus religions have always associated cosmic phenomena with things that can transcend the human condition.

The scientific heritage

Ever since ancient times, astronomy – which was still mingled with superstitions – helped to gradually impart a rational meaning to the sky by means of long-term observations that enabled an inventory of the stars to be drawn up or the orbit of the planets to be determined. From these observations it gradually became possible to figure out how the cosmos functions. The mathematical models that were devised of the mechanics of the sky made it possible to predict certain phenomena such as the eclipses or the return of the comets. Gradually the pointless fears that linked these phenomena with events such as epidemics, famines or wars were eliminated.

Modern science owes a great deal to astronomy. Galileo Galilei with his telescope and Newton with his law of gravitation were the main founders of



TEACHING AND CONFERENCES

The organisation of the annual lectures of the Swiss Society for Astrophysics and Astronomy (SGAA/SSAA) started in 1971. The topics of these courses concern the main subjects of contemporary astronomy and more than one hundred professional astronomers toke part in the lectures. (SGAA/SSAA)

FORMATION OF STARS AND PLANETS

Located at the distance of 410 light-years, the globule B68 is one of the nearest dark interstellar clouds. Its mass is about three times the solar mass, and its matter is made of gas and microscopic dust, which produce a total absorption of the light of the background stars (image taken with the unit ANTU of the VLT). The solar system could have been formed 4.6 billions years ago by the collapse of such cloud.

(FORS TEAM, ESO)

modern physics. Along with many other people, they derived a fair proportion of their scientific inspiration from the questions raised by the celestial phenomena. Thus Einstein benefited from astronomical facts to make progress in his work on relativity: the constancy of the speed of light emitted by stars moving at different speeds in relation to us, or the advance of the perihelion of Mercury.

Over the last few centuries it has gradually become clear that the Earth functions according to the same laws as those that govern the Universe, except that the physical conditions prevailing on Earth are to be found within a very narrow range compared with those of cosmic phenomena. We no longer conceive of ourselves as the centre and *raison d'être* of the Universe but as very special products of its evolution. Nothing obliges us to think that human beings are the culmination of complexity that nature is capable of producing from an ordinary cosmic gas cloud.

One important contribution of space exploration has been to give us images of the Earth seen in its globality, looking tiny in its solar orbit. Thanks to these images, in most people's minds the Earth has ceased to be flat and boundless and has become a globe which is reduced to a dot when seen from afar. This growing awareness has greatly helped to get environmental constraints taken into account for the future of humanity and to gradually change our behaviour patterns.

Our eyes distinguish only the basic colours, the so-called colours of the rainbow. By comparison, today's astronomical instruments expand our perception of the electromagnetic spectrum emitted in the Universe, which extends from gamma radiation to radio waves. At the same time as space probes discover that each body of the solar system is an original world, we glimpse the existence and nature of hundreds of other planetary systems millions of times more distant. At the same time as we discover the global structure of our galaxy, the Milky Way, we discover the global structure of the Universe, which is thousands of times vaster than the Milky Way. Evidently over the coming decades many surprises coming from astronomy will do much to further revolutionize our perception of the Universe and our relationship with it. To paraphrase Socrates, it can be said that even though we have considerably increased our knowledge about the Universe, what remains to be discovered is even vaster!

FUNDAMENTAL ASTRONOMY, SPACE MISSIONS

The Earth seen from the Moon by the Japanese space probe Kaguya in November 2007. (JAXA/NHK)

SWISS ASTRONOMY AND THE EUROPEAN SOUTHERN OBSERVATORY (ESO)

AN ESSENTIAL AND PRODUCTIVE ASTRONOMICAL SYNERGY

MILLIMETER ASTRONOMY, INSTRUMENTATION

A vision of the near-future ALMA antenna array in construction on the Chajnantor site in Chile at the altitude of 5100 m. Computer-generated models of antennas were superimposed on a real photograph and adjusted for perspective and lighting.

(ESO)

Georges Meylan
Ecole Polytechnique Fédérale de Lausanne (EPFL)
President of the Swiss Commission for Astronomy

During the last four decades, the European Southern Observatory (ESO) has deeply and widely transformed ground-based astronomy and has given Europe leadership in the field.

All along the 20th century, the USA significantly dominated observational astronomy, with their four most famous instruments: the Yerkes refractor, with its 1.02 m diameter, the largest ever of its kind, built in 1895; with the Mount-Wilson Hooker telescope, with its 2.5 m diameter, built in 1917; with the Palomar Hale 5.1 m telescope, built in 1948; and with the twin Keck telescopes, each with a 10 m diameter, built in 1993 and 1996. However, with the construction between 1998 and 2001 of the Very Large Telescope (VLT), made of a set of four 8.2 m telescopes, supplemented with four 1.8 m auxiliary telescopes for the VLT Interferometer (VLTI) mode, Europe has built the most advanced optical and infrared telescope in the world. This started about half a century ago...

After the destructions related to World Wars I and II, a few European countries decided in the late 1950's to join forces in order to build an observatory in the Southern hemisphere. Indeed, the Southern sky contains the galactic centre and the Magellanic Clouds, among other marvels. A convention was signed in 1962 by

Belgium, France, Germany, the Netherlands, and Sweden, creating the intergovernmental organisation known as ESO (*European Southern Observatory*).

A few Swiss astronomers immediately recognized the interest there would be for their country to join the young organisation. However, not all of them were convinced... The Swiss astronomical community needed about 20 more years to realize where its future was: Switzerland became an ESO member country in 1982. In the meantime, the ESO Headquarters, originally located at CERN, had moved to Munich in 1981. Had Switzerland been slightly faster, ESO headquarters might still be in Geneva!

Nowadays, ESO is made of 14 European countries (in order of entrance in the organisation): Belgium, France, Germany, The Netherlands, Sweden (1962), Denmark (1967), Italy, Switzerland (1982), Portugal (2000), United Kingdom (2002), Finland (2004), Spain (2006), Czech Republic (2007), and Austria (2008).

INTERSTELLAR MATTER, PLANETS, STARS, GALAXIES, COSMOLOGY

The Very Large Telescope (VLT) of ESO at Cerro Paranal in Chile. The telescope VISTA is seen in the foreground.

(ESO)

In spite of this slow Swiss start, there was, nevertheless, since the early 1970's, some active collaboration between ESO and Switzerland. A Swiss 1 m class telescope was installed in 1975 at the ESO Observatory of La Silla, atop of a 2400 m high mountain 600 km North of Santiago de Chile, home of the 3.6 m ESO telescope. This high-quality site immediately provided Swiss astronomers with a flood of excellent photometric data, soon complemented with radial velocities obtained with CORAVEL, a spectrometer installed on the Danish-ESO 1.5 m telescope. Over the years, various generations of Swiss telescopes and instruments were built at La Silla. Currently, the Swiss dome hosts a 1.2 m telescope with a high-quality imaging CCD camera, for stellar and cosmological studies, while the spectrometer CORALIE measures precise radial velocities, with uncertainties of the order of 10 m/s (instead of the 500 m/s with CORAVEL), allowing the discovery of extrasolar planets.

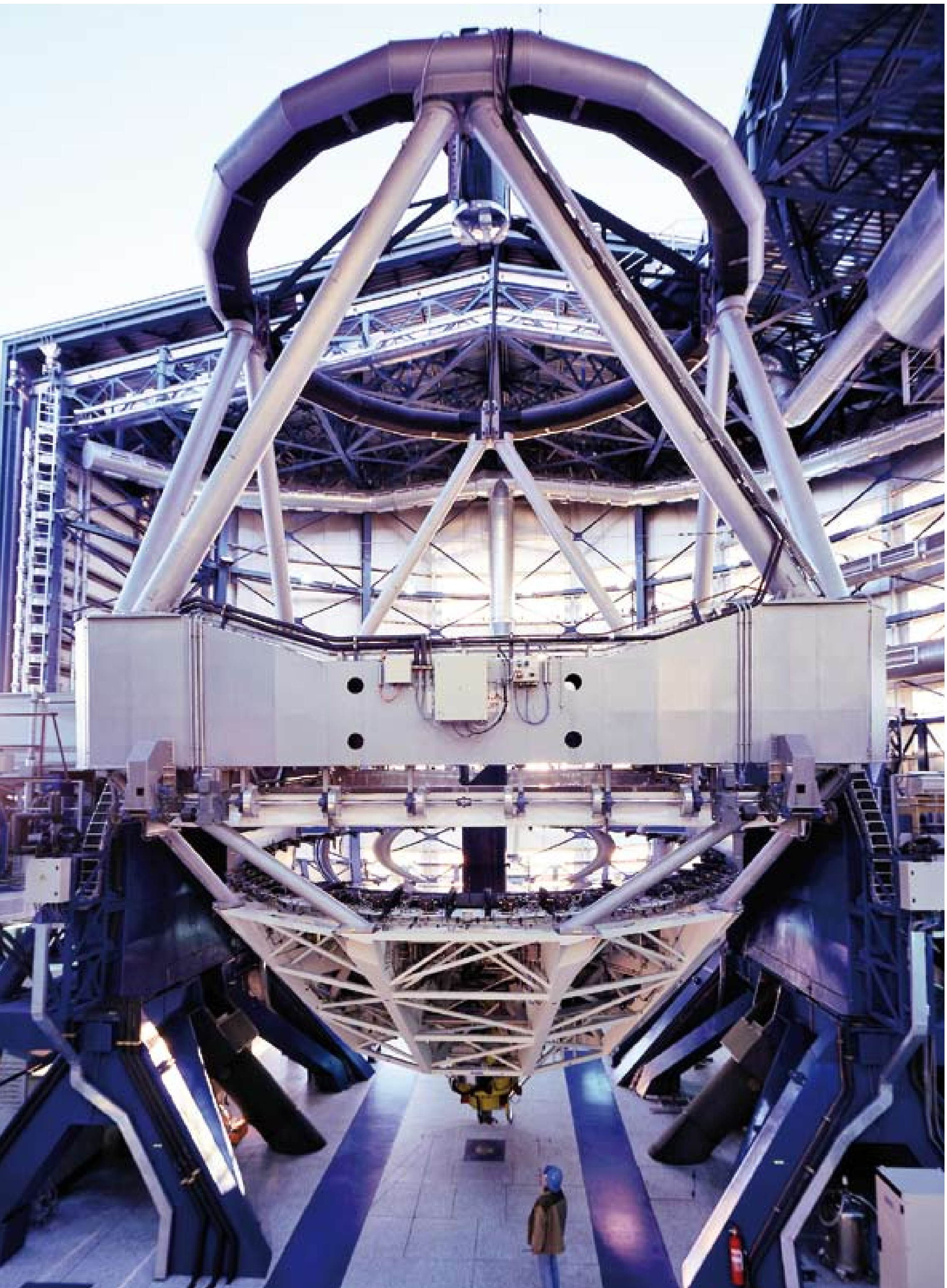
Since 1998, Swiss astronomers have also used the four 8.2 m units of the Very Large Telescope (VLT) at the ESO Observatory of Paranal, atop of a 2600 m high mountain, about 1400 km North of Santiago. With its new design, instrument complement, and operating principles, the Paranal Observatory, with its unique set of telescopes and instruments, set new standard for ground-based optical and infrared astronomy. This outstanding observatory gave back to Europe, in the beginning of this 21st century, the leadership for ground-based astronomy, that had started with Galileo in 1609!

Switzerland is very active in the construction and the use of various instruments at La Silla and at Paranal. Swiss institutes built HARPS in 2003, the *High Accuracy Radial velocity Planet Searcher*, mounted on the 3.6-m telescope. This very high accuracy instrument is dedicated to the discovery of extrasolar planets and is currently the best planet finder in the world. On the other hand, significant hardware and software components for PRIMA, one of the VLTI instruments, have been developed and built by Swiss astronomical institutes, and Switzerland participates in SPHERE, an instrument for the VLT.

ESO is also the focal point for Europe's participation in the Atacama Large Millimeter/submillimeter Array (ALMA), an intercontinental collaboration with North America, East Asia and Chile. The ALMA partners are constructing this unique facility at the high-altitude site (above 5000 m) of Chajnantor in the Chilean altiplano. ALMA will become operational in 2012, and promises to transform modern astrophysics, just as the Hubble Space Telescope did, soon after its launch in 1990.

The next step beyond the VLT and ALMA, currently under study, is to build the European Extremely Large optical/infrared Telescope (E-ELT) which will have a primary mirror 42-m in diameter. ESO has developed a pioneering new design for this giant, and is drawing up detailed construction plans together with its community. The E-ELT will provide the first images of Earth-like planets around other stars, the first direct measure of the expansion of the Universe, two among other truly remarkable milestones. Switzerland is already strongly involved in this impressive project.

It is obvious that the future of European ground-based astronomy will be made through ESO. This emphasizes the absolute importance for Swiss astronomers of an active participation in all present and future ESO flagship facilities!



INSTRUMENTATION

One of the 4 main units of the VLT, the telescope KUEYEN, with his primary mirror of 8.2 m in diameter. The size of the operator can be noted below the telescope...

(ESO)

SPACE EXPERIMENTS

In December 1999, the astronauts Claude Nicollier and C. Michael Foale install a new instrument on the Hubble Space Telescope (HST).

(NASA, ESA, ST103 MISSION)

SWITZERLAND AND SPACE SCIENCES

AN OVER 40 YEARS OLD SUCCESS STORY

Willy Benz

Universität Bern

President of the Swiss Space Commission

Space research in Switzerland, as well as in many other European countries, is eminently an international endeavour. Given the infrastructure (and the associated costs) required to carry out this type of research, the need for international collaborations in these matters was seen from the beginning as a necessity rather than a choice. Today, it is regarded by most as a unique opportunity to bring together research teams from across Europe and the world to work jointly on designing unique space missions in order to address a common science question.

Switzerland recognized these opportunities from the beginning and became very active in the negotiations that took place to create the *European Space Research Organisation* (ESRO) in 1962. A little more than a decade later in 1975, when the concept of a single European Space Agency (ESA) regrouping all various European space activities imposed itself, Switzerland was again amongst the ten founding Member States (Belgium, Denmark, France, Germany, Italy, The Netherlands, Spain, Sweden, Switzerland, and the United Kingdom). Today, ESA counts 17 Member States (15 of them are also EU members) and additional countries are negotiating to join the Agency. Finally, in 1986, following a proposal from Switzerland, ESA created its first optional science programme: PRODEX (*PROgramme de Développement d'EXpériences scientifiques*). This programme allows countries without a space agency on their own to finance space experiments developed by their research institutes and/or universities, directly related to ESA missions or in line with the overall science objectives of the Agency. As the founding State, Switzerland was initially the only member of the programme but was rapidly joined by other countries. Today, the PRODEX programme includes Switzerland, Ireland, Belgium, Norway, Austria, Denmark, Hungary and Czech Republic.

PRODEX gave Swiss scientists working at research institutes and universities the financial means to participate fully in the design and construction of space experiments. With the requirement that half of the allocated funds be spent in contracts with industry, PRODEX also brought together the academic and the space industry world of the country. Over the years, this has not only led to very successful hardware developments but also to a tradition of collaboration and exchanges that may otherwise not have taken place at least not to this extent.

The twenty-year commemoration of the creation of the "bridge to experimental space research" as PRODEX is sometimes called, took place in 2007 in form of a Symposium held in St-Gallen and Altenrhein[1]. Looking back was impressive indeed and made clear that Swiss scientists participated in one form or another to many of the most important space missions to date. During these 20 years, a budget of CHF 109 million was allocated to forty-four development projects originating from all over the country and covering a vast area of sciences ranging from astronomy, earth observations, and fundamental physics to biology. Starting in 2008, Switzerland will have an annual budget of around EUR 7.2 million to be used for PRODEX projects. Swiss researchers can use this funding for hardware and software development projects in all disciplines relating to space research.

Today, a record number of ESA missions or missions with a significant ESA involvement are in operations exploring the Sun (SOHO, Ulysses), the solar system (Mars and Venus Express, Rosetta, Double Star, Cluster, Cassini-Huygens), and the Universe (Integral, XMM-Newton, Hubble). The wealth of data received from these missions is enormous and has contributed significantly to a better understanding of the Universe. Who has not been impressed by the extraordinary im-

1 *see http://www.sbf.admin.ch/htm/dokumentation/publikationen/raumfahrt/Prodex_dokumentation.pdf*

SPACE MISSIONS, GALACTIC ASTRONOMY, STELLAR PHYSICS, ASTEROSEISMOLOGY, FUNDAMENTAL ASTRONOMY

The future satellite GAIA of the European Space Agency (artist's view). Launched in 2011, this satellite will measure the positions and distances of 1 billion stars, with a precision never reached today. It will also make a monitoring of the variability of the objects measured, allowing the discovery of several millions of new variable stars...

(ESA)

ages from Hubble Space Telescope and who can forget the breath taking images of Claude Nicollier, the Swiss ESA Astronaut, fixing and upgrading it?

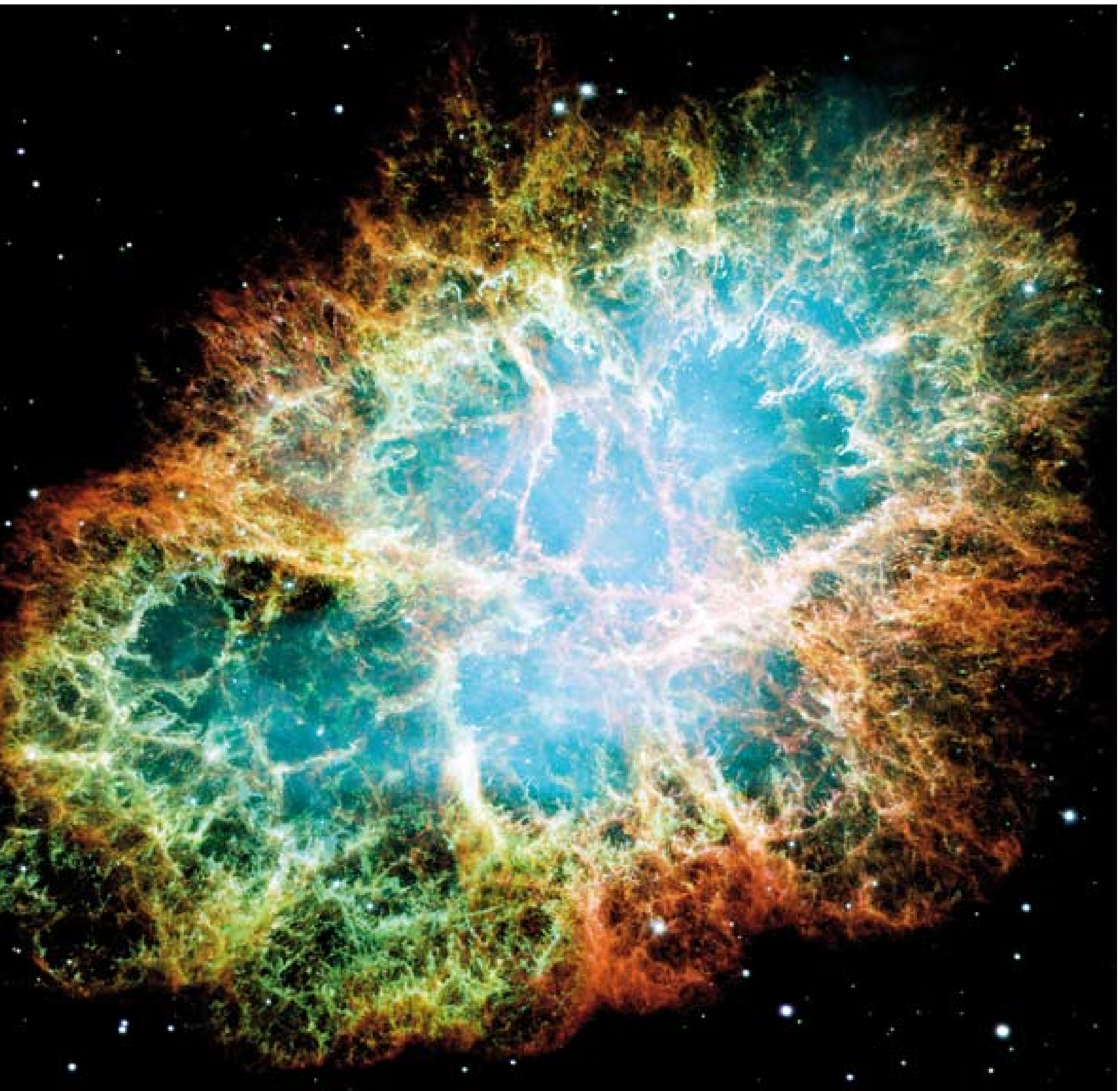
In the implementation phase we have a mission to the planet Mercury (BepiColombo), two missions devoted to the early universe and its constituents (Herschel and Planck), one dedicated to the three-dimensional mapping of our own Galaxy (Gaia), as well as the successor of the Hubble Space Telescope (JWST). All of them have Swiss involvement in one way or another.

The longer-term future of astronomy from space in Europe has been defined by the *Cosmic Vision 2015-2025* exercise organized by ESA. In April 2004, ESA issued a call for the science themes of the future and received in response 151 novel ideas from individual scientists across Europe. After the distillation of these ideas through ESA's advisory structure and a public workshop, the four main questions that will underpin the space efforts during the years 2015-2025 emerged:

1. What are the conditions for planet formation and the emergence of life?
2. How does the Solar System work?
3. What are the fundamental physical laws of the Universe?
4. How did the Universe originate and what is it made of?

Clearly, profound questions that were impossible to address scientifically two decades ago are now being raised with a clear expectation for answers. These will have to be provided by space missions designed around these themes. A staggering 50 mission concepts were received by ESA in response to its Call for Proposal. A first selection of nine candidate missions for the first launches of *Cosmic Vision* (2017 and 2018) has already been made. These candidates span a large spectrum of sciences ranging from the mapping of the dark Universe (Euclid) and the detection of gravitational waves (Lisa), high energy astrophysics (Xeus), the formation of galaxies, stars and planets (Spica), the detection of exoplanets (Plato), the study of the giant planets in our own solar system (Laplace and Tandem), a sample return from a near Earth asteroid (Marco Polo), to the study of the fundamental length scales in plasmas (Cross Scale). Swiss scientists are again involved at various levels in almost all of these missions.

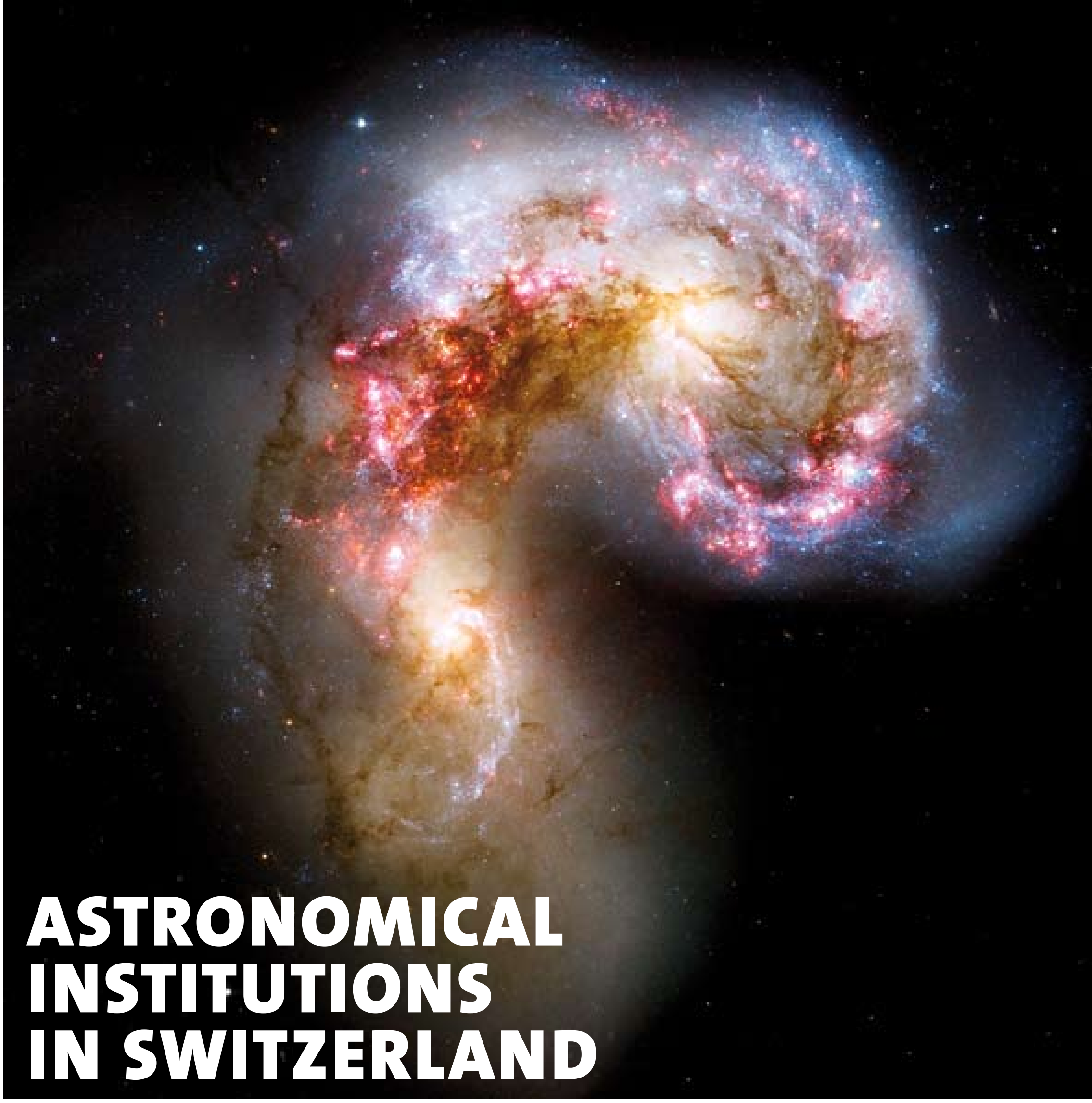
Not surprisingly, the path between the idea and its realization is long and sometimes difficult. New technology has to be developed, science goals have to be refined, financial difficulties have to be overcome but in the end we will have learned something more about how the Universe came to be, how it is evolving, and our place in it. Finally, and perhaps equally important, we will also have demonstrated our abilities to work together to address some of the greatest scientific and technological challenges of our times.



SUPERNOVAE, PARTICLE ASTROPHYSICS, COSMIC RAYS

The most detailed view of the Crab Nebula (M1) ever made, was assembled from 24 individual exposures. M1 results from a supernova explosion observed on the Earth in 1054. The size of the nebula is about 11 light-years and its distance is 6500 light-years.

(NASA, ESA, HST)



EXTRAGALACTIC ASTRONOMY, STELLAR FORMATION

Antennae Galaxies, two colliding galaxies located at 45 millions of light-years. Millions stars are forming (red regions) due to the interaction of gas and stars from the two galaxies.

(NASA, ESA, HST)

ASTRONOMICAL INSTITUTIONS IN SWITZERLAND

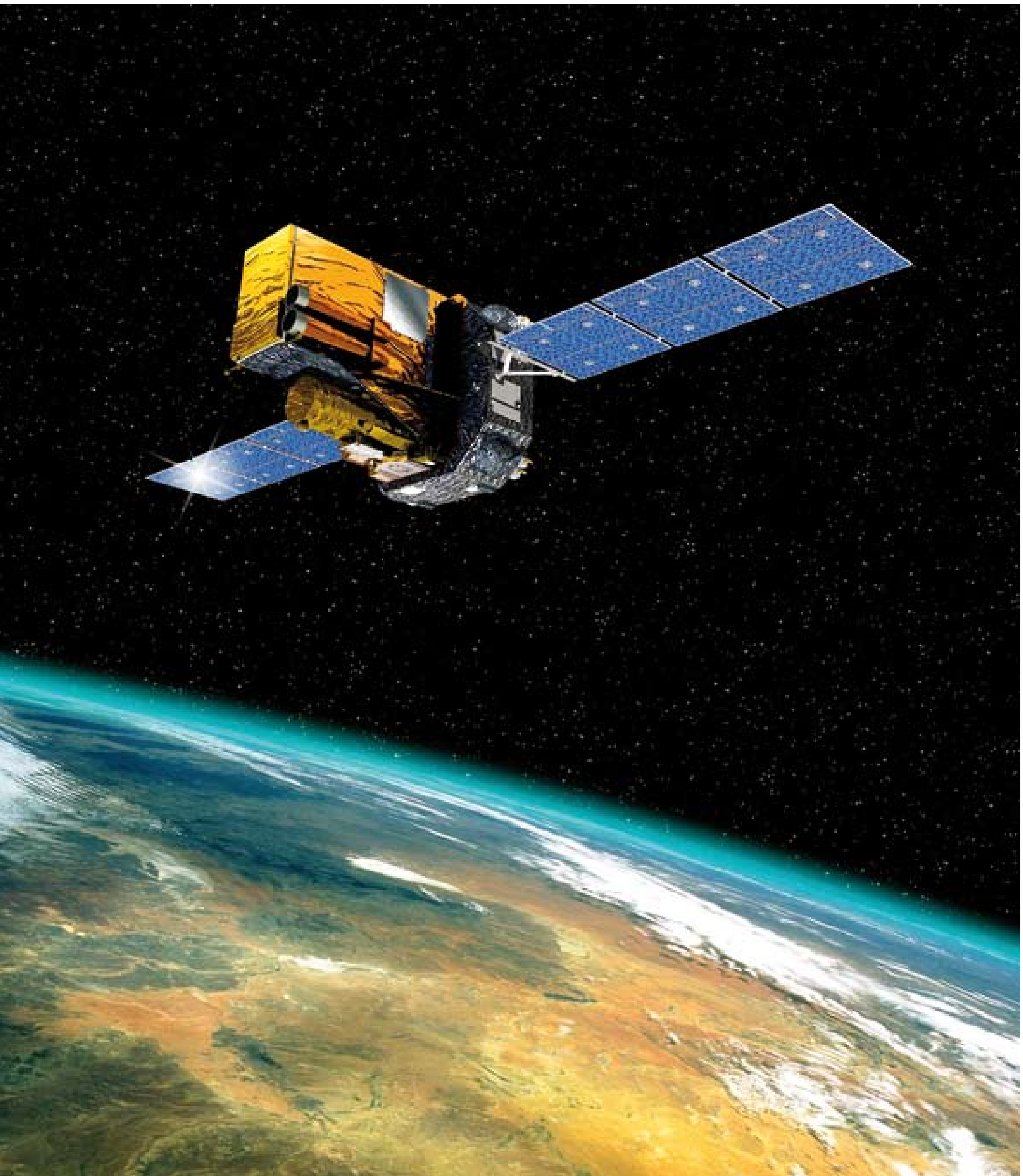
Hans-Martin Schmid
Eidgenössische Technische Hochschule Zürich
President of the Swiss Society for Astronomy and Astrophysics (2005-2008)

Daniel Schaerer
Université de Genève
President of the Swiss Society for Astronomy and Astrophysics (2008-2011)

Many of the astronomical institutions in Switzerland have grown historically from Observatories ("Sternwarten" or "Observatoires"), built in particular to provide accurate time measurements or to monitor solar activity. For example, since the 1770's timekeeping and later geodesy was an important task of the Geneva Observatory until it progressively became a true astrophysical research institute in the 1960's.

Nowadays, the major astronomical institutions are attached to a University or one of the ETHs, and they belong to the corresponding Astronomy, Physics, or Physics and Astronomy Departments. They are listed in Table (p. 27). The Astronomy Department (Observatory) of UNIGE and the Laboratory of astrophysics of EPFL form the *Centre Romand d'Astronomie* governed by a partnership agreement. Of somewhat different type are the *International Space Science Institute* (ISSI) in Berne, the *Physikalisch-Meteorologisches Observatorium Davos* (PMOD) in Davos, the *Istituto Ricerche Solari* (IRSOL) in Locarno and the *Integral Science Data Center* (ISDC) in Geneva. PMOD operates the *World Radiation Center* (WRC) for the *World Meteorological Organization* as Swiss contribution to the *World Weather Watch*; ISSI is co-funded by the European Space Agency; the solar research institute IRSOL is run by a private foundation; ISDC is an institute attached to the Observatory of UNIGE.

In 2006, the personnel employed in Swiss astronomy was a total of approximately 270 researchers and 100 technical and support personnel. Less than 22% of the researchers have permanent positions. Most professional astronomers are members of the Swiss Society for Astrophysics and Astronomy (SSAA), a society member of the Swiss Academy of Sciences (sc|nat).



SPACE MISSIONS, HIGH-ENERGY ASTROPHYSICS

The INTEGRAL satellite of the European Space Agency was launched by a Proton rocket the 17th of October, 2002. The aim of this space mission is the measure of the gamma radiation, the most energetic part of the electromagnetic spectrum, produces by various sources in the Universe: gamma-ray bursts, supernovae, black holes, pulsars, X-ray binaries, etc. The INTEGRAL Science Data Centre (ISDC), based in Switzerland, is receiving all data from the spacecraft and is providing the data to the scientific community worldwide.

(ESA)

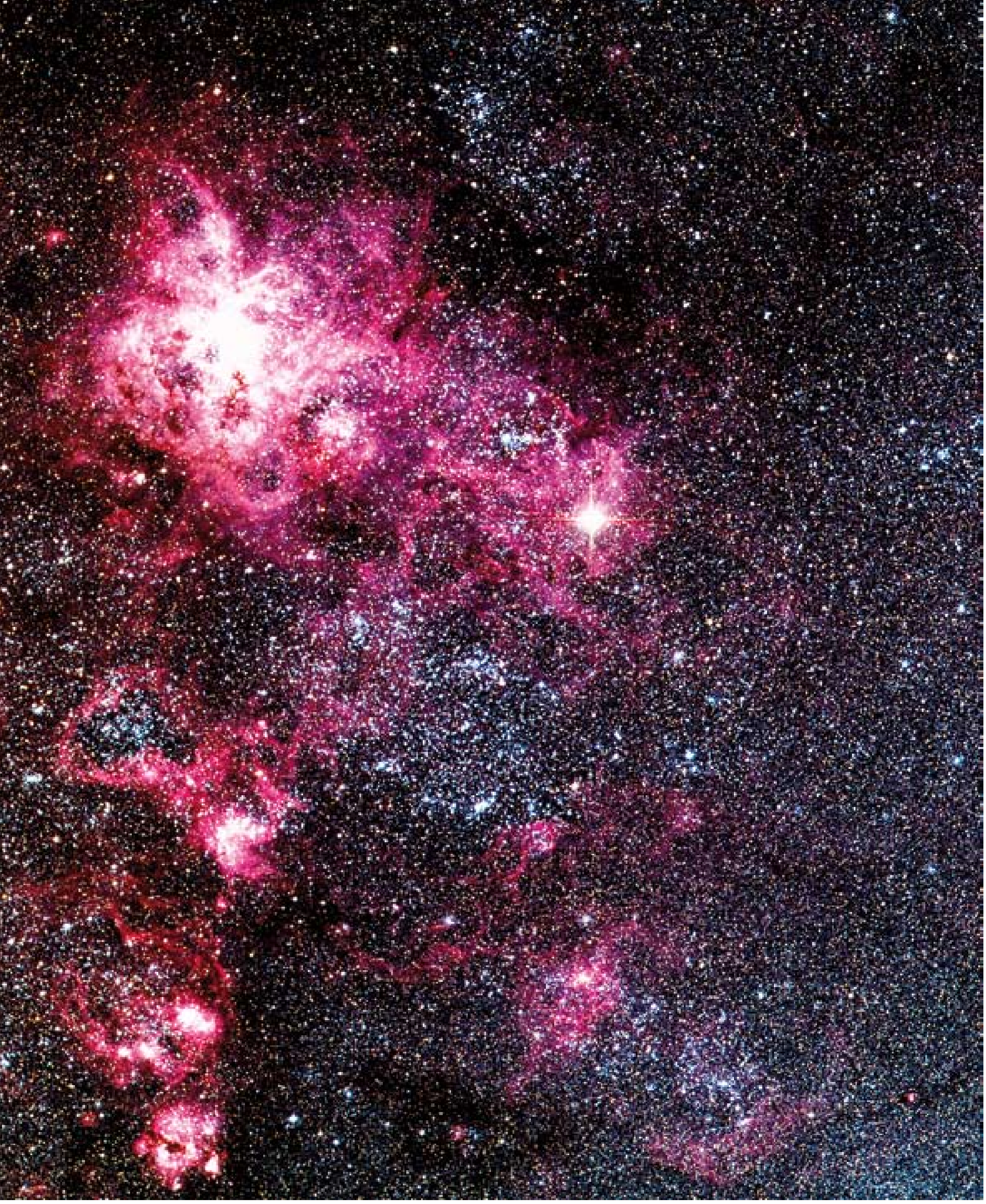
COSMOLOGY, EXTRAGALACTIC ASTRONOMY

View of the spectacular spiral galaxy NGC 1232, located 100 millions light-years away, taken with Unit 1 (ANTU) of the VLT. Image obtained by the assemblage of 3 images in near ultraviolet, blue and red.

(ESO)

The swiss astronomical institutes and their main expertise

Universität Basel: Departement Physik	Supernovae, Binary stars, Nucleosynthesis, Chemical evolution, Particle astrophysics
Universität Bern: Astronomisches Institut, Physikalisches Institut, Institut für Angewandte Physik	Fundamental astronomy, Planetary science, Formation and evolution of planets, Solar system research, Cosmic rays, Space experiments
Université de Genève: Observatoire de Genève (Département d'Astronomie), Integral Science Data Centre, Section de Physique	Extrasolar planets, Stellar evolution, Nucleosynthesis, Asteroseismology, Galactic and extragalactic astronomy, Cosmology, High-energy and particle astrophysics, Space missions, Instrumentation
EPF Lausanne: Laboratoire d'Astrophysique, Laboratoire de Physique des Particules et de Cosmologie	Galactic and extragalactic astronomy, Cosmology, Gravitational lensing, Particle astrophysics
Universität Zürich: Institut für Theoretische Physik	Computational and theoretical astrophysics, Cosmology, Extragalactic astronomy, Planet and star formation, Particle astrophysics
ETH Zürich: Institut für Astronomie, Institut für Teilchenphysik	Solar physics, Star and Planet Formation, Extragalactic astronomy, Cosmology, Astronomical instrumentation, High-energy and particle astrophysics
International Space Science Institute, Bern	Space Sciences, Interdisciplinary meetings
Physikalisch-Meteorologisches Observatorium und World Radiation Center, Davos	Solar physics, Solar radiation and Earth climate, Space experiments
Istituto Ricerche Solari, Locarno	Solar observations, Polarisation
Hochalpine Forschungsstationen Jungfraujoch und Gornergrat	Atmosphere physics, Solar radiation, Cosmic rays, Millimeter astronomy



SUPERNOVAE, STELLAR EVOLUTION, HIGH-ENERGY ASTROPHYSICS

Tarentula Nebula in the Large Magellanic Cloud, a satellite galaxy of the Milky Way, located at the distance of 160'000 light-years. At the centre of this image, taken the 24th February 24 1987, is the famous supernova SN1987A, the first visible with naked eye since the one observed by Johannes Kepler in 1604!

(ESO)

The main missions of the astronomical institutes and observatories are teaching, research, and various services including for the general public.

Services

Services include for example satellite data reduction and archiving for the European Space Agency (Integral Science Data Centre), astrometric services and measurements of space debris (Uni Berne), atmospheric turbidity monitoring for the Global Atmosphere Watch program (PMOD/WRC) etc. Outreach activities to the general public on a broad variety of topics related to astronomy and other natural sciences are important for all institutions.

Research

To carry out their research mission, groups at different institutions develop state-of-the-art instruments, carry out observations, undertake computer simulations, and do theoretical work. Most research projects are done in the framework of national and international collaborations. The Swiss institutions have expertise in many different fields of astronomy (see Table, p. 27), ranging from planets, stars and galaxies to cosmology. Their work is recognized world-wide.

In the past, Swiss institutions have developed and used their own telescopes, e.g. in Zurich, at the Jungfraujoch and Gornergrat, and in other places in Switzerland and abroad. Currently they still run telescopes in Locarno, Zimmerwald, on La Palma, and at La Silla in Chile. Most important is that Swiss astronomers have access to and use frequently the first class facilities at ESO (*European Southern Observatory*)[1] and different satellites of ESA (*European Space Agency*)[2] and NASA. Several groups also develop and construct new instruments for these ground-based and space observatories.

Teaching

Teaching, i.e. the training of physicists, professional astronomers, and others in astronomy and related fields is given at the Universities of Basel, Bern, Geneva, and Zurich, as well as at the EPF in Lausanne and the ETH in Zurich. These are the major research centres for astronomy, which are ideally suited for the education of young researchers. Courses are given at the Bachelor, Master, and PhD level, as well as for the general public.

The International Year of Astronomy 2009 provides a unique opportunity to bring astronomy and the Swiss astronomical institutes closer to the public and to share our knowledge and excitement about the Universe with everyone!

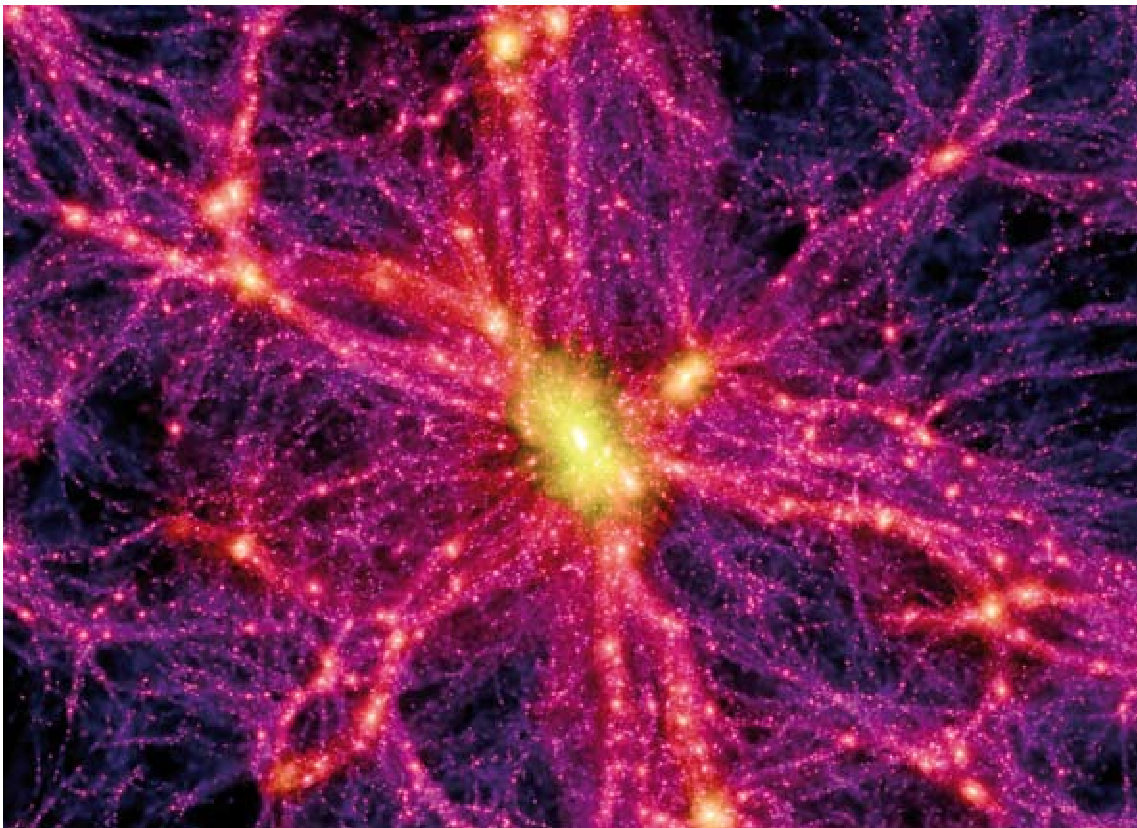
1 *See the text "Switzerland and the European Southern Observatory" by Georges Meylan*

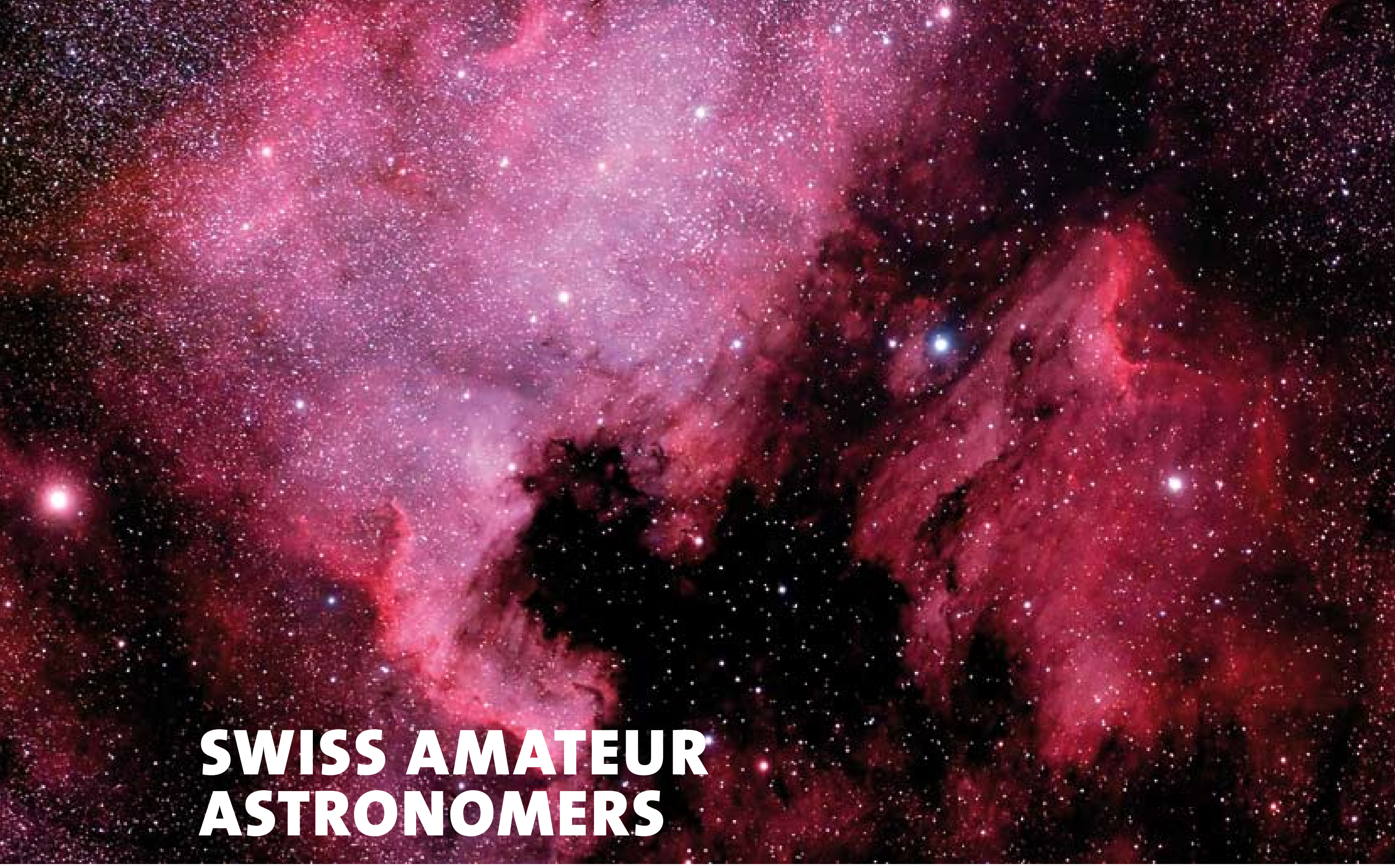
2 *See the text "Switzerland and space sciences" by Willy Benz*

THEORETICAL AND COMPUTIONAL ASTROPHYSICS, COSMOLOGY

International teams of researchers have developed computer programs that simulate the growth and expansion of the Universe after the Big Bang, including the formation of galaxies, clusters and quasars. The "Millennium Simulation" for example used 10 billion virtual particles of matter, and traced their movements as the Universe evolved. This simulated area contains 20 million virtual galaxies, and account for dark energy expanding the Universe, cold dark matter, and regular matter. The image shows the distribution of matter in the simulated Universe.

(V. SPRINGEL, MPA)





SWISS AMATEUR ASTRONOMERS

Max Hubmann
Central President of the Swiss Astronomical Society (SAS)

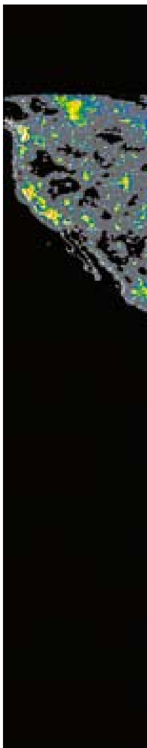
STELLAR AND CHEMICAL EVOLUTION, INTERSTELLAR MATTER
Image of the North America Nebula, obtained with a 110 mm telescope (mosaic of 4 exposures).
(MARTIN MUTTI, SAS)

Amateur astronomers and science, or what does "amateur" mean?

A few years ago a journalist asked me whether amateur astronomers can also make a scientific contribution to astronomy. After reflecting for a moment about the scientific equipment of professional astronomers, I replied in the negative. In the printed article two sentences after my reply a professional astronomer and renowned professor said: amateurs really make a scientific contribution to astronomical work. Where does this difference of assessment come from? Probably from an overestimation of reality in both replies, one from a professional and the other from an amateur!

A small fraction of amateur astronomers "chase" new bodies such as comets, supernovae or other unforeseeable phenomena. Others systematically monitor the light variations of certain stars or the spots on the surface of the Sun during long observation sequences that sometimes extend over several decades. As the amateurs are spread across the world, their results are generally independent of the local meteorological conditions; they can then make a genuine scientific contribution to the description of the cosmos.

Owing to time constraints and their persistent determination to obtain good-quality measurements, the results of amateur astronomers complement those of professional astronomy. One difference that should be stressed is that amateurs



are in general not subsidized, for themselves or for their equipment. However, according to my estimations, very few Swiss amateurs take part in such projects compared with the 2,500 members of the Swiss Astronomical Society. I will be speaking here mainly about this majority of amateurs who passionately practise astronomy as a pastime.

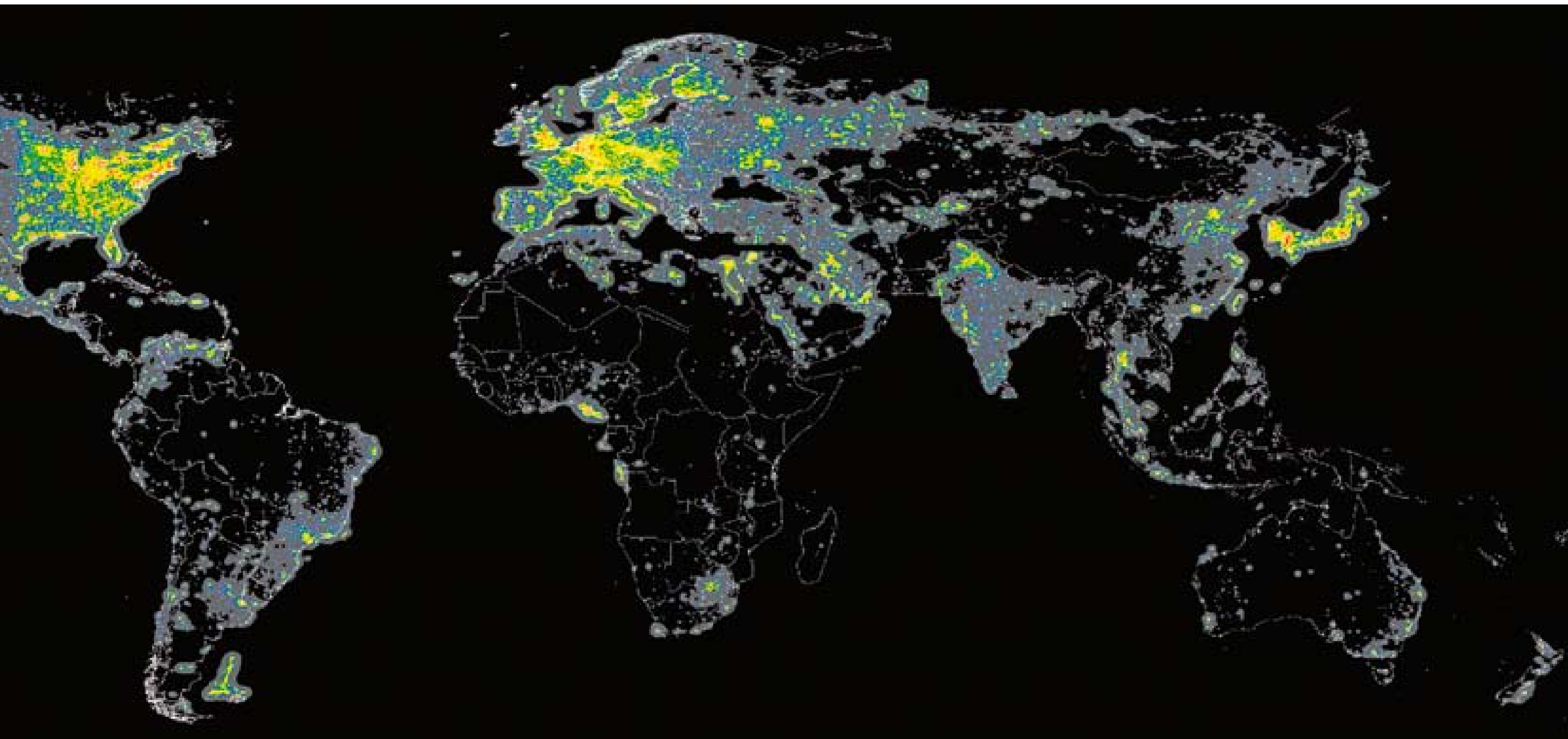
Amateur astronomers, yesterday and today

A number of observers of the sky who felt very concerned by this occupation practised as a leisure activity grouped together in 1939 to found the *Swiss Astronomical Society* (SAS), the aim of which is to bring together in an association all those who have a keen interest in astronomy. These founding members had very different backgrounds, and still do today: teachers, craftspeople, bank employees, dentists as well as members of various universities. The common aim was to exchange knowledge and experience. Furthermore since 1943 SAS has been responsible for the publication of an amateur astronomy magazine, ORION.

Astronomical cooperation between scientists and amateurs needed to be strengthened. This is how, for example, amateurs participated in several expeditions to observe solar eclipses. The amateurs' different origins and competencies provided welcome support for the construction of instruments, in particular for the polishing of telescope mirrors. These amateur activities were acknowledged by the award of a number of honorary doctorates by the Universities of Bern and Basel, among others, to the Toggenburg farmer Friedrich Schmid for his observations of zodiacal light, to the Schaffhausen confectioner Hans Rohr and the Bernese industrialist Willy Schaerer.

DARK SKY AWARENESS

Earth illumination by the artificial light. It is now urgent to preserve and protect dark night skies for posterity in places such as sites connected to astronomical observations. The ongoing loss of a dark night sky for much of the world's population is a serious and growing issue that not only impact astronomical research, but also global environment and energy conservation. (P. CINZANO, F. FALCHI (PADOVA), C.D. ELVIDGE (BOULDER))



Today amateurs only occasionally build their own telescopes. Good-quality instruments can be purchased directly in stores and amateurs devote large sums of money and their equipment lasts for decades. Observation of the celestial bodies is not called into question by financial considerations; amateurs who develop and use their own observatories, which are sometimes of impressive size, are interested in the laws of nature and are enthusiastic observers of the sky.

Observatories

About half of the 35 local societies affiliated to SAS own their own observation station, which they open to schools and the general public by offering "guided tours of the sky". The mountains and craters of the Moon, the phases of Venus and Mercury, Jupiter and its satellites or Saturn's rings remain subjects of wonder even 400 years after Galileo Galilei's discoveries.

The guides point to the open or globular stellar clusters. They show that brilliant nebulae and dark clouds provide visible evidence of matter between the stars. Under good conditions of atmospheric transparency, the galaxies may be observed at a distance of millions of light years. Demonstrations give rise to discussions about the mysteries of the Universe and the scientific explanations of its content. On their way back home, the visitors thus realize that the Universe can be understood and explained, at least partially.

Lectures

Many amateur astronomy societies organize lectures for their members and the public, which are generally free of charge. Specialists come along to explain in language that can be understood by everybody the latest results of current research work. It is also an opportunity for the members of the societies to present what they have developed and what their activity is. A transfer of knowledge is thus achieved from the specialist to the public thanks to amateurs. It is one of the best ways of getting citizens – who subsidize science – to participate in the recent discoveries, which are often as mysterious as they are spectacular. This is one important contribution that amateur astronomers make to scientific work, as I mentioned in my introduction.

Observations

In addition to the activities described above, a large number of amateurs indulge in their passion for astronomy in a more individual manner. However, in most cases they are not isolated, as is shown by the many meetings that are often organized informally. Groups meet for joint nocturnal observations, often lasting until the morning. The equipment currently available for recording images allows some remarkable results to be achieved, which are the starting-point for many fruitful discussions about the bodies observed and the improvements to be made to the instrumentation.

Protecting the night sky – a major problem for observation

The darkness of the sky is unfortunately dangerously threatened by the excessive illumination of streets and buildings. Observers of the sky therefore have to travel to increasingly remote sites. And what about those who have to stay at home? They have to be content with observing the classic brilliant bodies, the Moon and planets. Is the unimpaired dark night not a natural resource to which everyone should be entitled?

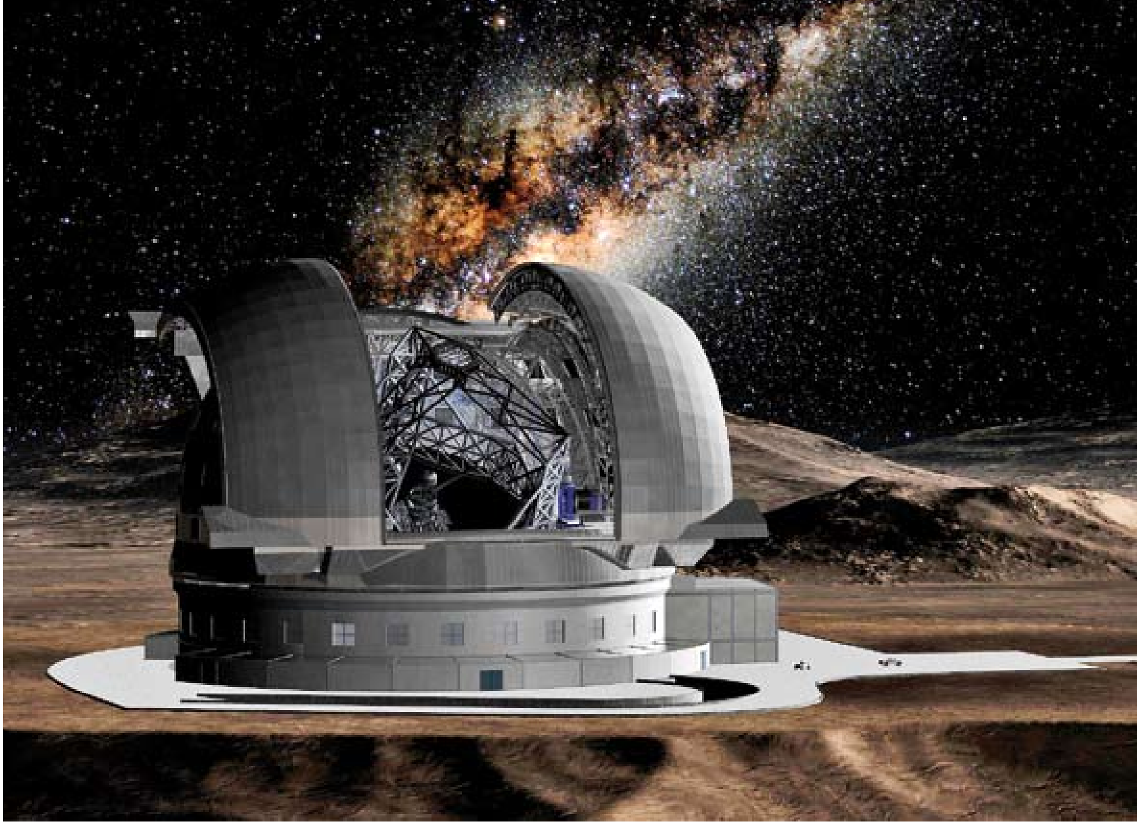
All those who think that observation of the sky should be a possibility open to everybody under good conditions may contact local amateur astronomer societies. They will probably be given a warm and attentive reception. A prior knowledge of astronomy is not necessary, enthusiasm is sufficient!

STELLAR EVOLUTION, NUCLEOSYNTHESIS, INTERSTELLAR MATTER

The star cluster of the Pleiades (naked-eye visible) located at the distance of 440 light-years, image obtained with a telescope of 140 mm (mosaic of several images). (HANSJÖRG WÄLCHLI, SAS)

H. Detouche (1854-1913):
Galileo Galilei and the Doge of Venice

CONTENT



Future European Extremely Large Telescope (artist's view). (ESO)

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The list of the large number of events organised during the International Year of Astronomy 2009 can be obtained in the sites:

INTERNATIONAL

www.astronomy2009.org

NATIONAL

www.astronomy2009.ch

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