Astronomy in Austria

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Austria officially became the fourteenth ESO member in June 2009. A brief outline of the recent developments and scientific highlights of astronomical research in Austria is presented. Having started from a relatively low level a few years ago, astronomical research is now expanding very rapidly thanks to the accession to ESO.

Research in astronomy in Austria is conducted at three universities: the University of Vienna at the Institute of Astronomy; the University of Innsbruck at the Institute of Astro- and Particle Physics; and the University of Graz at the Institute for Physics. Some additional astronomy or related research is conducted at various other places such as the Institute for Space Research of the Austrian Academy of Sciences in Vienna. In total there are currently 27 staff members and many young people working at the three university institutes. The research topics cover a very wide range: from solar physics at Graz[1]; astroseismology, the late stages of stellar evolution, planetary systems, the interstellar medium, the Milky Way, structure of galaxies, galaxy clusters, the history of astronomy and participation in the CoRoT and Herschel missions at Vienna[2]; to planetary nebulae, novae, galaxy structure, galaxy clusters and astroparticle physics at Innsbruck[3].

Recent developments

For many decades it was the goal of Austrian astronomers to join ESO. Fortunately, accession to ESA was achieved in 1987, but accession to ESO proved to be more difficult. There were several attempts and a lot of effort spent by the scientists to convince the relevant authorities that ESO membership is a must for an active astronomical community. Several studies evaluating the quality of the institutes and the scientists were conducted. Astronomers have made increasing efforts over recent years to increase national and international visibility, working towards eventually securing a positive result. These efforts included the acquisition of an increasing number of grants (from national and international sources), of extending international collaborations, of enhancing public outreach activities and of increasing the publication rate (see Figures 2, 3 and 4). Eventually, the ESO accession document was signed in 2008 (see the ESO press release of 30 June 2008) and ratified in February 2009.

With Austria's new place in the international scientific community confirmed by its accession to ESO, further development is secured. In Innsbruck a new full professorship was recently filled in astroparticle physics, in Vienna two new full professors for astrophysics are in the process of being appointed and in Innsbruck two more astronomy(-related) full professorships are planned, to be announced in 2010. So from the low state in 2001, with just one full professorship in astronomy, with three more filled before the ESO accession and the five new ones in prospect, there will be nine full professors within a few years, i.e. an increase by a factor of nine over ten years. This development allows an optimistic view of the future of Austrian astronomy.

Furthermore, the number of science topics being pursued has developed in recent years. Previously the Austrian strength was mainly in stellar astrophys-

Figure 1. The Institute of Astronomy at the University of Vienna.

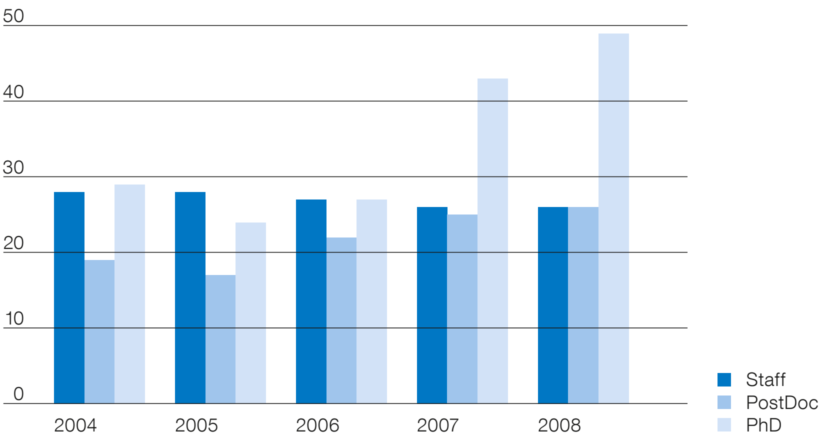


Figure 2. Growth in the total number of personnel at the three university astronomical institutes in Graz, Innsbruck and Vienna over the last five years. While the permanent staff numbers have stayed almost constant, there is a clear increase in the number of postdocs and PhD students. In 2009 an even greater increase in these numbers is expected.

ics, but there are now several active extragalactic groups, along with more connections to other fields such as mathematics and computer science, a natural extension because of the large numerical simulations performed by some groups. This year has also seen the establishment of astroparticle physics in Austria (including membership of the High Energy Stereoscopic System [HESS] collaboration).

As in the rest of Europe, the Bachelor/Master system was also introduced in Austria. While the Universities of Graz and Innsbruck offer a Bachelor of Physics and a Master of Physics, which include many astrophysics courses, the University of Vienna offers a Bachelor of Astronomy and a Master of Astronomy. All three universities also offer a PhD programme, partly in connection with doctorate schools.

The Austrian Society for Astronomy and Astrophysics

In order to adequately represent the Austrian astronomical community in pursuing the accession to ESO, the Austrian Society for Astronomy and Astrophysics (ÖGAA) was founded in 2002. This was an important step towards ESO membership, but, increasingly, it also serves many other purposes. This society holds an annual meeting, at which all Austrian astronomers meet to present new results and discuss new developments. The society performs joint public outreach activities, keeps in contact with amateur astronomers and supports young people.

Scientific highlights

Austrian astronomy can look back on a long history of astrophysics, including the Nobel laureate Victor Franz Hess, who discovered cosmic rays in 1911. Nowadays many modern science topics are addressed, of which a few recent highlights are selected and presented here.

Figure 3. Number of refereed publications resulting from the three university astronomy institutes in Austria over the last five years.

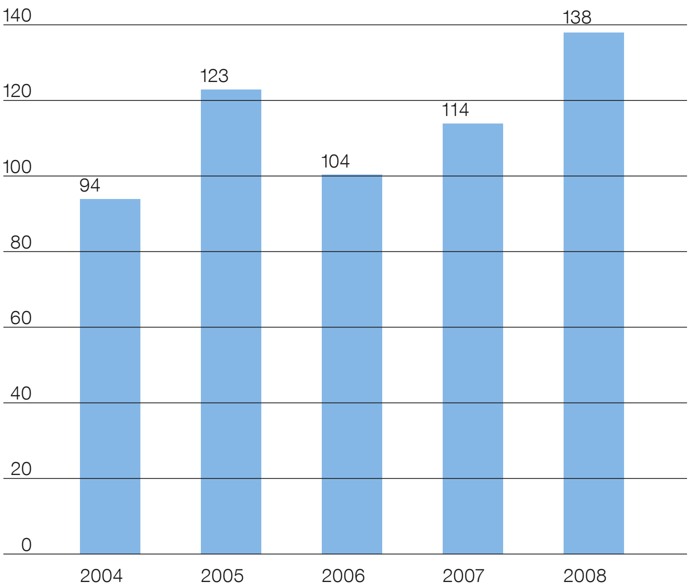
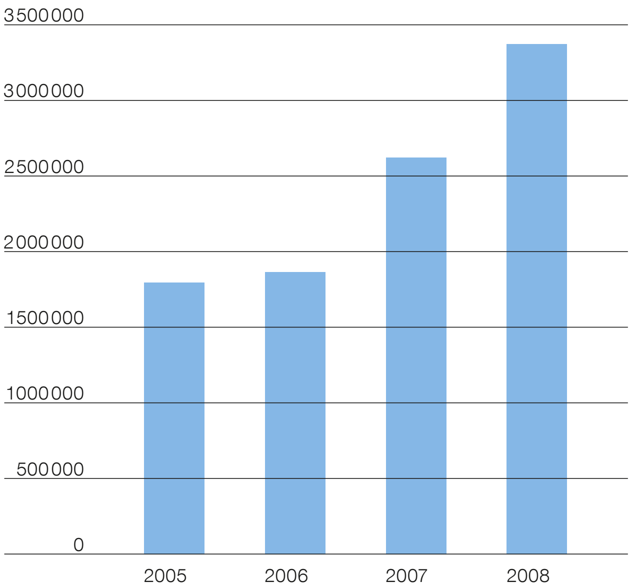


Figure 4. Acquired grants (in €) for the three Austrian university astronomy institutes over the last four years.

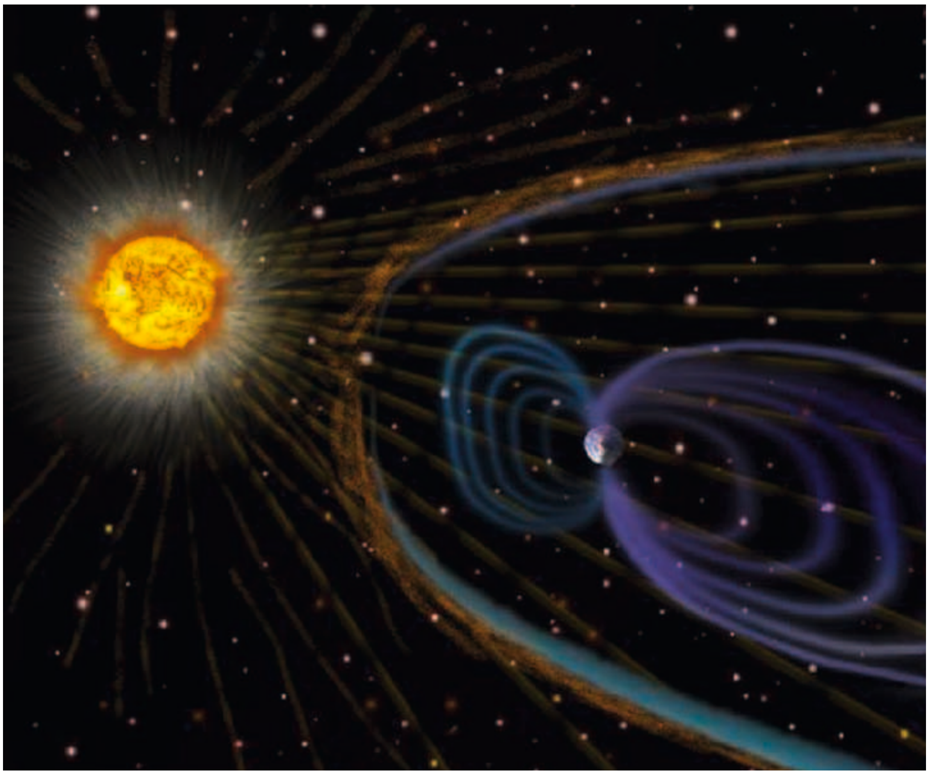


Towards a new Maunder Minimum?

The current solar activity minimum is longer lasting than previous ones (up to around 1900). Will there be a new prolonged phase of strongly reduced solar activity like that during the Maunder Minimum, which lasted from 1645–1715 and coincided with the peak of the "little Ice Age" in Europe? The activity of the Sun is monitored and "space weather", which is strongly influenced by solar activity, is studied. Solar activity influences the ionisation of the upper atmosphere and the propagation of radio signals and GPS signals can be severely disturbed (see the depiction in Figure 5). Due to the expanding atmosphere, satellite orbits can become unstable and the radiation can endanger human activities in space. At the solar monitoring observatory at Kanzelhöhe, data are taken and used in combination with other observations to predict the upcoming solar activity maximum. The first predictions for the new maximum (2011) were revised and the next maximum is expected to occur two or three years later, and its amplitude is predicted to be lower than the previous one. Applying methods of nonlinear dynamics, it has been shown that solar activity behaves regularly on a longer term basis, but is affected by the onset of chaos on smaller scales (Brajša et al., 2009). For these calculations solar activity proxies have been used (such as cosmogenic isotopes).

Star formation between galaxies

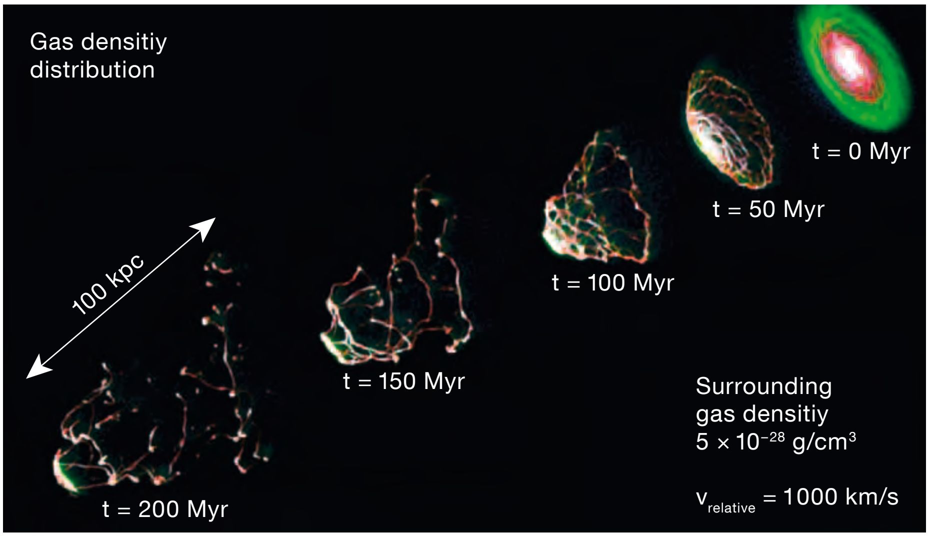
While it was thought previously that galaxy evolution is mainly determined by internal processes, it is now clear that the environment plays an important role. Ram-pressure stripping of galaxies in clusters (removal of the interstellar medium by the pressure of the intracluster medium) in particular has turned out to be much more efficient than previously thought (Rödiger & Hensler, 2005; Schindler et al., 2005; Domainko et al., 2006). Therefore numerical simulations of spiral galaxies moving through the intracluster medium have been performed. It was found that gas is stripped, not simply dispersed, into the intracluster medium, and it becomes clumpy, due to external pressure and radiative heating (Figure 6).



In this clumpy gas new stars can form, so that the star formation rate is increased considerably by the stripping process, and in extreme cases the increase in star formation can even be up by a factor of ten (Kronberger et al., 2008). Interestingly the stars not only form in the disc, but also in the wake behind the galaxy. Many of these stars are not bound to the galaxy, so that we have found a process that produces a population of new stars in

Figure 5. The solar wind interacting with the Earth's magnetosphere. It compresses the magnetosphere on the side facing the Sun. This can cause magnetic storms and, during strong solar events, such as flares or coronal mass ejections, even power lines on Earth can fail.

Figure 6. Simulation of a galaxy moving through the intracluster gas. The interstellar medium is stripped off by ram pressure and forms clumpy structures behind the galaxy. In these structures stars, which are no longer bound to the galaxy, can form.



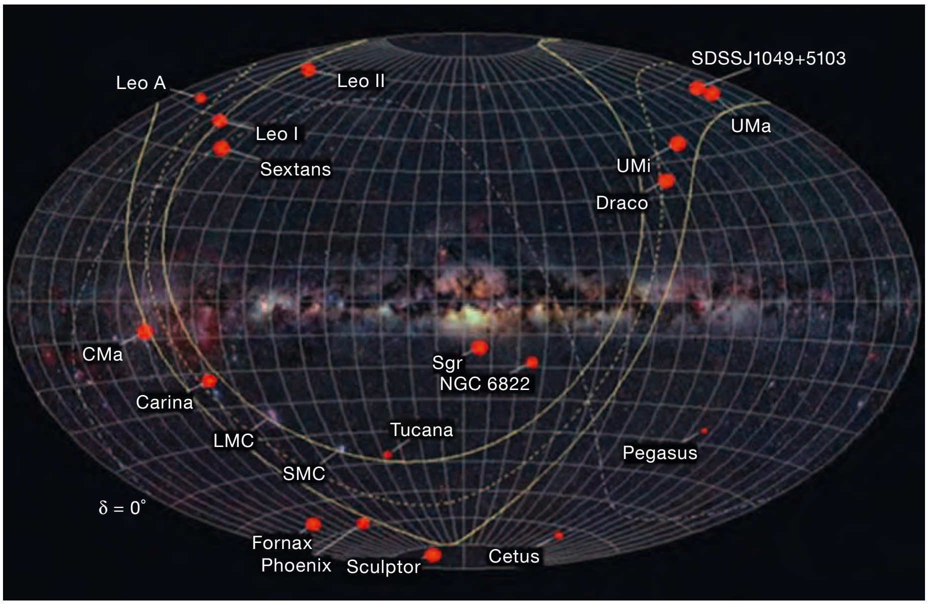


Figure 7. The disc of satellites around the Milky Way.

the space between the galaxies (Kapferer et al., 2009). The required densities for this process to take place are not as high as expected: ram pressure with star formation can also take place at distances of 1 Mpc from the cluster centre, i.e. it is expected that this is a very common process.

Galaxy mergers and the origin of satellite galaxies

Gravitational tides are widely understood to strip and destroy galactic substructures. In the course of a galaxy merger compressive tides may develop and prevent star-forming regions from dissolving, after they have condensed to form clusters of stars. A statistical study of such compressive modes of the galaxy merger in NGC 4038/39 (the Antennae) showed that around 15 % of the disc material undergoes compressive tides at the pericentre (Renaud et al., 2008). In addition, secondary structures form when gas-rich galaxies interact: conservation of angular momentum and energy leads to expanding tidal arms which fragment and form star clusters of varying size up to dwarf galaxy type objects. The formation of such "tidal dwarf galaxies" is therefore an inherent part of any cosmological structure formation theory. Detailed modelling of the evolution of such tidal dwarf galaxies in their host's potential shows that they are not easily destroyed by the host tide or their own internal energy release due to star formation (Hensler et al., 2004; Recchi et al., 2007). This issue combines two effects seen in the satellite galaxies surrounding our Milky Way: first, there are far fewer than expected from the Lambda Cold Dark Matter (ΛCDM) cosmology; and, secondly, the eleven brightest satellites of the Milky Way lie more or less in the same plane (see Figure 7 and Kroupa et al., 2005) and rotate with the same spin direction as the orbit vector. This phenomenon leads one to argue that it can only be explained if the satellites were created a long time ago through collisions between younger galaxies, i.e. be of tidal origin (Metz et al., 2009). As a very strong but logical consequence, the satellite galaxies should also be free of dark matter, a finding that stands in fundamental conflict with kinematically derived total masses for these dwarf galaxies.

Detection of non-radial oscillation modes with long lifetimes in giant stars

Towards the ends of their lives, stars like the Sun expand greatly to become red giant stars. Such evolved stars can provide stringent tests of stellar theory, as many uncertainties in the internal stellar structure accumulate with age. Important examples are convective overshooting and rotational mixing during the central hydrogen-burning phase that determine the mass of the helium core, but which are not well understood. The analysis of radial and non-radial stellar oscillations can be used to constrain the mass of the helium core. Although all giants are expected to oscillate, it has hitherto been unclear whether non-radial modes are observable at all in red giants, or whether the oscillation modes have a short or a long mode lifetime, which determines the observational precision of the frequencies. Using data from the CoRoT mission, radial and non-radial oscillations were detected in more than 300 giant stars (De Ridder et al., 2009). For at least some of the giants, the mode lifetimes are of the order of a month. So far, no satisfactory theoretical explanation currently exists for these observations.

Public outreach

To "share exciting discoveries and the beauty of the Universe with the broad public" (as phrased by ESO), has been, is and will, of course, be an important goal for Austrian astronomers in the future. Promotion of astronomy to the Austrian public will be enhanced by membership of ESO through the, already widespread, activities that have taken place, partly within the framework of the International Year of Physics 2005, the International Heliophysical Year 2007 and the International Year of Astronomy 2009. Such activities comprise: lectures at various types of adult education centres, elementary and secondary schools (see Figure 8), universities and clubs (like Rotary Clubs, Lions Clubs, etc.); advanced training courses for school teachers; regular (and irregular) guided tours, including public use of telescopes at our institutes; various open air activities, partly in cooperation with amateur astronomers; indoor activities at, say, shopping centres, fairs and the like; an annual Austrian astronomy day; popular articles for newspapers and magazines; exclusive interviews for the press, as well as for radio and TV stations; and last, but not least, answering the widely varied questions sent in by telephone or e-mail on phenomena in the night and day sky.

This list of outreach activities could easily be extended. It is expected that this kind of work will certainly "wax, rather than wane". Austrian astronomers are pleased to react to their new membership at ESO, not only with respect to an improved scientific output, but also in regard to an increased interaction with the public. After all, Austrian taxpayers (also) have the right to know what happens when their money is spent on "heavenly matters".

Figure 8. Children at a 3D presentation of simulated galaxies.

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Links

[1] http://www.uni-graz.at/igamwww
[2] http://astro.univie.ac.at
[3] http://astro.uibk.ac.at

Adriaan Blaauw, the former ESO Director General (1970–1974), paid a return visit to ESO Headquarters on 16 July 2009. He is shown here seated in the library where he was consulting the Oort Library, donated by the late Jan Hendrik Oort to ESO. Adriaan Blaauw, now aged 95, is the author of *ESO's Early History* and set up the ESO Historical Archives collection, which is housed at ESO headquarters. During his visit he reviewed the collection and was able to include some additional historical documents.