'The 100-m telescope is better than ever before'

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For four decades, a white dish has dominated the landscape around the village of Effelsberg in the Eifel. This is where the 100-metre telescope of the Max Planck Institute for Radio Astronomy was inaugurated on May 12, 1971. For many years it was the world's largest fully steerable radio antenna and its huge dimensions still impress all who see it. In scientific terms, as well, the precision instrument has accomplished a great deal. We talked with Michael Kramer, one of the four Institute Directors, about the telescope's past and its future.

Thousands of publications bear witness to the rich harvest which the researchers have gathered so far with the radio telescope. What do you think were the highlights?

Kramer: "That's a difficult question to answer, of course, because every scientist is going to have a slightly different "ranking". Maybe the best-known result – because it can be found in almost every book on radio astronomy – is the map of the radio sky from the famous 408-megahertz survey by a team working with Glyn Haslam. Other colleagues would surely mention many other areas of astrophysics where outstanding achievements have been made. New molecules and spectral lines have been discovered in interstellar space, for example, and important molecules, such as ammonium and water, were detected for the first time outside the Milky Way. At the same time the telescope has also shown that there are enormous, ordered magnetic field structures in other galaxies. And it discovered the most distant water in the universe, at a distance of eleven billion light years! For me personally it was a fantastic result that we at Effelsberg detected the relativistic effect of geodetic precession outside the solar system and in strong gravitational fields.

The telescope is now 40 years old. Can it keep up with the current technical standards?

Of course! It's not only still the largest telescope in Europe and only a few metres smaller than the Green Bank telescope in the USA, the 100-metre antenna is really better than ever: the design of the telescope is every engineer's dream and, thanks to good maintenance and regular updates, it is still in top condition, even today. At the moment we are working on updating the receiving systems, because the huge progress in digital electronics in recent years has provided us with outstanding technical possibilities of which we could only dream before. We can therefore now significantly improve the telescope's characteristics – even after 40 years.

Have the observation tasks of the radio telescope shifted?

Not really. Even today astronomers from all over the world come to carry out experiments of all kinds. These include observations at high and low radio frequencies, the spectroscopy of interstellar molecules, measurements of the polarization of galaxies, and the networking of Effelsberg with other telescopes to generate "sharper" images. But the fact of the matter is that some of the observations required can now be done by two telescopes of the 100-metre class: by ours in Effelsberg and by the Green Bank telescope in the USA. Both have different strengths, but we now have the chance to use valuable time for large, very ambitious projects. So for the first time in the history of Effelsberg we are now conducting a sensitive search of the whole sky for cosmic clocks, the so-called pulsars. This is very exciting, because you never know what you will find.

There are radio telescopes all over the world; your institute is an important partner of the Atacama Pathfinder Experiment (Apex) in Chile, for example. Max Planck researchers are also working with the radio antennas on the Plateau de Bure in the French Alps. What role does the 100-metre telescope in Effelsberg play in this respect?

In contrast to the visual part of the electromagnetic spectrum, radio frequencies cover a much larger region, relatively speaking, which is reflected in the incredible breadth of the science. At high radio frequencies, as are measured with Apex or on the Plateau de Bure, the focus is on investigating thermal sources, where we usually deal with low-energy processes. Although with Effelsberg we measure photons with even lower energy, these have often been generated by the most energized processes we know. In order to understand the universe overall, we must therefore cover all of these frequencies so that the different radio telescopes optimally complement each other. A good example here is again the pulsars which we cannot see with Apex or on the Plateau der Bure. For this we really need telescopes like Effelsberg.

How do you make the telescope fit for the future?

As we have done in the past, we would like to increase the sensitivity of the telescope even further. However, it is almost impossible or too expensive to enlarge it. Formerly, researchers regularly tried to improve the amplifiers of our receiver electronics. But even here our engineers are at the limit of what quantum mechanics allows. Two possibilities therefore remain: to enlarge the simultaneously measured frequency range or the size of the sky sector observed. The latest electronics and digital technology mean that both have become possible in recent years, as never before. We are therefore working on receivers and systems with very large bandwidths which enhance the range of vision by a factor of ten or more. This not only means we can survey the sky more rapidly, we can also take the liberty of increasing the “exposure time”.

How do you see the future of observing radio astronomy?

It is clear that at the high radio frequencies the new ALMA telescope in Chile represents the future. At the lower frequencies, which Effelsberg covers, the future is quite clearly in the combination of high survey speed and high sensitivity. As I indicated, this is where the 100-metre telescope plays an important role. In the long term, however, the ambitions are much, much greater! In around 15 years’ time a radio telescope is to be operated in the southern hemisphere which will exceed the receiving area of Effelsberg by a factor of 100! Since we are not able to build one individual telescope that large, it is synthesized from a network of smaller telescopes which are electronically connected. This Square Kilometre Array is not only a hundred times more sensitive, but also has a survey speed which is 10,000 to 100,000 times higher than that of existing telescopes. Astronomers from 20 different countries are already getting excited about what might be possible with such a telescope.

What is motivating radio astronomy at the moment? Which mysteries must be solved?

Owing to the diversity of the research which is possible, various colleagues would again provide different answers here. But I believe they would agree with me when I say that, on the one hand, we want to understand how complex molecules, stars and planets are formed. And on the other, we are also working on much more fundamental questions: how did the structure in the cosmos form, how – and when! – has the universe changed as a result of the formation of the first stars and galaxies? What is dark energy? Is it a new force of nature or the breakdown of Einstein's general theory of relativity? This last question, in particular, is what spurs me on personally. And we can expect that radio astronomy can and will provide the decisive answers - especially in relation to this issue, as it has done in the past.

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