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Greetings from the director

Dear Effelsberg Observers,

As it has become customs for the first newsletter of the year, I would like to express my best wishes to all of you for the new year!

As all of us, I sincerely hope that this year will see a return to a certain degree of normality. The pandemic has caused a lot of disruptions in our life. Hence, I am even more grateful to the dedication of our staff to ensure an uninterrupted operation of the telescope, so that the observers can get the data that they need. Thanks to extra effort of the staff, we have not lost a single day of observing time to the pandemic. Unfortunately, other events did produce some further interruption during summer last year. The massive flooding in the area surrounding the telescope caused a lot of damage and, sadly, even the loss of life. In comparison the impact on Effelsberg was very modest. It is true that the telescope appeared to be in located in the middle of two merging large rivers of water. Creeks that are usually small and harmless, were not so little and harmless anymore. but had a strength that destroyed a large fraction of the LOFAR antenna field next to the 100-m telescope. But we were lucky with the 100-m telescope itself, which was not affected at all. We did have a short interruption of operations, but we were on the sky again after only a couple of days - again thanks to our skillful engineering team.

Indeed, the challenges were overcome, and this is perhaps best illustrated by the excellent science results that were published last year. Some of the results will be presented in this newsletter, others you have seen in the press. I wish that 2022 continues to produce such excellent exciting results. In other words, have a successful good new year and hopefully there is a time when outside observers can visit us again!

Best wishes,

Michael Kramer

Call for proposals

Note in Advance

For various reasons, this newsletter appears somewhat later than usual. We apologize for any inconvenience this might have caused. Due to the late notification, the deadline for submitting proposals will be extended to **Feb 10, 1500 UT**.

Call for proposals – Deadline Feb 10 2022, UT 15.00

Observing proposals are invited for the Effelsberg 100-meter Radio Telescope of the Max Planck Institute for Radio Astronomy (MPIfR).

The Effelsberg telescope is one of the World's largest fully steerable instruments. This extreme-precision antenna is used exclusively for research in radio astronomy, both as a stand-alone instrument as well as for Very Long Baseline Interferometry (VLBI) experiments.

Access to the telescope is open to all qualified astronomers. Use of the instrument by scientists from outside the MPIfR is strongly encouraged. The institute can provide support and advice on project preparation, observation, and data analysis.

The directors of the institute make observing time available to applicants based on the recommendations of the Program Committee for Effelsberg (PKE), which judges the scientific merit (and technical feasibility) of the observing requests.

Information about the telescope, its receivers and backends and the Program Committee can be found at http://www.mpifr-bonn.mpg.de/effelsberg/astronomers (potential observers are especially encouraged to visit the wiki pages!).

Observing modes

Possible observing modes include spectral line, continuum, and pulsar observations as well as VLBI. Available backends are several FFT spectrometers (with up to 65536 channels per subband/polarization), a digital continuum backend, a number of polarimeters, several pulsar systems (coherent and incoherent dedispersion), and two VLBI terminals (dBBC and RDBE type with MK6 recorders).

Receiving systems cover the frequency range from 0.3 to 96 GHz. The actual availability of the receivers depends on technical circumstances and proposal pressure. For a description of the receivers see the web pages.

Please note, that observing proposals for the new Phased-Array-Feed cannot yet accepted – the system is still being commissioned.

How to submit

Applicants should use the NorthStar proposal tool for preparation and submission of their observing requests. North Star is reachable at https://northstar.mpifr-bonn.mpg.de .

For VLBI proposals special rules apply. For proposals which request Effelsberg as part of the European VLBI Network (EVN) see:http:/www.evlbi.org/proposals/

Information on proposals for the Global mm-VLBI network can be found at

http://www3.mpifr-bonn.mpg.de/div/vlbi/globalmm/index.html .

Other proposals which ask for Effelsberg plus (an)other antenna(s) should be submitted twice, one to the MPIfR and a second to the institute(s) operating the other telescope(s) (eg. to NRAO for the VLBA).

Important Remarks

Please note, that the Effelsberg Programme Committee (PKE) is composed of several scientist with different backgrounds. It is hence advisable to write the proposals in a way that they could be understood by readers who are not working in the particular field.

Furthermore, it should be noted that all proposals are treated confidentially. Therefore, it is not necessary to withhold or obscure information, which on the contrary might lead to a downgrading of the proposal.

The following deadlines will be on Jun 1st, 2022, 15.00 UT and on Sep 29th, 2022, 15.00 UT.

Opticon-RadioNet-Pilot Transnational Access Programme

The new Opticon-RadioNet-Pilot (ORP) project (see http://www.orp-h2020.eu) includes a coherent set of Transnational Access (TA) programs aimed at significantly improving the access of European astronomers to the major astronomical infrastructures that exist in, or are owned and run by, European organizations.

Astronomers who are based in the EU and the Associated States but are not affiliated to a German astronomical institute, may also receive personal aid from the Transnational Access (TA) Program of the ORP. This will entail free access to the telescope, as well as financial support of travel and accommodation expenses for one of the proposal team members to visit the Effelsberg telescope for observations.

One – in exceptional cases more – scientists who are going to Effelsberg for observations can be supported, if the User Group Leader (i.e., the PI – a User Group is a team of one or more researchers) and the majority of the users work in (a) country(ies) other than the country where the installation is located. Only user groups that are allowed to disseminate the results they have generated under this program may benefit from the access.

For more details see http://www.orp-h2020.eu/TA-VA .

After completion of their observations, TA supported scientists are required to submit their feedback to the ORP project management and the EU. Publications based on these observations should be acknowledged accordingly:

The research leading to these results has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004719 [ORP].

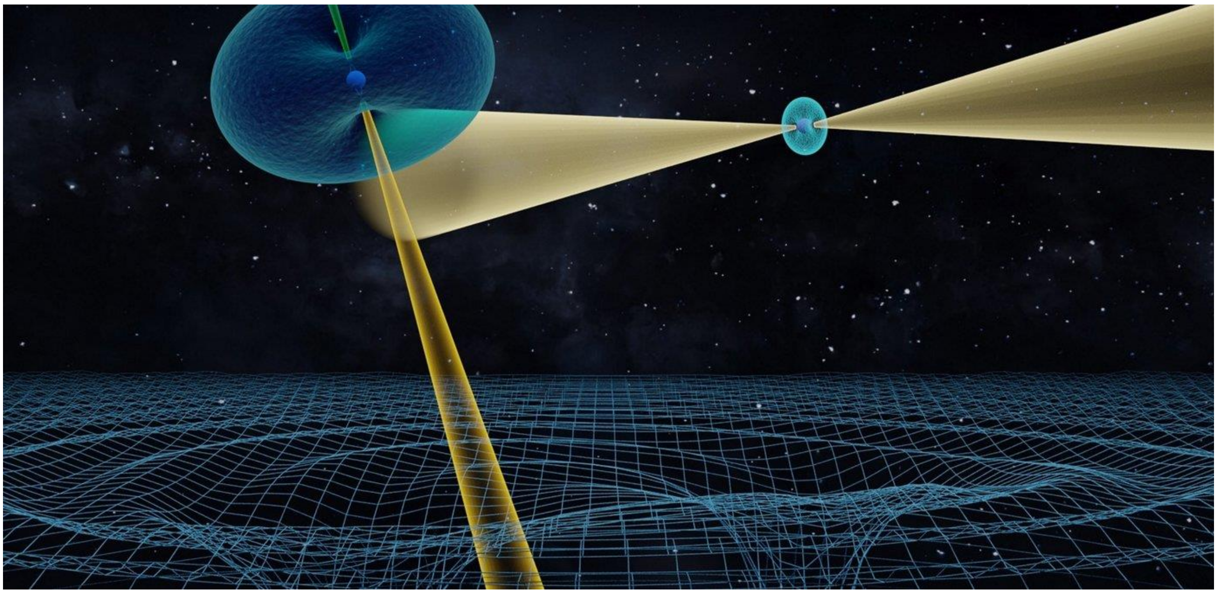
by Alex Kraus

Winter in Effelsberg (by. N. Tacken).

Einstein wins again

The theory of general relativity passes a range of precise tests set by pair of extreme stars

An international team of researchers from ten countries led by Michael Kramer from the Max Planck Institute for Radio Astronomy in Bonn, Germany, has conducted a 16-year long experiment to challenge Einstein's theory of general relativity with some of the most rigorous tests yet. Their study of a unique pair of extreme stars, so called pulsars, involved seven radio telescopes across the globe and revealed new relativistic effects that were expected and have now been observed for the first time. Einstein's theory, which was conceived when neither these types of extreme stars nor the techniques used to study them could be imagined, agrees with the observation at a level of at least 99.99%.



Artistic impression of the Double Pulsar system, where two active pulsars orbit each other in just 147 min. The orbital motion of these extremely dense neutrons star causes a number of relativistic effects, including the creation of ripples in spacetime known as gravitational waves. The gravitational waves carry away energy from the systems which shrinks by about 7mm per days as a result. The corresponding measurement agrees with the prediction of general relativity within 0.013%.
© Michael Kramer/MPIfR

More than 100 years after Albert Einstein presented his theory of gravity, scientists around the world continue their efforts to find flaws in general relativity. The observation of any deviation from General Relativity would constitute a major discovery that would open a window on new physics beyond our current theoretical understanding of the Universe.

The research team's leader, Prof Michael Kramer from the Max Planck Institute for Radio Astronomy (MPIfR) in Bonn, Germany, says: "We studied a system of compact stars that is an unrivalled laboratory to test gravity theories in the presence of very strong gravitational fields. To our delight we were able to test a cornerstone of Einstein's theory, the energy carried by gravitational waves, with a precision that is 25 times better than with the Nobel-Prize winning Hulse-Taylor pulsar, and 1000 times better than currently possible with gravitational wave detectors." He explains that the observations are not only in agreement with the theory, "but we were also able to see effects that could not be studied before".

Prof Ingrid Stairs from the University of British Columbia at Vancouver gives an example: "We follow the propagation of radio photons emitted from a cosmic lighthouse, a pulsar, and track their motion in the strong gravitational field of a companion pulsar. We see for the first time how the light is not only delayed due to a strong curvature of spacetime around the companion, but also that the light is deflected by a small angle of 0.04 degrees that we can detect. Never before has such an experiment been conducted at such a high spacetime curvature."

This cosmic laboratory known as the "Double Pulsar" was discovered by members of the team in 2003. It consists of two radio pulsars which orbit each other in just 147 min with velocities of about 1 million km/h. One pulsar is spinning very fast, about 44 times a second. The companion is young and has a rotation period of 2.8 seconds. It is their motion around each other which can be used as a near perfect gravity laboratory.

Prof Dick Manchester from Australia's national science agency, CSIRO, illustrates: "Such fast orbital motion of compact objects like these - they are about 30% more massive than the Sun but only about 24 km across - allows us to test many different predictions of general relativity - seven in total! Apart from gravitational waves, our precision allows us to probe the effects of light propagation, such as the so-called "Shapiro delay" and light-bending. We also measure the effect of "time dilation" that makes clocks run slower in gravitational fields. We even need to take Einstein's famous equation $E = mc^2$ into account when considering the effect of the electromagnetic radiation emitted by the fast-spinning pulsar on the orbital motion. This radiation corresponds to a mass loss of 8 million tonnes per second! While this seems a lot, it is only a tiny fraction - 3 parts in a thousand billion billion(!) - of the mass of the pulsar per second."

The researchers also measured - with a precision of 1 part in a million(!) - that the orbit changes its orientation, a relativistic effect also well-known from the orbit of Mercury, but here 140,000 times stronger. They realized that at this level of precision they also need to consider the impact of the pulsar's rotation on the surrounding spacetime, which is "dragged along" with the spinning pulsar. Dr Norbert Wex from the MPIfR, another main author of the study, explains: "Physicists call this the Lense-Thirring effect or frame-dragging. In our experiment it means that we need to consider the internal structure of a pulsar as a neutron star. Hence, our measurements allow us for the first time to use the precision tracking of the rotations of the neutron star, a technique that we call pulsar timing to provide constraints on the extension of a neutron star."

The technique of pulsar timing was combined with careful interferometric measurements of the system to determine its distance with high resolution imaging, resulting in a value of 2400 light years with only 8% error margin. Team member Prof Adam Deller, from Swinburne University in Australia and responsible for this part of the experiment, highlights: "It is the combination of different complementary observing techniques that adds to the extreme value of the experiment. In the past similar studies were often hampered by the limited knowledge of the distance of such systems." This is not the case here, where in addition to pulsar timing and interferometry also the information gained from effects due to the interstellar medium were carefully taken into account. Prof Bill Coles from the University of California San Diego agrees: "We gathered all possible information on the system and we derived a perfectly consistent picture, involving physics from many different areas, such as nuclear physics, gravity, interstellar medium, plasma physics and more. This is quite extraordinary."

"Our results are nicely complementary to other experimental studies which test gravity in other conditions or see different effects, like gravitational wave detectors or the Event Horizon Telescope. They also complement other pulsar experiments, like our timing experiment with the pulsar in a stellar triple system, which has provided an independent (and superb) test of the universality of free fall", says Paulo Freire, also from MPIfR.

Michael Kramer concludes: "We have reached a level of precision that is unprecedented. Future experiments with even bigger telescopes can and will go still further. Our work has shown the way such experiments need to be conducted and which subtle effects now need to be taken into account. And, maybe, we will find a deviation from general relativity one day…"

Just a few weeks before that, the European Pulsar Timing Array collaboration reports on the outcome of a 24-year observing campaign with five large-aperture radio telescopes in Europe, resulting in a candidate signal for the since-long sought gravitational wave background due to in-spiraling supermassive black-hole binaries. The collaboration brings together teams of astronomers around the largest European radio telescopes including the 100-m Effelsberg radio telescope of the Max Planck Institute for Radio Astronomy in Bonn, Germany, as well as groups specialized in data analysis and modelling of gravitational wave signals. Although a detection cannot be claimed yet, this represents a significant step in the effort to finally unveil gravitational waves at very low frequencies in the Nanohertz regime. The candidate signal has emerged from an unprecedented detailed analysis using two independent methodologies and shares strong similarities with results found from the analyses of other teams.

Original publications:

Strong-Field Gravity Tests with the Double Pulsar

M. Kramer et al, 2021, Physical Review X **11**, 041050 (December 13, 2021), DOI: 10.1103/PhysRevX.11.041050.

Common-red-signal analysis with 24-yr high-precision timing of the European Pulsar Timing Array: Inferences in the stochastic gravitational-wave background search

S. Chen et al: 2021, Monthly Notices of the Royal Astronomical Society, October 27, 2021 (DOI: 10.1093/mnras/stab2833).

Picture by Norbert Tacken.