

Making radio telescopes see

Professor Oleg Smirnov is the first SKA Chair in Radio Astronomy Techniques and Technologies, which is hosted by Rhodes University.

As a young boy, Prof Oleg Smirnov became fascinated with Africa after hearing stories about the continent from his grandfather, who was the Soviet ambassador in Kinshasa in the late 1960s. In a fitting turn of fate, the 39-year old scientist, who spent his professional career in Russia and the Netherlands, will now play a crucial role in putting Africa at the forefront of scientific discovery.

Prof Smirnov is the first Square Kilometre Array (SKA) Chair in Radio Astronomy Techniques and Technologies, which is hosted by Rhodes University. The Chair forms part of the Centre for Radio Astronomy Techniques and Technologies (RATT) within the Rhodes Department of Physics and Electronics, and will help develop algorithms and techniques for the SKA.

Prof Smirnov's appointment is seen as a coup for Rhodes. "Quite simply he is one of the most outstanding radio interferometrists in the world and without a doubt the most exciting young talent in the area of the analysis of radio astronomy data," says Dr Paul Alexander of the Department of Physics of the University of Cambridge.

Prof Smirnov has great ambitions for RATT and wants to turn it into a world leader in radio astronomy. His first priority will be recruiting "some bright postdocs and students". "I need to get a group together. There are currently too few people working on these things - certainly fewer than the SKA will need - so there's quite a vacuum to be filled.

Prospects are good!" Prof Steve Rawlings of the University of Oxford, who died tragically earlier this year, wrote in his recommendation of Prof Smirnov for the SKA chair that he would attract the world's best young astronomers, engineers and software developers to Rhodes.

Prof Smirnov has spearheaded a novel software package called MeqTrees that has been adopted by radio astronomers at the cutting edge. It is no exaggeration to say that the Smirnov's "entirely novel thinking" has re-defined the field, Prof Rawlings wrote. "(But) unusually for someone with such a strong background in mathematics, physics and computing, Oleg is a superb communicator."

According to those who have worked with Prof Smirnov, he is an inspirational speaker and a *de facto* leader who can rally astronomers, engineers and postgraduate students around projects. He has also been widely praised for making very challenging concepts accessible

Radio astronomy is a uniquely complex field, which incorporates a range of different disciplines – including physics, mathematics, computing and electronics - to allow scientists to collect and study the radio waves emitted by stars, galaxies, quasars (the brightest and most distant objects in our universe) and other astronomical objects.

Prof Smirnov explains his area of interest as "making radio telescopes see". "Imagine yourself lying on the bottom of a swimming pool, and looking up through the water. You are the radio telescope and the water is the Earth's atmosphere and ionosphere. Now imagine that there's a ceiling up overhead, with faint frescoes that you're trying to make out through the water.

The frescoes are the faint objects of the universe.” “Then, somebody goes and puts a thousand bright lights on the ceiling (the radio-bright objects of the universe) - you’re now trying to make out the frescoes behind the lights’ glare. And then the wind picks up so the water gets choppy.”

“That’s more or less what we’re trying to do right now. We used to study the bright lights – because that’s all we could hope to make out - but now we have ways to detect the faint stuff underneath.”

“My study is not in what we see *per se*, but how to make the telescope ‘see’ it better. In a way it’s almost like solving puzzles - even older telescopes don’t often work to their full potential because the ‘true’ signal is hidden behind the distortions, and by learning to remove the distortions better and better, we can disentangle useful science even from old observations.

This is probably what fascinates me the most.” Prof Smirnov is excited about the SKA, which will be far more sensitive than present-day radio telescopes, and so should be able to see much fainter objects than ever before. But because the telescopes will be more sensitive, more subtle distortions will also be picked up, and algorithms will have to be designed to correct for these distortions in order to unlock the SKA’s full potential.

“It will be up to groups like mine to provide the required breakthroughs in techniques,” says Prof Smirnov whose interest in astronomy emanated from his fascination with computers as a teenager. He grew up in Moscow, but his father worked in the foreign trade ministry and he spent some time in Aden (Yemen) as a toddler, and in his early teens he lived in Vancouver (Canada) for two years.

“The latter was an especially formative experience, since very few Soviet children were allowed to spend time in the ‘wicked West’ during the Cold War years. My parents had to jump through a lot of hoops to get me out there, for which in hindsight I’m really grateful to them.”

While in Canada, he got hooked on software and computers. When the family returned to Russia he brought with him the iconic home computer, the Commodore 64. But he soon needed “more serious computers” - which in the 1980s Moscow were few and far between.

A family friend, Nikolai Piskunov, an astronomer and now a professor at Uppsala University in Sweden, started taking the young Oleg to the Institute of Astronomy of the Russian Academy of Sciences in Moscow to play with PCs. “That gradually got me into astronomy.”

Prof Smirnov, who studied mathematics at the Moscow State University, kept working at the institute through his undergraduate years and was offered a PhD position there on completion of his first degree. After graduating with his doctorate he continued working at the institute as a researcher, particularly focusing on developing software and techniques for image processing and data analysis.

“This was optical astronomy, so quite a different beast from what I do now.” During that time, he started working at a private company to develop software for air traffic control

systems. “In the 90s, a Russian scientist’s salary was utterly miserable, so everybody needed a second job just to make ends meet.” However, he wanted to be a full-time academic - like his grandfather, who became a professor at what was then called the Moscow Institute for International Relations, following a stint as diplomat.

“He was the real academic of the family, always busy writing and publishing something, so I suppose in that way I’ve taken after him.” The desire to focus solely on his science led him to entertain job offers from abroad, and a chance meeting with Jan Noordam, a researcher at ASTRON, the Netherlands Institute for Radio Astronomy, lured him to the Netherlands.

He joined ASTRON in 1999 and, together with Noordam, became the primary developer of the MeqTrees systems for calibration of radio interferometers (astronomical instruments that combine multiple radio telescopes into a single system).

“Over the past three years, Oleg has increasingly dominated the international development of novel software for radio astronomy,” Prof Rawlings wrote of this work. When he was approached with the opportunity to take up the SKA chair at Rhodes University, Prof Smirnov says he simply followed a piece of advice he received early in his career, which has served him well: Don’t pick the job, pick the people you want to work with first.

“The SKA SA project already has a fantastic team in place, and Rhodes provides a great environment to work in. This made my decision rather easy - and this was even before the SKA site announcement, which is really the gravy on top.”

Rhodes has been at the forefront of the development of radio astronomy in South Africa since the 1950s, and Professor Justin Jonas of the Department of Physics and Electronics is the Chief Scientist on the SKA project.

Prof Smirnov plans to split his time between Cape Town and Grahamstown. He has also been asked to lead the Radio Astronomy Research Group at the MeerKAT project office in Cape Town, which will work together with RATT on the same subjects. As SKA’s precursor, MeerKAT needs research into the same kinds of problems (and more urgently, as it will be built sooner), so it made sense to unite the two groups, says Prof Smirnov.

“It will also give my Rhodes students an opportunity to spend time with the MeerKAT project, which is a fantastic environment for young people to get immersed in.” His wife Valeriya is also Russian. “She works in the fashion and modelling industry, and she hopes to continue doing this in Cape Town, which is why we’ll make our home there. Our daughter Alina is only two and a half, so she’s not communicating her preferences very clearly yet. But she does have an obsession with lions and elephants, so I think she’ll fit in well in South Africa.”

Prof Smirnov thinks the SKA will have fantastic knock-on effects for the country - more international scientists arriving, raising the level of research at universities, producing more local specialists, which in turn will have an effect on the whole educational system in general.

“There will be increased public awareness of science, and more kids drawn to science in school. Also more high-tech jobs in the economy, in addition to the obvious investments in infrastructure. And international prestige. There’s a good reason why Australia wanted to host it just as badly!”

As a scientist, he is most excited by the opportunities the SKA may present to detect gravitational waves through pulsar timing, and to directly observe the Epoch of Reionisation (when the first stars ignited after the Big Bang and their radiation turned gas atoms into ions). But that's just as far as the "planned" discoveries go, or "the things we expect to be able to see, based on present-day knowledge, given an SKA-scale telescope".

"What I am hoping is that these will be topped by the serendipitous discoveries - the things that nobody expected to see, and that often prove to be the most exciting things in science."