From mathematics to invasion science

Cang Hui is currently a professor in the Department of Mathematical Sciences at Stellenbosch University. *Quest* asked him about his career.

Where did you go to university and what degrees/qualifications do you have?

I did my studies at Xi'an Jiaotong University and postgraduate studies at Lanzhou University, both in China. My degrees (BSc, MSc and PhD) are all in the field of applied mathematics, related to biomathematics.

Describe the career path that led you to your current role. Where did you work before this?

I came to Stellenbosch University immediately after my PhD in 2004. From 2004 to 2007, I was a postdoctoral associate in the Department of Conservation Ecology and Entomology, funded by the Centre for Invasion Biology (C•I•B). I was a staff researcher at the C•I•B from 2008 to 2013. I was promoted to full professor in 2014 in the Department of Mathematical Sciences, which coincided with my appointment by the NRF to the Tier 1 South African Research Chair (SARChI) in Mathematical and Theoretical Physical Biosciences, co-hosted by the African Institute for Mathematical Sciences (AIMS) in Cape Town.

What are your current duties?

I'm working on the interface between mathematics and biology. My duty is mainly research and postgraduate training.

Tell us about your interest in invasion science. Why did you choose to follow a career in invasion science?

I want to understand how a complex adaptive system (CAS) emerges and functions. Ecological systems are ideal natural models for CAS. To understand the function and structure of ecological systems, we cannot rely on observations alone. Instead, we also need to see how the system responds to intrusion, perturbation and disturbance. Invasive species are natural/human-driven forces that can serve the purpose for understanding the robustness and function of the recipient ecological system, like viruses to an immune system, meteors to a planetary system. Invasion science is a trans-disciplinary research field, requiring team works from scientists in all fields of natural and social sciences. I like the multi-disciplinary philosophy in invasion science.

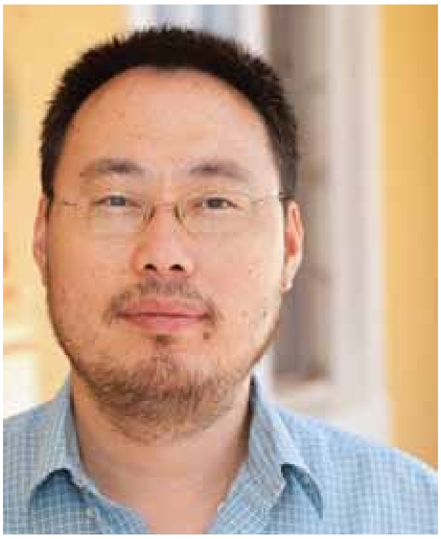
Why is research such as yours important for South Africa? What is important about your work?

Training applied mathematical students to work on real world issues and training ecological students to embrace numerical approaches are important steps to make South Africa's young scientists more globally competitive. I think my research first benefits South African students by equipping them to work at the forefront of scientific research. Graduates with competent skills will serve the country, especially in the emerging field of bio- and eco-informatics, helping to explore/manage/industrialise the potential of renewable natural resources and putting the country onto a green and sustainable trajectory.

My work is curiosity driven, intellectually interesting and challenging. Many results from my research have been picked up by scientists locally and globally for more efficiently monitoring and managing endangered and invasive species when facing global changes.

What were the skills you had to have to do the work your work?

A good understand of the system (e.g. ecology), together with competence in mathematics and computer science.



Cang Hui. Image: Cang Hui

Not many youngsters look at science as a career path, what led you down this path? What attracted you to it?

I have never wanted to do anything else other than science, as long as I can remember. Science is humanity's crown jewels. I don't think we need any persuasion in this regard.

What do you enjoy most about your work; what makes it all worthwhile?

To steadily understand how a system works. So, the joy is comprehension, motivated by curiosity. Thomas Edison said 'Genius is one percent inspiration and ninety-nine percent perspiration' – in other words it is all about hard work.

What do you do to unwind?

I love tennis.

Everyday products originating in outer space

What do jewellery, the petroleum industry, cellphones, batteries and camera lenses have in common? Apart from being used regularly by millions across the globe, they are all made from various heavy elements such as platinum, gold, silver, uranium and lanthanum that originate in outer space.

These heavy elements are produced when massive stars explode and matter, which makes up much of our planet, is hurled into space. Powerful explosions or supernovae provide the prefect astrophysical conditions for the production of approximately 70% of all heavy elements we observe here on earth and across the universe, says Dr Vincent Kheswa who recently obtained his doctorate in Physics at Stellenbosch University.

Kheswa's study focused on lanthanum and more specifically on how a specific lanthanum isotope (138La) an atom with the same number of protons but different number of neutrons is produced. He says the astrophysical conditions, under which this isotope is formed, has long puzzled scientists. Kheswa says that apart from camera lenses and battery-electrodes, lanthanum is being used in hydrogen storage. He adds that a better understanding how 138La is formed could also help us determine the age of the universe.

Collaborating with researchers from iThemba LABS and the Universities of Oslo and Brussels, Kheswa performed an experiment where particles were smashed together to create the rare 138La nuclei. Nuclei are the very dense regions of protons and neutrons at the centre of an atom. The decay products from these nuclear reactions were then studied using different advanced detector systems. Kheswa says scientists use accelerator laboratories to study nuclear physics properties, which lie at the heart of elemental formation. He adds that each measurement provides pieces of the puzzle to unravel the secrets of the production of elements and provides constraints on the hot and dense environments necessary for efficient production.

Kheswa says his measurement 'suggests that the interaction with neutrinos, which are very small and elusive but very abundant particles during a supernova explosion, remains the main reaction that produces 138La in the cosmos and not photodisintegration which is the process whereby protons and neutrons are ejected by the continuous absorption of high-energy photons'.

'This finding provides important insight into the production of heavy elements and places stringent constraints on the astrophysical environments that must exist in the cosmos to produce heavy elements.'

'In particular, the confirmation of neutrinos being almost exclusively responsible for the production of 138La will no doubt serve as a driving force for more research into this rare process.'

Kheswa says the wealth of information garnered from this experiment significantly improves our understanding of the astrophysical processes involved in the production of many heavy elements found on earth and elsewhere in the universe. He adds that it also helps scientists explain the ability of nuclei to absorb and emit light that influence overall reaction rates in astrophysical environments during a supernova.

'This study provides more information on the underlying nuclear structure of nuclei which describes how reactions proceed and in which astrophysical environments they take place,' says Kheswa.