QUADRAAD
DECEMBER 2015

FACULTY OF ELECTRICAL ENGINEERING,
MATHEMATICS AND COMPUTER SCIENCE

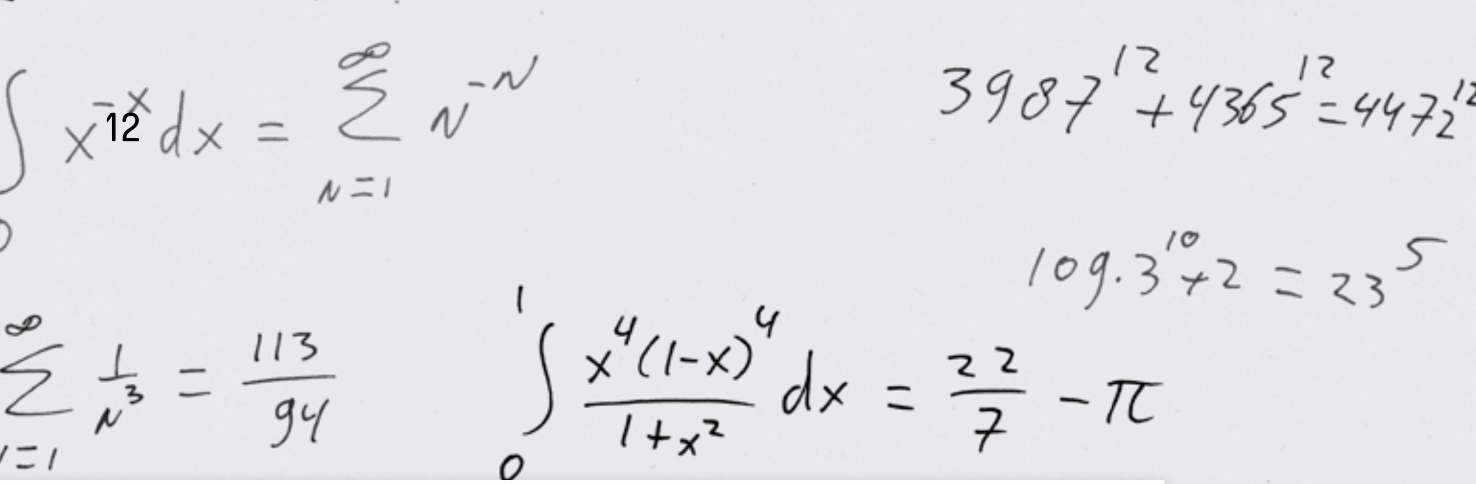
Partnership QuTech and Intel: the quantum computer
BLIND, BUT INCREDIBLY FAST

TEACHER OF THE YEAR:
FOKKO VAN DE BULT

ONLINE EDUCATION:
ANYWHERE, ANY TIME FOR ANYONE

AKIRA ENDO:
RESEARCH INTO THE UNIVERSE

TU Delft



a lot of first-year classes. We also teach at a variety of levels: teaching maths to Physics students is on a different level than teaching it to IDE students."

What do you enjoy most about teaching?
"When I realise that students have suddenly understood something and their eyes light up.... I like that."

What is your favourite type of student?
"Obviously, the type of student that asks good questions, does the work, and makes every effort to understand. I have a lot of great students who make a lot of effort. But quite often, students go out partying and the next morning they're zoning out in my lecture. But I also understand that there's more to life than their degree programme, let alone the mathematics in their degree programme."

How do you envisage mathematics teaching in the future?
"In the last forty years, mathematics has not changed and it is also unlikely to change much in the decades ahead. Ultimately, students need to understand the same things, broadly speaking. Of course, the students of today are very different from those in the 1970s, which means we need to approach the subject differently. I would like to use the computer more for visualisation. For example, through the use of applets: small programs that you can use without any knowledge of large calculation programs like Maple, Matlab or Mathematica. Applets make it very easy to draw the solution to a differential equation. Without having to calculate anything yourself, you can then explore how the solutions depend on the variables."

You are also involved in updating mathematics teaching at TU Delft. What does this involve?
"Mathematics teaching for first-year Bachelor's students is being completely updated. The focus is on encouraging students to prepare effectively for lectures. Examples of this could include pre-lecture videos with an explanation, online exercises and applets to encourage understanding. The focus during the lectures themselves is then on developing understanding and actively applying new concepts. With the new method, students get much more frequent feedback on their progress in the subject. A pilot was launched in Civil Engineering in September 2015.

You helped create the Pre-University Calculus MOOC. What was that like?
"I was one of the four lecturers on this online English-language mathematics course. This MOOC enables secondary school students to get their knowledge of mathematics up to speed. It was interesting to be a part of something like that. The subject matter is presented via videos. For the MOOC, I had to appear on camera a lot." [laughs] "I'm still not entirely at ease. The thing I don't like about a MOOC is that there isn't any direct interaction with your students. Sure, there's Skype, but that's not feasible with 1,000 students."

What was it that made you choose mathematics in the first place?
"My mother teaches mathematics and my father studied astronomy. When I became interested in numbers at an early age they were able to encourage my innate interest. When at school, I also won the Dutch Maths Olympiad. During the Olympiad, you learn so much more than they teach you at secondary school. It really appealed to me. Otherwise, I would probably have chosen to study Physics."

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CV

As a secondary school student, Fokko van de Bult (34) won the Dutch Maths Olympiad, a mathematics competition held annually for high school students. He studied and obtained a doctorate in Mathematics at the University of Amsterdam. He then spent time as a post-doc at Caltech, the California Institute of Technology. In 2012, he joined the Faculty of EEMCS at TU Delft as a service-teaching mathematics lecturer. In 2015, he was voted best lecturer in both the Nanobiology degree programme and the Faculty of Applied Sciences.

ASTRONOMER AKIRA ENDO

'We could discover something that could change our whole view of the universe'

Astronomer Dr **Akira Endo** is working on a brand-new measuring instrument that should lead to great improvements in how astronomers study the most active galaxies. This new spectrometer, named DESHIMA, could give us insights into the origins of stars and galaxies. We talked to this ambitious Japanese scientist from the Tera-Hertz Sensing research group at the Faculty of EEMCS about key moments in his scientific career.

Author: Stan van Herpen **Photography:** Marcel Krijger

Dr Akira Endo (b. 1981) talks animatedly about his work. Endo: "I want to make a significant contribution to the way in which we look at the universe. I have the feeling that we're working on something that's incredibly fundamental – that we could discover something that could change our whole view of the universe. Some theorists say that they know how the universe was created, but we're experimentalists; we want to see it, we want proof. It's difficult for us to study the most active galaxies in the history of the universe, but I think that it's precisely the development of these galaxies that could teach us a great deal. With 3D mapping of submillimetre galaxies such as these, we hope that we will see completely new phenomena."

University of Tokyo, 2005: introduction to superconductors
Akira Endo hesitated for a long time between studying chemistry (his father's field) and astronomy. "I wasn't sure whether I would really be able to build a career on looking at stars." A friend advised him to follow his heart. He chose astronomy, and in 2005 Endo was introduced to superconducting sensors for the first time. He immediately became interested in the combination of astronomy and the development of measuring equipment using superconductivity. To his fellow students, this appeared as making a turn 'from science to instrumentation': reflecting the culture that the two are distinctly separate concepts. What Akira was beginning to see was a path of 'instrument science'. Development of fundamentally new instruments is only possible with a fundamentally better understanding of the underlying physics. He was starting to realise that this is the best, if not the only, way to ground-breaking astronomical discoveries, even though it is certainly a long and high-risk/high-gain road to follow.

April 2009, arrival in Delft
Endo obtained his doctorate with credit from the University of Tokyo in March 2009. Just a month later, he arrived in Delft. "If you view the earth from a distance and look for where people are doing serious research on superconductivity and the development of new astronomical measuring instruments, then TU Delft is one of the few bright spots." With the work of Prof. Teun Klapwijk as his most important source of inspiration, for Endo, coming to Delft was like coming home. "Here, the development of instruments is really seen as a science."

October 2009, Atacama Desert, Chile (5,100 metres)
The Atacama Desert in Chile is home to the ASTE telescope, for which Endo is developing the DESHIMA spectrometer (acronym for Deep Spectroscopic High-redshift Mapper). It was here in October 2009 that he ventured an attempt to look at one of his favourite galaxies using a similar telescope called APEX. The results were mediocre. "Then I thought: we must be able to do this better with the possibilities that we have in Delft." While in Chile, Endo had the idea for a spectrometer using superconductivity in combination with a large number of detectors (see also text box).

Some time in 2009: first meeting with colleague Jochem Baselmans
Dr Jochem Baselmans from SRON, now also an associate professor in the Tera-Hertz Sensing research group, is Endo's most important partner in developing the new spectrometer. "Jochem is so smart … Initially I was always exhausted when I'd spent a day with him. Jochem is like a fountain that's constantly producing amazing ideas. The synergy between the two of us is fantastic."

2014: move to the Faculty of EEMCS
In 2014 Endo moved from Applied Sciences to EEMCS. He explains: "I think that one of my strongest points as a scientist is that I find it natural to cross boundaries, such as national and disciplinary boundaries. Take disciplines, for example: I spent five years as an astronomer before entering physics. The fact that I was an 'astronomer embedded in a nano-physics environment' meant that I had a very different perspective from that of other astronomers and nano-physicists. The personal network that I have in both fields is an invaluable treasure to me. When I'd been in nano-science for six years, it was time to look for another discipline that would have the strongest synergy with my existing background (astronomy and nano-science); and that turned out to be terahertz electronics. Being embedded in one of the world's best groups in this field, it's fascinating to see how new concepts for terahertz sensing are being developed. Crossing the boundary from the natural sciences to engineering was certainly a different kind of jump from that from astronomy to nano-science. I feel that this combination has given me a new perspective on science and technology."

The ultimate origins of the universe
Our conversation takes place just after the first Nobel Prize-winners have been announced. This prompts me to ask: if they discover something spectacular, will it be potential Nobel Prize-winning material? "If we discover something really new, something that revolutionises current theories of the universe, then anything might happen. Around half the Nobel Prizes for astronomy have had something to do with new instruments; but it really depends on what we see. Rather than being interested in ego or status, he's driven by curiosity. "We're taking a look at the ultimate origins of the universe and searching for answers to such fundamental questions as why are we here, where do we come from?" He says, laughing: "It's a good thing that I'm pretty persistent. Research like this takes an awfully long time. You devote a major part of your life to it, while the outcome is extremely uncertain. So you're only able to keep going if you're motivated by curiosity."

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The ultimate goal of the research

The ultimate goal is to create 3D maps of so-called submillimetre galaxies that, in contrast to 2D maps, also show distance and time. Although submillimetre galaxies are the most active star systems, we have difficulty studying them using traditional telescopes because they produce a large amount of dust. The research is focusing on the period from when the universe was a sixth of the way through its history, up until roughly half-way through its history. This was the time at which the galaxies and their stars were at their most active. The developments in such systems can be investigated by studying protons and terahertz waves.

What is a spectrometer?

A spectrometer is an essential part of a telescope: it is an instrument that describes the light that has been captured. The spectrometer that Akira Endo is working on with his colleague Jochem Baselmans uses superconductivity to measure the age of photons (in other words, the light that a telescope captures). If you know the age of the light that is produced by celestial bodies, then you also know the distance between the celestial bodies themselves and between the celestial bodies and the earth. Endo and Baselmans called their spectrometer DESHIMA. This is also the name of an artificial island in Japan, where the Dutch VOC traded with the Japanese from the 17th till 19th century.

What makes the DESHIMA spectrometer even more special?

One of the advantages of using superconductivity is that the spectrometer can be made a lot smaller. This one will soon fit on a chip the size of a CD. What's more, lots of detectors are used in this spectrometer, meaning that the light can ultimately be measured very accurately. To give an example: whereas a digital camera makes images using only primary colours in one pixel, Endo hopes that they will soon be able to capture five hundred colours in one pixel. 'That's our dream.'

When will we know whether it works?

The first tests will be carried out in Delft in the summer of 2016. In early 2017, they hope to test the spectrometer in the telescope for which it is intended: the ASTE telescope in Chile.