TEXT: MARC LAAN | PHOTO: RIKKERT HARINK >

GRAVITY PLAYING GAMES WITH FLUID EXPERTS

More than a year Varghese Mathai spent in the Twente Water Tunnel at the UT. The doctoral degree cadidate pursued there the missing link in his theory on fast-flowing water. Ultimately he discovered the role of a simple force of nature: gravity.

'The classic physics models we used did not offer a solution'

Varghese Mathai came to Enschede three years ago. Peviously he studied applied physics at the India Institute of Sciences in Bangalore. At the invitation of the University of Twente professor Detlef Lohse, in 2013 he began a PhD study of fluid mechanics, or fluid dynamics, at the MESA+ nanotechnology centre. During this doctoral research of the way in which fast water streams continually contort, creating turbulence, Varghese Mathai came across some inconsistencies as to the movement of tiny particles in a turbulent stream of liquid. The PhD candidate explains: 'In order to follow movements in fast-flowing water, for example, we introduce tiny particles and air bubbles into the liquid. These reflect light when we shine lasers on them. Up to now physicists have assumed that these particles, if they are small enough, will follow the flow exactly. However, almost a year ago, we noticed results in our analyses that did not appear to conform to this classic theory. We were certain that this was not due to faulty measurement but we were unable to find the cause.'

Mathai works together with Professor Chao Sun from Tsinghua University in China, which is affiliated with the University of Twente. 'We saw unmistakable differences in the speed of tiny particles and air bubbles compared to the surrounding liquid,' he confirms. 'We couldn't explain them. The classic physics models we used did not offer a solution.'
Mathai and his colleagues tested various hypotheses in a vain attempt to explain the anomalies they observed. Eventually, only one possibility remained: could it be gravity that was playing games with their research?

How did you arrive at gravity?
'We subjected the anomalous particles to further research in the Twente Water Tunnel, an advanced testing apparatus with a high-speed camera. We saw that microscopically small particles have the tendency to creep upwards in flowing water, very slowly. This movement cannot be observed with the naked eye. Usually you just see a chaos of moving particles, which are a maximum of 100 microns in diameter. But through the water tunnel's camera we were able to see that, within this chaos, the particles were rising a couple of millimetres per second on average. This may seem like a very small movement but it has major implications for the results of studies into turbulence in fluids.'

What does your discovery mean in practice?
'We work together with a group of researchers. One colleague from Lille, Enrico Calzavarine, was able to replicate the anomalies in mathematical simulations on the computer. This enabled us to formulate a new theoretical model, which was able to predict the up to then unexplained behaviour of the particles. It has since become a wider theory on the behaviour of all small particles and air bubbles that are heavier or lighter than the liquid in which they are moving. It also helps us to explain the behaviour of dust particles in wind, for example. We can now predict a little more accurately how aerosols behave in air.'
The new theory, which the researchers published in July in the American magazine Physical Review Letters, makes short shrift of the traditional assumption that tiny particles always follow the flow of liquids exactly. Professor Detlef Lohse, Mathai's thesis supervisor, is convinced of that too. 'The classic assumption that small particles and air bubbles follow the flow of liquids exactly needs to be corrected,' he says. 'Even small bubbles and particles have the tendency to drift in a stream of liquid. This is difficult to see with the naked eye. We had to build a special, moving, high-speed camera in order to make this discovery.'

Who will notice something of this discovery?
Mathai expects this to have major implications for all branches of fluid physics. 'Not only for everyday lab experiments but also for the development of models for climate processes and even for studies into the cause of rain from clouds. In the near future, this theory may also throw light on the course taken by heavy ash particles after volcanic eruptions, such as the recent eruption in Iceland.' |

TWENTE WATER TUNNEL

The Twente Water Tunnel in the Meander building at the UT is unique in the world. This eight metre-high experiment apparatus allows physicists to observe the turbulences in fast-flowing fluids, such as water. Because water is transparent and its winding movements are therefore invisible, researchers introduce microscopically small particles and air bubbles into the artificially created super-fast streams, enabling them to follow the contortions of the fluid. Using a special, high-speed, 3D camera, they film how the particles move, collide and speed up or slow down in the streams of fluid.