Abu Dhabi Scientists Seek to Unravel Turbulence

We might associate turbulence almost exclusively with air travel and bumpy flights, but the phenomenon is visible as a daily occurrence in many facets of our lives. Formula One racing car drivers hate it, since the aerodynamic drag it incurs can mean the difference between winning and losing. White-water rapids kayakers and rafters love it, since it constitutes the main thrill of the experience.

Meanwhile, most people barely notice it when they turn on the tap to brush their teeth in the morning, when the direction and regularity of the flow becomes unstable as the pressure increases. But despite the fact turbulence is such an everyday event, we still know remarkably little about how this enigmatic process works. Determined to right that wrong, Professor Nader Masmoudi at New York University Abu Dhabi is seeking to investigate the heart of this commonplace conundrum.

The Navier-Stokes Equation

The mystery of turbulence is inextricably tied to the Navier-Stokes Equation, which is often dubbed the most difficult and complex formula in the world of science. Named for the French and Irish scientists who penned it at the start of the 19th century, the formula is supposed to explain how fluids will react according to Isaac Newton's laws of motion.

However, things are not nearly so simple as all that. In the first place, the Navier-Stokes Equation has many different forms, including a conservation form, a convective form and a constitutive form, among others. Moreover, the equation is non-linear, meaning that tiny changes to it can have massive ramifications for the end product. This makes the formula highly unreliable when putting in various properties and expecting a consistent result.

Scientists have been wrestling with how to achieve more dependable results using the equations ever since it was first written, with largely unsuccessful results. In the 1990s, a pair of scientists tried to dispense with the unpredictable variables inherent in the equation and use a more stripped-down version of it to determine the velocity of the River Nile, but only came out with the impossible answer of 330,000km per hour. Clearly, something had gone wrong.

Expanding our knowledge

Now, Professor Masmoudi is hoping to find out exactly what that something was. By using technology in the laboratory alongside cutting-edge techniques in computing and mathematics, he and his team hope to shed some fresh light on this centuries-old problem. In this way, they aim to discover how and why fluids stop flowing smoothly when turbulence arises.

Most crucially, the team are also hoping to investigate how this phenomenon can impact real-world situations, such as traffic flow at rush hour, coastal erosion from waves or even human relationships. “Stability is a word we use in our daily life, not only in math and physics”, he explained. “What’s interesting is the kind of questions we ask in math or physics, you can ask in social sciences, political sciences, or even relationships.”

While the challenge is certainly a difficult one, Professor Masmoudi is perhaps the most qualified man on the planet to undertake it. In 1992, he became the first ever Arab teenager to win a gold medal at the International Mathematical Olympiad, before going on to study turbulence and winning various prizes for his work in doing so. Next step: putting Navier-Stokes to bed, once and for all.