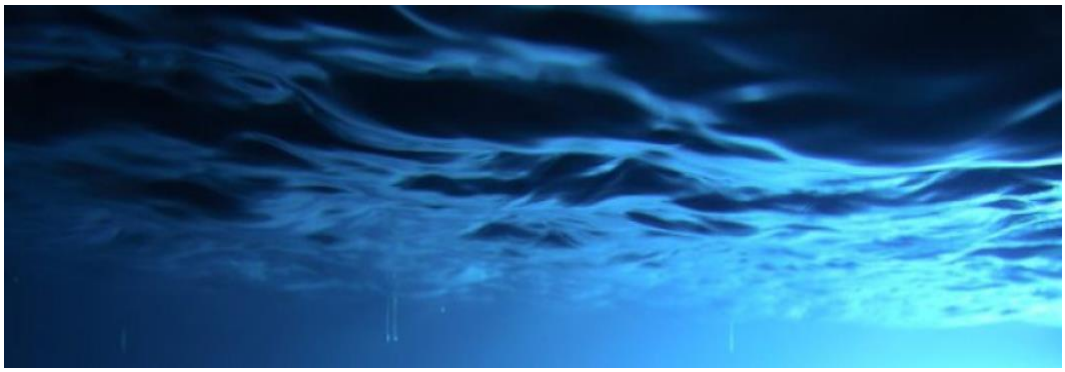
**PRESS RELEASE**

# A turbulent paradox: the unexpected link between two unsolved problems in physics unveiled

**An interdisciplanary research team from SISSA and the University of Padua analysed the Fermi-Pasta-Ulam-Tsingou problem in an innovative way and discovered a link to turbulence in fluids**



Some of the physical phenomena that we encounter in our daily lives are still not fully understood. A prime example is turbulence in fluids. The complexity of turbulence, which is described by the Navier-Stokes equations governing fluid dynamics, is one of the problems of the millennium. Another example of an open problem is the approach to thermodynamic equilibrium in isolated systems. A new collaborative study between SISSA and the University of Padua, published in *Physical Review Letters*, analyses in detail a previously unknown link between these two types of phenomena and could open up new avenues for understanding them.

In the mid-1950s, Enrico Fermi, John Pasta, Stanislaw Ulam and Mary Tsingou became interested in the problem of the approach to thermodynamic equilibrium in isolated systems. They had the idea of simulating on a computer the dynamics of a very simple system, consisting of interacting nonlinear oscillators, with the hope of developing insights in a more general theory. The unexpected results of this pioneering study were recognised as the 'Fermi-Pasta-Ulam paradox' (which discounted Mary Tsingou's important role). Instead of observing the system as it gradually approached thermodynamic equilibrium, the authors made what they called a 'small discovery': the system seemed never to reach that state. Today, almost seventy years later and after countless studies, it has been discovered that what Fermi, Pasta, Ulam and Tsingou observed was nothing more than a 'metastable' state that the system remained in for a long time before reaching equilibrium. From other studies, we know that this metastable state occurs when the system is given low energy, but not when the system has sufficiently high energy.

In the new research, the authors studied the structure of the metastable state of the Fermi-Pasta-Ulam-Tsingou model and found that it has significant similarities with fluid turbulence. In addition, the timescales of the problem (the time lapse between the system reaching this 'intermediate state' and leaving it) are 'universal', i.e., they depend on the parameters of the system in a known way, are exactly calculable and do not depend on the details of the interaction.

Antonio Ponno, Associate Professor in the Department of Mathematics at the University of Padua and author of the study, says: “The idea for this work arose a few years ago following the thesis of Matteo Marian, a physics student at the University of Trieste. Stefano Ruffo and Matteo Gallone of SISSA were also involved from the outset, giving birth to a research group that is still active today.” The work just published involves four generations of researchers, three academic institutions and two scientific-disciplinary fields.

“This work was only able to achieve important results thanks to the multidisciplinary environment at SISSA,” comments Matteo Gallone, first author of the study. The research combines cutting-edge mathematical methods with numerical simulations to illuminate problems in statistical physics. “The synergy between mathematics and physics allowed us to approach the analysis of the Fermi-Pasta-Ulam-Tsingou problem in an innovative way and build a bridge to turbulence,” adds Gallone.

“Constructive collaboration between different schools, centred on the promotion and circulation of young people - a firm principle of our university - is the key to the quality of research,” Ponno concludes.

**USEFUL LINKS**
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**IMAGE**
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