High-speed cameras reveal behavior of microplastics in turbulent water

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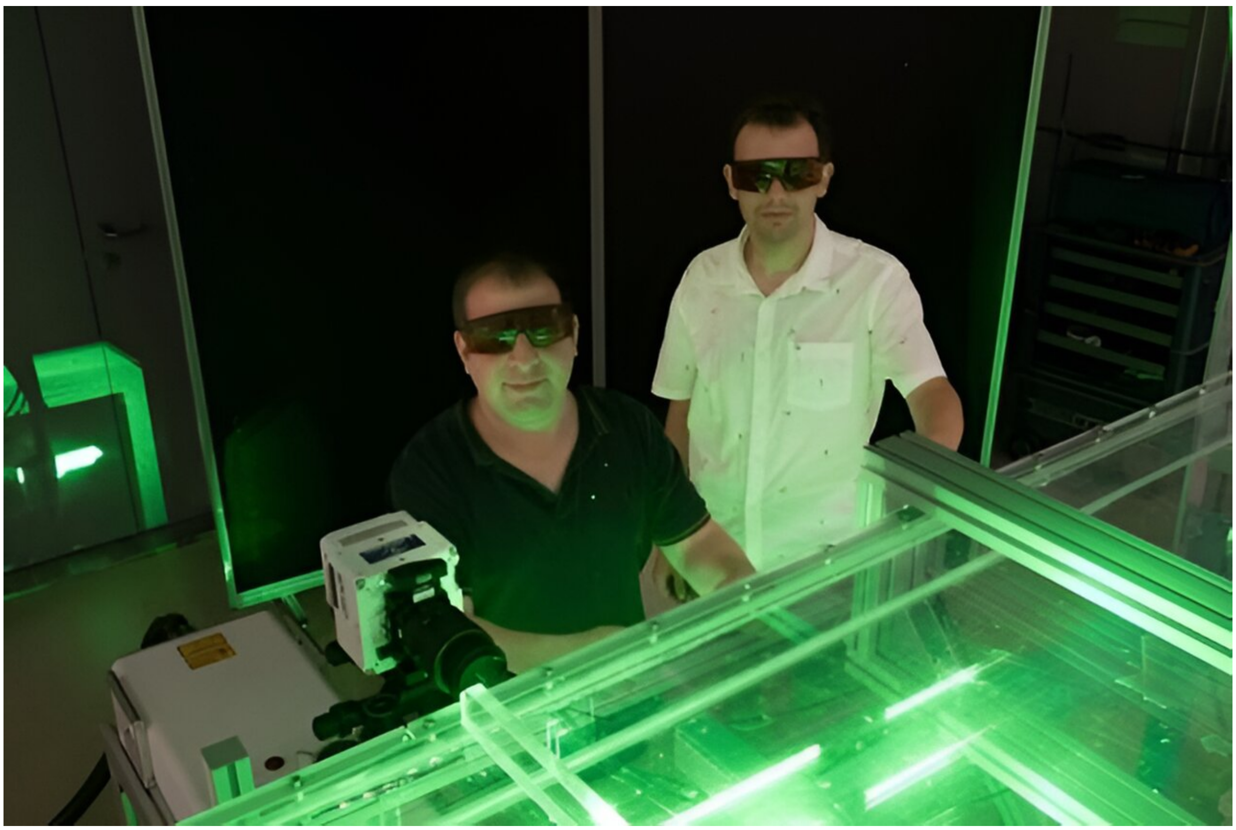

Giuseppe Caridi (left) and Vlad Giurgiu (right). Credit: Dalmonia Rognean

Microplastics are a global problem: they end up in rivers and oceans, they accumulate in living organisms and disrupt entire ecosystems. How tiny particles behave in a current is difficult to describe scientifically, especially in the case of thin fibers, which make up more than half of microplastic contamination in marine life-forms. In turbulent currents, it is almost impossible to predict their movement.

Scientists at TU Wien (Vienna) have now succeeded in characterizing the behavior of such microplastic fibers in experiments in a channel flow with the help of high-speed cameras. This should now form the basis for new models that can be used to predict the spread of microplastics globally.

The results have been published in the journal *Physical Review Letters*.

Small, curved fibers

"How microplastic particles move, disperse, and settle depends on their rotational dynamics," explains Vlad Giurgiu, first author of the current publication and doctoral student in Prof Alfredo Soldati's team at TU Wien.

"This is easy to analyze in the case of almost spherical particles. But usually, microplastics are elongated, curved fibers." In this case, complicated effects occur: The fibers can rotate in all three spatial directions, and this rotation also influences their interaction with the surrounding flow.

"In a perfectly uniform, laminar flow we would be able to predict theoretically the behavior of simple objects, like spheres or ellipsoids," says Marco De Paoli, who collaborates with the team at the Institute of Fluid Mechanics and Heat Transfer at TU Wien.

"But in the real world, you're neither dealing with perfectly laminar flows nor with perfectly symmetric particles. Instead, turbulence and complex shapes are present, which significantly influence the transport of the particles. This makes theoretical predictions impossible."

What exactly happens is difficult to calculate. "There have already been various computer simulations, but they rely on simplified models to describe the fiber's behavior," says Giurgiu. "You therefore need experimental data with which you can compare and improve these theoretical models."

Precisely this kind of data can be obtained in the TU Wien Turbulent Water Channel, located at the Arsenal Science Center (Vienna). Controlled flows can be generated over a path length of 8.5 meters. Small, curved microplastic fibers with a length of 1.2 millimeters were introduced into the water and exposed to a turbulent flow.

Six cameras see more than two

The team installed six special cameras just above the surface of the water: at a frequency of 2,000 images per second, they collected high-resolution images of the microplastic particles in the current. The three-dimensional position and orientation of each individual microplastic particle can then be computed by analyzing these images.

"Theoretically, this would also work with just two cameras, but with six cameras, the data is even more reliable and accurate, especially when the concentration of particles is high," explains Giuseppe Carlo Alp Caridi, co-author of the study and Head of Optical Reconstruction at the Institute of Fluid Mechanics and Heat Transfer at TU Wien.

In this way, a large amount of data can be extracted about the motion of hundreds of thousands of microplastic particles and then analyzed statistically. "For example, it turned out that the fibers show a completely different behavior near a wall than in the middle of the water flow, far away from the walls," explains Giurgiu.

This means that reliable data is now available for the first time to validate theoretical calculation models on the behavior of such particles. In the future, it should also be possible to predict the propagation of microplastic fibers on a large scale.

"Imagine you have a ship that can filter microplastics from seawater," says De Paoli. "Then you need to know where best to send this ship—after all, the ocean is really big. If you understand the behavior of the particles precisely, then the answer can be calculated with great reliability."

More information: Vlad Giurgiu et al, Full Rotational Dynamics of Plastic Microfibers in Turbulence, *Physical Review Letters* (2024). DOI: 10.1103/PhysRevLett.133.054101. On *arXiv*: DOI: 10.48550/arxiv.2406.12462

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