A Dance of Particles and Smoke

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As we move through the world, we are surrounded by an invisible dance: particles of air and matter silently in motion around us, their choreography dictated by rules of the universe, diffusion, and fluid dynamics. It may seem like we are overcomplicating and romanticising this process in equal measure, but understanding how this matter moves through our environment is an immensely complicated and important process for us to understand. From aerodynamics to public health, understanding how air and matter move through the world does matter to us, because it affects the behaviour of flying aircraft and the spread of airborne pollutants, just to give a few examples!

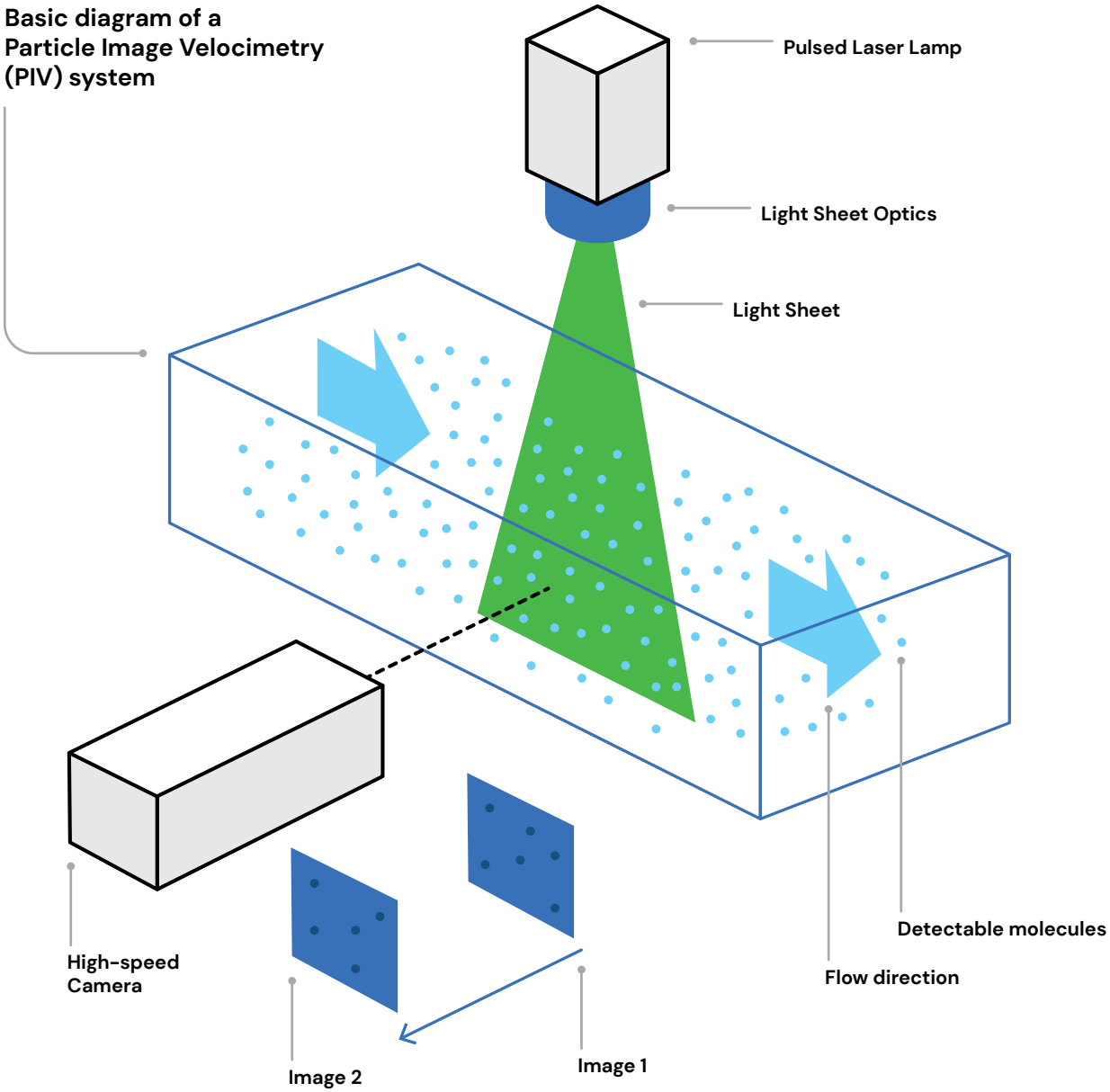
But how do we make the invisible visible? One method that you may be familiar with is using a wind tunnel, and the fundamentals of how these work are pretty simple. An object is placed within a closed environment, and smoke or some other detectable gaseous agent is blown around the object. The speed and direction of these smoke particles can then be measured as they move around the object, just as you would measure the speed of any moving body by using the fundamental equation we all learnt at school: Speed = $\frac{Distance}{Time}$. But how do researchers gather this information from so many tiny objects, such as gas molecules moving through an air current? The answer is **Particle Image Velocimetry (PIV)**.

PIV is a method of visualising the velocity of parcels of gas or liquid molecules. This is done using a laser and a specialised high-speed camera. When the laser is fired, the detectable matter present within the air current is illuminated, and then the camera takes two consecutive images. By comparing these two images, the speed and velocity of the particles can be measured, similar to how a speed camera works to figure out the speed and direction (velocity) of a moving vehicle. This data is then processed using specialised computer software to create a map of the velocity of small clusters of particles present in these photographs and figure out the general speed and direction of these clouds, rather than the velocity of each individual particle.

Although you may be aware of some of the general uses for PIV in wind tunnels (such as measuring the aerodynamics of plane wings), this methodology has more far-reaching application in matters that affect our general day-to-day existence. For example, at the University of Malta's new Environmental Design Laboratories, which are planned to be set up in the new Sustainable Living Centre currently under construction, we hope to use, in collaboration with the Mechanical Engineering Department of the Faculty of Engineering, two recently acquired PIV systems to research building ventilation, pollution transport, aerial disease transmission, wind and heat flow, and air flow over vegetation to investigate urban greening and its effect on pedestrian comfort.

While the whirls of particles and smoke continue to fascinate us, by better understanding their waltzes, we might be able to design healthier and more efficient spaces. And that's certainly something worth dancing about!

Basic diagram of a Particle Image Velocimetry (PIV) system



Learn more about the work being carried out by the Department of Environmental Design