# Velocity measurements in turbulent flows performed by a 2D-LASER cantilever anemometer

Jaroslaw Puczylowski[1], Michael Hölling[1], Joachim Peinke[1]

1: ForWind, University of Oldenburg, Institute of Physics, Germany, jaroslaw.puczylowski@uni-oldenburg.de

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In our contribution we present flow velocity measurements performed with a 2D-Laser Cantilever Anemometer (2D-LCA), which allows for velocity measurements in two dimensions in turbulent flows under laboratory conditions.

The sensor's setup is illustrated in figure 1. It's working principle has been adopted from atomic force microscopes. The crucial component of the sensor is a micro-structured cantilever of 140µm in length. When exposed to flow the cantilever experiences a deformation due to the acting force *F* caused by the moving medium

$$F = \frac{1}{2} \cdot c_d \cdot \rho \cdot A \cdot v^2 \cdot f(\alpha),$$

where $c_d$ is the drag coefficient, *v* is the velocity of the fluid, ρ is the density, *A* the cross section of the cantilever and *f(α)* a function which depends on the angle of attack.

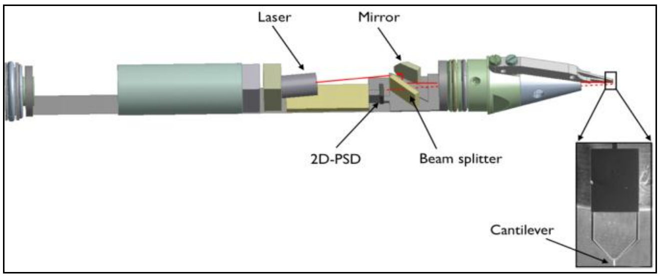


**Fig. 1** Setup of the 2D-Laser Cantilever Anemometer

A laser beam provided by a laser diode hits the tip of the cantilever and causes a reflecting spot on a 2-dimensional position sensitive detector (2D-PSD). The position of the spot is proportional to the deformation of the cantilever. The total deformation is a superposition of bending and twisting, whereas twisting only occurs if the cantilever is exposed to flow coming from angles of attack different from 0°. Therefore measurements of velocity components in two dimensions are achieved [1],[2].

The small dimensions of the cantilever and an eigenfrequency far beyond 100kHz allow measurements with high temporal and spatial resolutions comparable to x-wires. Unlike x-wires the 2D-LCA is capable of operating in particle-laden flows as well as under water and therefore represents a great alternative sensor.

Measurements of turbulent flow in a wake of a cylinder were performed using the 2D-LCA and an x-wire. The sensors were aligned behind a cylinder with a diameter of 2cm in a distance of 66cm. The wind speed used in this setup was 8m/s. Figure 2 shows a comparison of the power spectra between both sensors for the longitudinal and transversal velocity components. The power spectra of the longitudinal velocity component show an excellent agreement in terms of shape and dynamical range. The dynamical range of the transversal velocity component, which corresponds to the twisting behavior of the cantilever, is much weaker compared to the x-wire. The measurement therefore shows that the cantilever is not equally sensitive to both velocity components.

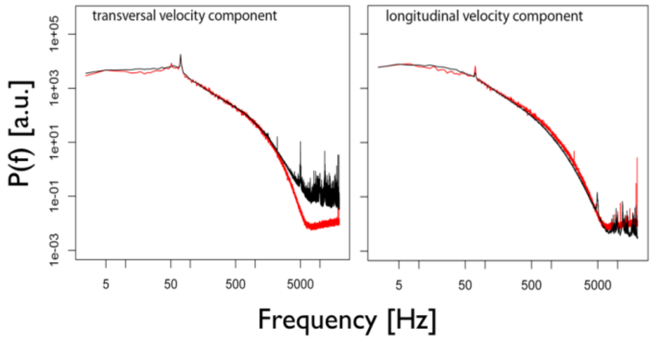


**Fig. 2** Comparison of power spectra for the longitudinal and transversal velocity component of the 2D-LCA (black) and an x-wire (red).

In order to increase the sensor's sensitivity to cross winds, i.e. the transversal velocity component, two different approaches are of interest. On the one hand a new prototype of the cantilever was developed. The new design was acquired using FEM-simulations with the view of increasing the amount of twisting [3]. Unlike the original cantilever, the new cantilever is equipped with an additional structure, which will increase the contact area towards cross winds. First measurements with the new cantilever will be performed soon.

On the other hand future work will deal with the optimization of the laser beam path. Our intention is to "amplify" the vertical deflection by using a cylindrical lens, i.e. completely exploit the active area of the PSD-element.

## References

[1] Jaroslaw Puczylowski, Michael Hölling, Joachim Peinke Measurements with a 2D-Laser Cantilever Anemometer compared to x-wire probes, 80th Annual Meeting of the International Association of Applied Mathematics and Mechanics (GAMM 2009)

[2] Michael Hölling Sensorentwicklung für Turbulenzmessungen (Diss.), Carl von Ossietzky Universität Oldenburg, Germany (2008)

[3] Jaroslaw Puczylowski Weiterentwicklung des 2D-Laser Cantilever Anemometers, Carl von Ossietzky Universität Oldenburg, Germany (2009)