

Gradient-index based optical techniques for fluid dynamics diagnostics

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For a long time schlieren techniques have been used in aerodynamics. It relies on the deviation of light rays through an inhomogeneous index media. Classical schlieren provides very nice visualizations of convective flows or shock waves phenomena. However, obtaining quantitative results is quite complex due to the difficulty of calibrating such a system.

More recently, the background oriented schlieren (BOS), have been introduced. Its principle is relatively simple: it consists in imaging a textured background first without the flow, and then with the flow in between the camera and the background. The density variations inside the flow lead to a virtual displacement of the background which can be computed using image correlation techniques. One can then derive deviation maps from the displacements fields, knowing the camera calibration.

At ONERA, we have developed a 3DBOS technique which exploits the recording of BOS images from multiple points of view (12) to reconstruct instantaneous 3D density fields. We have set up the technique in a research wind tunnel on hot subsonic jet configuration and compared the result with thermocouples measurement. We have also investigated an underexpanded jet at different nozzle pressure ratio and highlighted the periodic vortex shedding thanks to phase averaging.