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Beam-steering artefacts correction for 100 kHz turbulent flow imaging at elevated pressure using a wavelet-based algorithm

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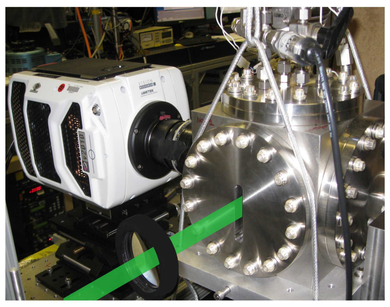
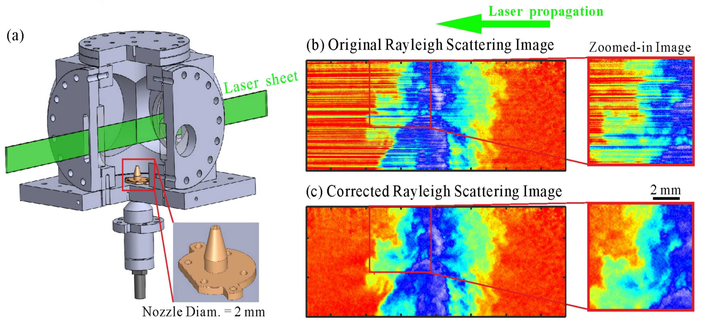
Beam-steering by index-of-refraction gradients poses a significant challenge for laser-based imaging measurements in turbulent reacting and non-reacting flows, particularly at elevated pressures. High fidelity imaging and quantitative data interpretation in turbulent flows can be considerably impeded by artefacts generated from beam-steering. A wavelet-based filtering scheme has been developed to recover the underlying turbulent flow structures from imaging measurements containing severe beam-steering artefacts. This is a general analysis technique that is equally applicable to imaging measurements in reacting and non-reacting flows. It is demonstrated using 100 kHz mixture fraction measurements in a transient turbulent jet flow at 8 bar using Rayleigh scattering imaging. The corrected images reveal the temporal evolution of highly coherent flow structures with negligible residual beam-steering artefacts. Tests of the sensitivity of the wavelet-based filtering scheme to noise indicate that it is a robust analytic tool for correcting severe beam-steering artefacts commonly encountered in laser-based imaging measurements at elevated pressures.

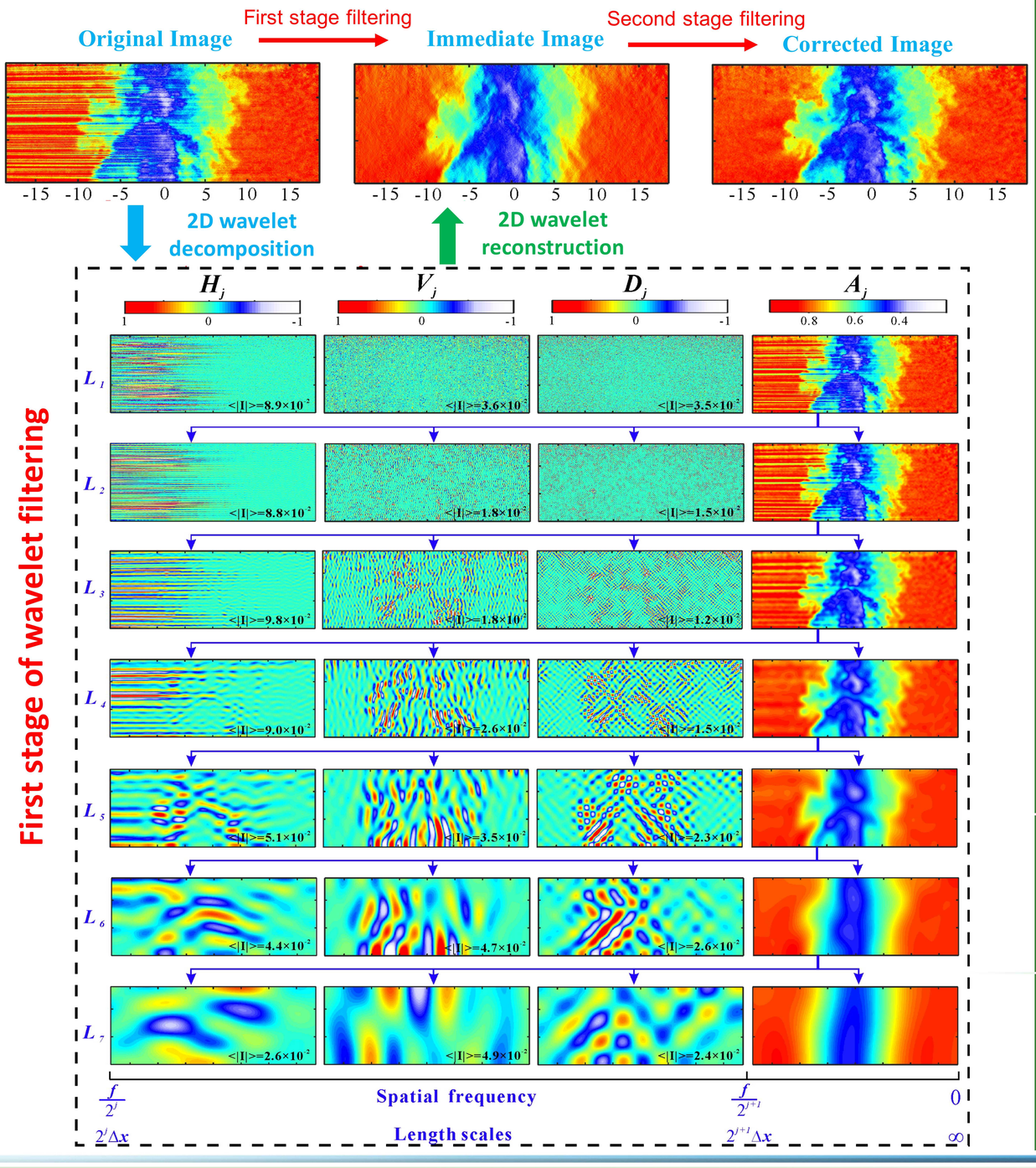
100 kHz Rayleigh Scattering Imaging in a high pressure vessel



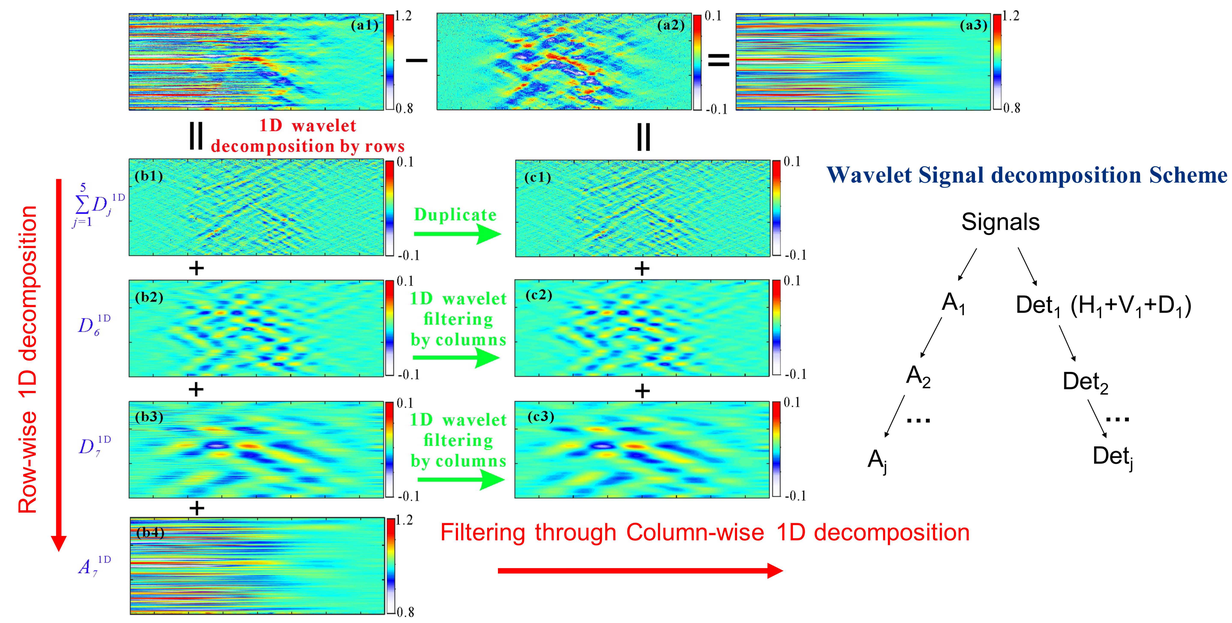


Jet	Jet pressure (bar)	Buffer gas	Buffer pressure (bar)	Injection duration
Argon	16	Methane	8	50 ms

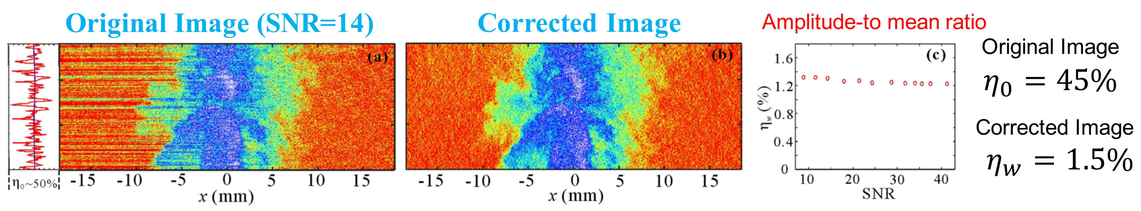
A wavelet-based algorithm for beam-steering correction



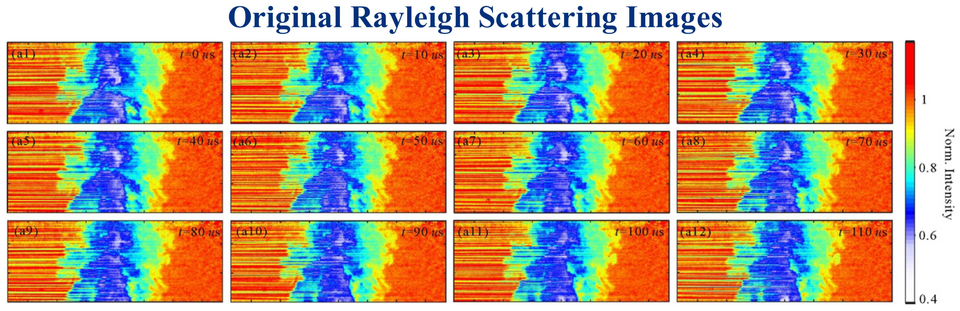
Second stage of wavelet filtering



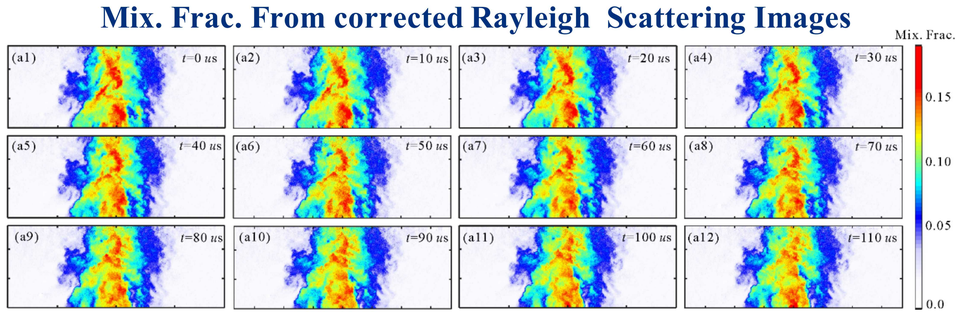
Effect of Image Noise



Original Rayleigh Scattering Images



Mix. Frac. From corrected Rayleigh Scattering Images



Summary

- 100 kHz Rayleigh scattering imaging of turbulent flow in high pressure using a pulse-burst laser is demonstrated.
- A wavelet-based algorithm is developed to successfully correct for severe beam-steering artefacts to enable quantitative 100 kHz mixture fraction measurements.
- The wavelet-based algorithm is shown to be immune to the noise level which is advantageous comparing with other beam-steering correction methods such as the ray-tracing method.

Acknowledgments

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