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SPECTRAL ANALYSIS FOR COMPARISON OF SECOND-ORDER FLOW STRUCTURE IN DNS SIMULATIONS

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We propose a fully spatiotemporal approach for identifying spatially varying modes of oscillation in fluid dynamics simulation output by means of multitaper frequency wavenumber spectral analysis. Two-dimensional frequency wavenumber spectral analysis allows one to decompose waveforms into standing or traveling variety. The extended higher-dimensional multitaper method [1, 2] proposed here is shown to have improved statistical properties over conventional non-parametric spectral estimators, and is accompanied by confidence intervals which estimate their uncertainty. Multitaper frequency-wavenumber analysis is applied to a canonical benchmark problem, namely, a DNS of von Karman vortex shedding of a square wall-mounted cylinder with two in flow scenarios with matching momentum-thickness Reynolds numbers $Re = 1000$ at the obstacle [3]. Frequency-wavenumber analysis of a two dimensional section of these data reveals that although both the laminar and turbulent in flow scenarios show a turbulent $-5/3$ cascade in the wavenumber and frequency, the flow characteristics differ in that there is a significantly more prominent discrete harmonic oscillation near $(f, \nu) = (0.2, 0.21)$ in wavenumber and frequency in the laminar in ow scenario than the turbulent scenario. This frequency-wavenumber pair corresponds to a travelling wave with velocity near one near the centre path of the vortex street.

REFERENCES

[1] Thomson, D. J. 1982 Spectrum estimation and harmonic analysis. *Proc. IEEE* 70 (9), 1055-1096.

[2] Simons, F. J. and Wang, D. V. 2011 Spatiospectral concentration in the Cartesian plane. *International Journal on Geomathematics* 2 (1), 1-36.

[3] Vinuesa, R., Schlatter, P., Malm, J., Mavriplis, C. and Henningson, D. S. Direct numerical simulation of the flow around a wall-mounted square cylinder under various inflow conditions. *Journal of Turbulence* (2015) 16, 555-587.