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Modal Energy Flow Analysis the Highly Modulated Wake of a Wall-mounted Square-based Pyramid[1] ROBERT MARTINUZZI, ZAHRA HOSSEINI, Schulich School of Engineering, University of Calgary, BERND NOACK, Institute PPRIME / CNRS, France — We present the first modal energy flow analysis of a time-resolved 3D velocity field from experimental PIV data for a highly modulated wake of a square-based pyramid protruding a boundary layer. The underlying low-order representation is optimized for resolving the base flow variation as well as the first and second harmonics associated with vortex shedding, thus generalizing the triple decomposition of Reynolds & Hussain (1972). The analysis comprises not only a detailed modal balance of turbulent kinetic energy as pioneered by Rempfer & Fasel (1994) for POD models, but also the companion mean-flow energy balance. The experimental results strikingly demonstrate how constitutive elements of mean-field theory (Stuart, 1958) near laminar Hopf bifurcations are still strongly expressed in a turbulent wake characterized by highly modulated, quasi-periodic shedding. The results emphasize, for instance, the stabilizing role of the mean-field manifolds, as explored in the POD model of Aubry et al. (1988). The proposed low-order representation of the flow and modal energy analyses may provide a novel framework for characterizing highly anisotropic wakes and vortex interactions; yielding important insights and reference data for computational turbulence modeling, e.g. URANS.

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