Abstract Submitted
for the DFD15 Meeting of
The American Physical Society

Koopman decompositions of periodically forced Hopf bifurcation flows and application to dynamic stall[1] BRYAN GLAZ, U.S. Army Research Laboratory, SOPHIE LOIRE, MARIA FONOBEROVA, Aimdyn, Inc., IGOR MEZIC, University of California Santa Barbara — Periodically forced Hopf bifurcation flows, such as oscillating cylinders, can exhibit rich spectral content. Though lock-on dynamics of systems forced near resonances are well understood, the underlying chaotic or quasi-periodic dynamics when forcing away from a natural frequency are not. This behavior can be critical for systems of practical significance, such as oscillating airfoils under dynamic stall. In this study, normal form theory and spectral decompositions based on Koopman operators will be used to reveal transitions from limit cycle attractors to chaotic/quasi-periodic dynamics in the cylinder Hopf bifurcation flow. Koopman operator methods are used since each mode is associated with a single frequency which allows one to observe the evolution to more continuous spectral behavior with forcing, while approaches such as proper orthogonal decomposition may obfuscate this transition. It will be shown that projecting onto a low order subspace of Koopman modes can capture features supported by normal forms. Using this, we show a mechanism that leads to regimes in which the system seems to exhibit shear-induced chaos. The new framework is applied to dynamic stall studies to establish periodically forced Hopf bifurcation dynamics as an underlying feature.

[1]Support for M. Fonoberova, S. Loire, and I. Mezic under U.S. Army Research Office project W911NF-14-C-0102, and U.S. Air Force Office of Scientific Research project FA9550-12- 1-0230 are acknowledged.

Bryan Glaz
U.S. Army Research Laboratory

Date submitted: 01 Aug 2015 Electronic form version 1.4