Recent developments in the field of echocardiography have introduced various noninvasive methods to image blood flow within the heart chambers. FDA-approved microbubbles can be used for intracardiac blood flow imaging and determining the velocity of the blood based on the displacement of the bubbles and the frame rate of the ultrasound scan. A limitation of this approach is that the velocity field information is only two-dimensional and inevitably contains noise. A weighted least square finite element method (WLSFEM) will be presented that can assimilate noisy, two-dimensional data from echocardiographic particle imaging velocimetry (echo-PIV) into a three-dimensional Navier–Stokes numerical model so that additional flow properties such as the stress and pressure gradient can be determined from the full velocity and pressure fields. The flexibility of the WLSFEM framework allows for matching the noisy echo-PIV data weakly and using the weighted least square functional as an indicator of how well the echo-PIV data are satisfying the numerical model. Results from the framework demonstrate the ability of the approach to more closely match the more accurate echo-PIV data and less closely match the noisy data. The positive impact of assimilating the echo-PIV data is demonstrated: compared to a conventional computational fluid dynamic approach, echo-PIV data assimilation potentially enables a more accurate flow model.

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Research interests:
- Using systems biology and dynamical system modeling to understand noise tolerance in microbial systems, especially oscillatory systems.
- Implicit Discontinuous Galerkin Methods for advection-diffusion problems and the Navier-Stokes equation
- Biofilm-fluid interaction and quorum sensing
- Using the higher-order finite elements and the spectral element methods to predict particle deposition in the human airways
- The modeling of biological systems in which there is a mechanical coupling between a moving fluid and tissues. Problems of current interest include the cricket sensory system and biofilms.
- Using a first-order system least-squares (FOSLS) and algebraic multigrid (AMG) to solve the Navier-Stokes equations with data assimilation.

Dr. Heys has authored 36 peer reviewed publications and one book.