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Magnetic Resonance Velocimetry ofa projectile spinning at constant rotation with sub-millimeter resolution NOAH W. SIEGEL, AARON P. SCHLENKER, Massachusetts Institute of Technology, BRET P. VAN POPPEL, MICHAEL J. BENSON, U.S. Military Academy, West Point, CHRISTOPHER J. ELKINS, Stanford University, GREGORY P. RODEBAUGH, Armament Center, Picatinny Arsenal — Magnetic Resonance Velocimetry (MRV) techniques were extended to obtain high-fidelity, three-dimensional veloc- ity field data sets around a projectile spinning at constant rotation with sub-millimeter resolution. A modified M193 5.56mm projectile was specially designed and built to thicken the hydrodynamic boundary layer for the purpose of investigating dynamic instabilities in spin-stabilized projectiles attributable to transient fluctuations in the Magnus moment as the projectile decelerates into the transonic flight regime. Computational fluid dynamics (CFD) simula- tions struggle to accurately predict the Magnus moment for these types of projectiles. The experimental rig rotated the projectile at uniform spin rates in a constant flow of copper-sulfate solution as part of a test section placed within a research-grade MRI magnet. The velocity fields for several spin rates and projectile angles of attack were analyzed and compared to Reynolds Averaged Navier-Stokes (RANS) CFD simulations to identify proposed causes of the Magnus moment, namely boundary layer asymmetries and attached lee side vortices. The experimental MRV data revealed notable lateral boundary layer asymmetries for some combinations of spin rate and angle of attack, while comparable RANS simulations showed no boundary layer effects due to spin or angle of attack. Experimental uncertainty was assessed and found to be similar to comparable methods for measuring velocity field data.

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