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Uncovering the Unique Mysteries of Baseball Aerodynamics

Barton Smith, Andrew Smith, John Garrett
Utah State University, Logan, UT, USA
Barton.smith@engineering.usu.edu

Abstract

The baseball is unique among sports balls due to the size and shape of its seams and their pattern on the ball. The seam shape has a property that promotes boundary layer separation. In addition, they are distributed around the ball such that many assymetries may be found.

As with any sports ball, baseballs are subject to the Magnus effect, or the force on a traveling, spinning ball. Baseballs are "pitched" toward a batter to begin each play. Pitchers are well versed in spinning the ball in a variety of ways to cause different movement due to the Magnus effect. For instance, a "fastball" is typically thrown with backspin while a "curveball" is thrown with topspin, causing the opposite movement from the fastball.

For over a decade, the movement of baseballs in high-level games has been measured by a series of increasingly powerful measurement systems. One of the more recent systems, Trackman, measures the full trajectory of the ball along with its spin rate. This system cannot, however, measure the axis on which the ball spins. Until 2020, the axis was inferred by applying a model of the Magnus force to the trajectory and spin rate information and solving for the axis. One interesting feature of this approach is that it consistently found a solution. Perhaps for this reason, the baseball community has accepted that the forces on a pitched baseball are 1) gravity, 2) drag, and 3) Magnus force. This talk will show that an additional force exists on baseball flight due to the presences of seams.

The Utah State University Experimental Fluid Dynamics Laboratory has investigated baseball aerodynamics using the unique approach for projecting baseballs across the lab and either tracking their motion or measuring the airflow around the ball with Partical Image Velocimetry (PIV). These tests have taught us that 1) baseball seams can advance the boundary layer separation point compared to turbulent flow over a smooth ball and 2) by placing the seams in a location near a plane passing through the center of the ball perpendicular to its direction of travel while maintaining that position as it rotates, the seams can alter the path of the ball.

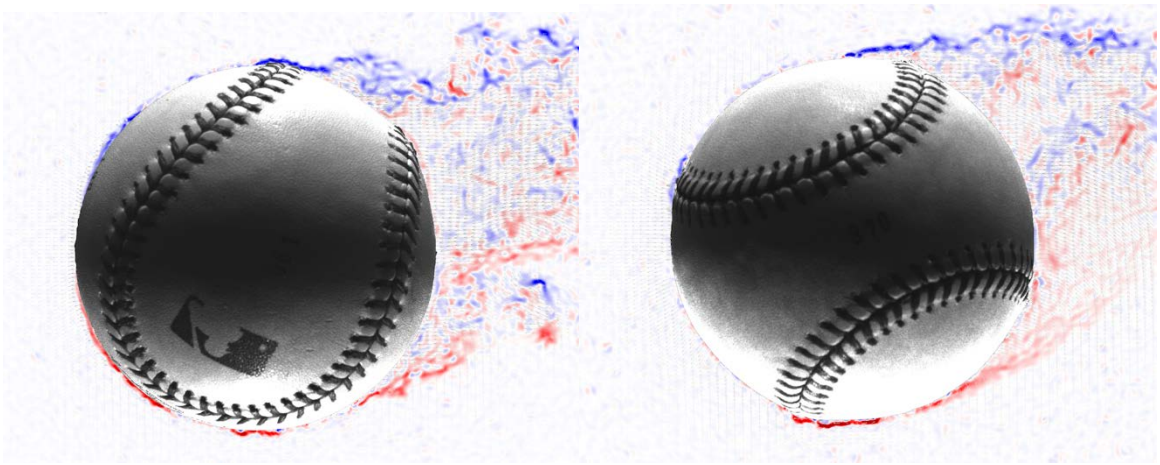

Fig. 1 Vorticity field around to pitched baseballs. In each cases, the boundary layer separation point is advanced due to the presence of a seam on top of the ball and the pressure distribution is altered as a result.