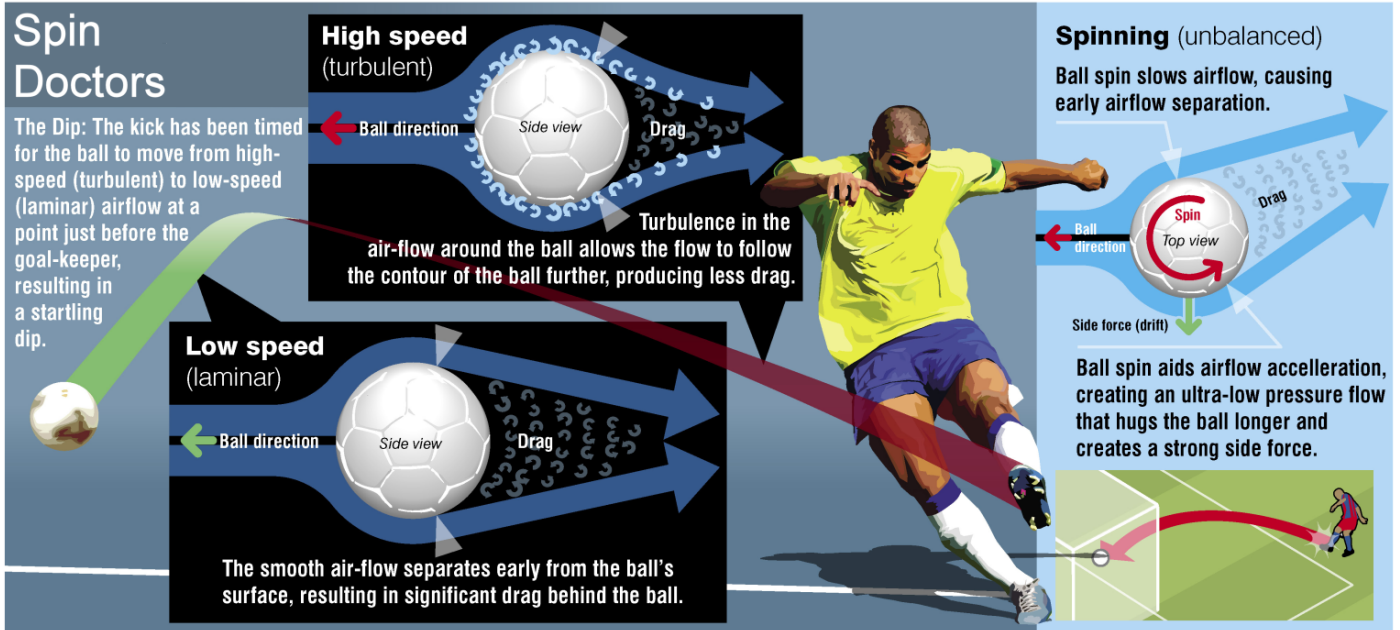




CAN YOU Believe it?

WITH ASSOCIATE PROFESSOR DEREK LEINWEBER

Surprise attack



Spin Doctors

The Dip: The kick has been timed for the ball to move from high-speed (turbulent) to low-speed (laminar) airflow at a point just before the goal-keeper, resulting in a startling dip.

High speed
(turbulent)

Ball direction → Side view → Drag → Turbulence in the air-flow around the ball allows the flow to follow the contour of the ball further, producing less drag.

Low speed
(laminar)

Ball direction → Side view → Drag → The smooth air-flow separates early from the ball's surface, resulting in significant drag behind the ball.

Spinning (unbalanced)

Ball spin slows airflow, causing early airflow separation.

Ball direction → Spin → Top view → Drag → Side force (drift) ↓

Ball spin aids airflow acceleration, creating an ultra-low pressure flow that hugs the ball longer and creates a strong side force.

IMAGINE you're a goalkeeper facing the world's best kickers, such as England's David Beckham, Brazil's Roberto Carlos or Germany's Michael Ballack. These guys make the ball bend, swerve and dip in ways that are impossible to imagine, even if you have the experience of the game's best goalkeepers.

A soccer ball moving off in one direction can bend in another, then dip as if hitting a brick wall – due to the complex way air flows over the spinning ball.

Take, for example, Beckham's legendary goal against Greece that put England into the 2002 World Cup tournament. Beckham hit the soccer ball about 8cm to the right of its centre with the instep of his right foot, accelerating it to 130km/h. The ball spun counterclockwise at about 8rps (revolutions per second) and started swerving to the left. The ball flew as if it would soar over the goal's crossbar. But then it suddenly slowed, curving harder to the left and dipping into the top left corner for the goal.

No, it wasn't magic. It was the result of exploiting pure physics. Through years of experimentation, trial and error and practice, the world's elite soccer players have come to intuitively understand the physics behind soccer ball motion. They understand the subtle link between speed and spin essential to working their magic.

Scientists have discovered the physics behind soccer ball motion through wind tunnel experiments, high-speed video analysis, computational fluid dynamics and computer trajectory simulations. They are using this knowledge to create new strategic options for attackers and defenders.

On the surface of the ball is a coating of air that is carried along with it. Farther out is air that is undisturbed by the ball's motion. Between these extremes is a layer of air known as the boundary

layer. And it is this layer that determines how the ball moves through the air. At the very high ball speeds obtained by today's best players, this air layer is compressed to just a few millimetres thick. This makes the surface texture and seams of the soccer ball a big deal in the ball's aerodynamics.

Kicking the ball hard and fast, as Beckham does in a free kick, makes the high-speed air flow in the boundary layer turbulent. Microscopic, rapid, random fluctuations of the air particles are superimposed on the regular flow around the ball. These fluctuations act to keep the airflow hugging the surface of the ball, reducing the wake and its associated drag. However, as the ball slows, turbulence in the boundary layer is lost. It happens quite suddenly as the ball drops below a critical speed for its surface to create turbulent flows.

But smooth (laminar) airflow separates early from the surface, creating a large low-pressure wake behind the ball. This wake creates a huge drag on the ball, suddenly slowing it even further at the moment when the airflow changes from turbulent to laminar. The effect of the transition is phenomenal, almost tripling the drag on Beckham's spinning ball. It happens in mid-air, at about 37km/h. It can be quite surprising as the ball suddenly drops like a stone just under the cross bar.

The world's best players know just how hard to kick the ball to have this transition from turbulent to laminar flows occur at the critical moment in the ball's trajectory. What might look like a wild shot, well over the net, can suddenly become a goalkeeper's nightmare. But this is not the only trick in the arsenal of the game's elite. The most amazing tactic is the use of spin on the ball to create lift and huge bends. That's a subject for another column.

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