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Footballers move around pitch like chaotic particles in a fluid

Time to turn 120 degrees left
Ricardo Beliel/Brazil Photos/LightRocket via Getty Images

By **Leah Crane**

IF YOU'VE watched any England football games recently, this news might not come as a surprise. Footballers seem to move around a pitch in much the same manner as particles move in a chaotic fluid flow.

In fluid dynamics, a turbulent flow is a swirling fluid with areas that move faster or slower and have higher or lower pressure. When a stream of milk curls and twists as you pour it into your tea, that chaotic behaviour is turbulence.

Wouter Bos at the École Centrale de Lyon in France and his colleagues have now tracked a turbulent fluid's motion by picking a point and following it as the fluid tosses it about. "You follow it in time on its spiralling turbulent trajectory and evaluate on which timescale, on average, its direction changes," says Bos.

The team calculated how each particle twisted and turned in two dimensions. Over very short periods of time, regardless of the particles' surroundings, they all appear to travel smoothly in a straight line: they haven't moved far enough for a change in direction to be detectable.

Give them a little longer and the average change in direction becomes 90 degrees – as one might expect, because it is the middle of all possible direction changes from 0 to 180 degrees. This is dictated by the lack of uniformity in the fluid.

But when the edges of the area are defined, the geometry of the system takes over. Confine the fluid in a rectangular space like a football pitch for a long period of time and, on average, the particles change direction by 120 degrees.

To confirm that those effects are due to the rectangular confines rather than the flow itself, the researchers compared their theoretical fluid particles with data taken from sensors on players during a football match at Nuremberg Stadium in Germany.

A football match is also constrained to a two-dimensional box, but the initial placements and movements of the players are (the coach would hope) not random, so any similarities between the scenarios were purely geometric. Nonetheless, the correspondence was striking (*Physical Review Fluids*, doi.org/b8sc).

On short timescales, the data set from the footballers isn't reliable: any time they are jostling around more than running, such as when there's a free kick or a penalty, it's nearly impossible to identify their trajectories.

On long timescales, though, the trajectories matched. The average angle by which the players changed direction, like for particles in a turbulent fluid, was 120 degrees.

"We expected some resemblance, but the fit was far better than expected," says Bos. You might think players would move in every direction equally, giving an average of 90 degrees, but they seem to open up that angle as they travel up and down the longer side of the pitch.

In other words, being confined to a rectangle was more important than the different natures of the system or even the fact that one contains random particles and the other strategically placed humans with minds of their own.

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