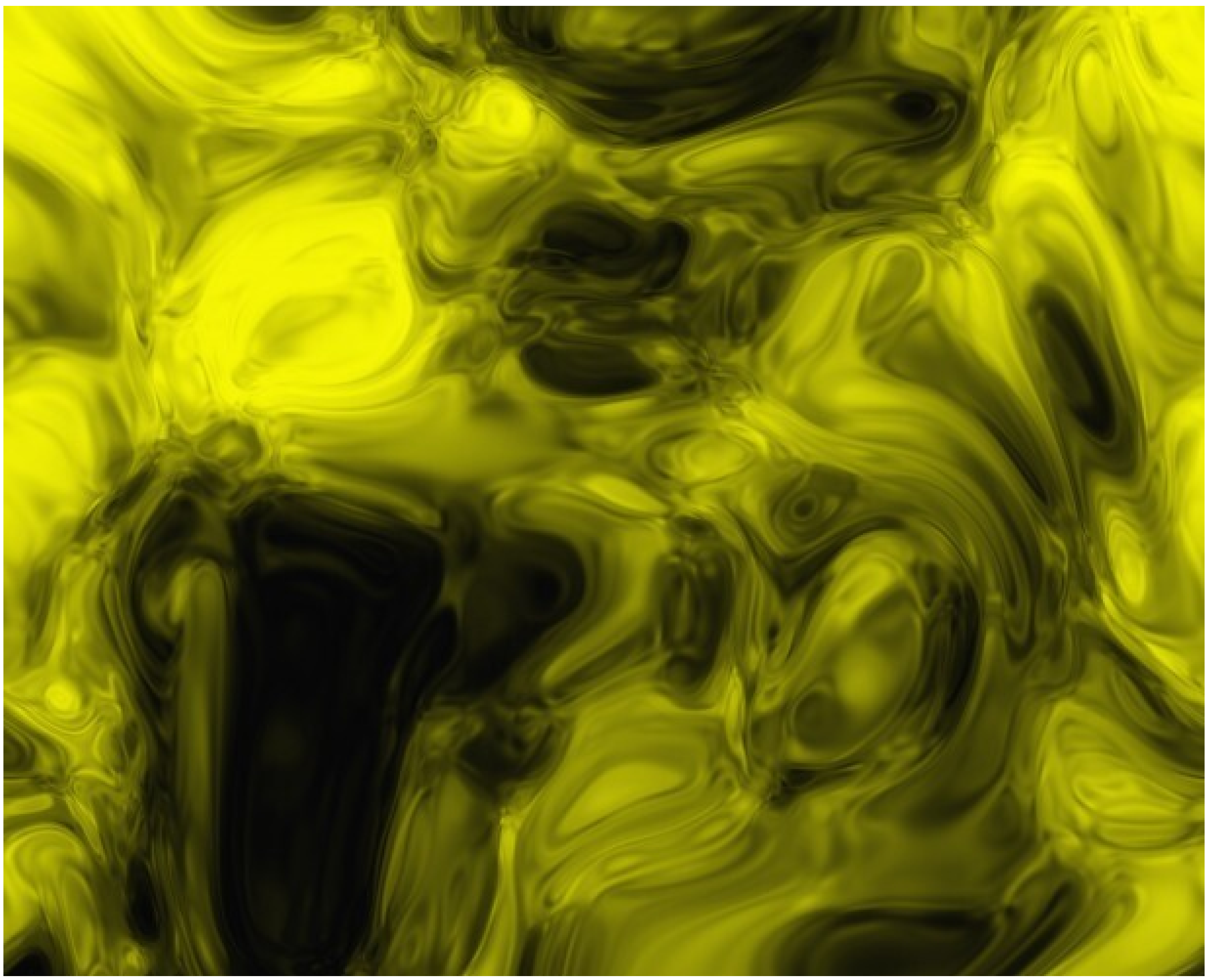
Model shows key features of transition of liquid from smooth to turbulent flow in a pipe

October 22 2015, by Bob Yirka

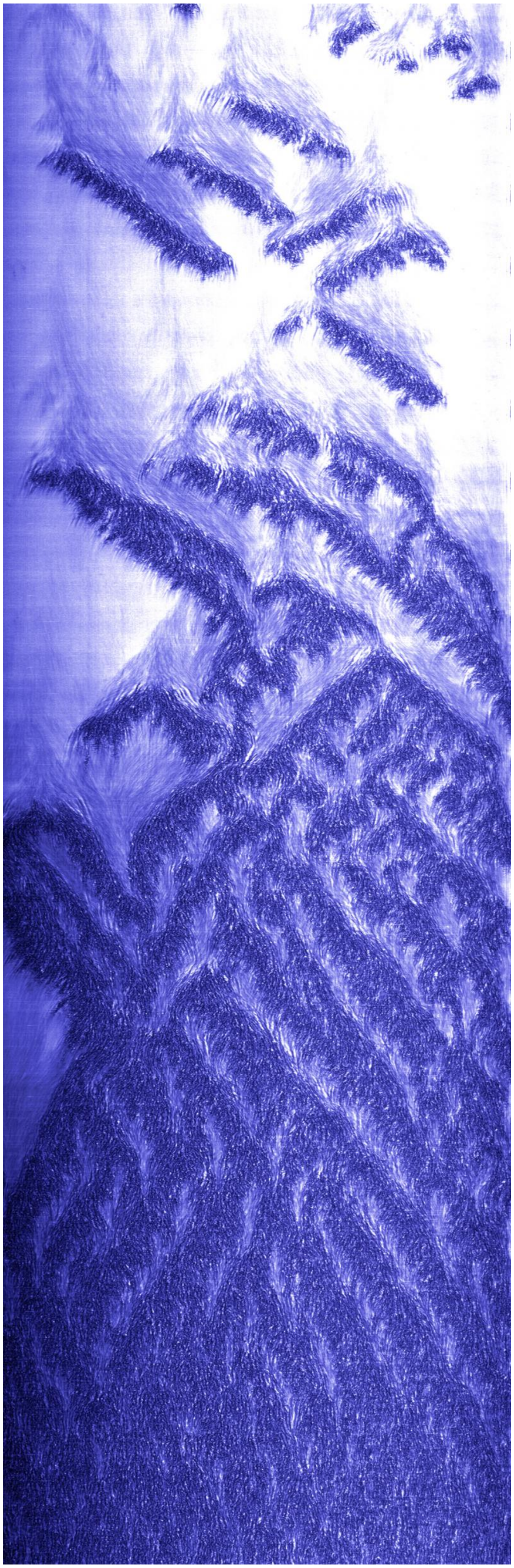


Credit: Piotr Siedlecki/public domain

(Phys.org)—A team of researchers from Austria, Germany and the U.K. has succeeded in building a model that shows the process that occurs when a liquid moves from a smooth state to one of turbulence inside of a pipe. In their paper published in the journal *Nature*, the team describes how they applied theory, experiments and computer simulations to create their model and suggest that it helps understand what actually happens as such transitions occur. Michael Graham, of the University of Wisconsin offers a News & Views piece on the work done by the team in the same journal issue, outlining the various concepts involved in fluid transitions and why he believes the model created by the team will lead to more complex models that could eventually have engineering ramifications.

When moving slowly over a surface, most fluids exhibit clean movement, known as laminar flow. When fluids speed up, however, turbulence tends to creep in, which can cause problems—with air moving over a wing for example, eddies develop that reduce efficiency. As the authors of this new effort, note, scientist have been trying for well over a century to understand how exactly turbulence gets its start and then becomes self-sustaining. To that end, they have created what they describe as a simple reaction-diffusion model to describe a very simple system—water moving through a pipe.

Even such a simple system has complexity, Graham notes, because turbulence itself is a complex process. To create such a model, factors such as Reynolds number (a ratio that describes momentum force versus viscous forces) must be taken into consideration along with travelling localized patterns and situations where excited states can come about. That leads to the necessity of using mathematical models that can describe excitable systems as well as those that are bistable, i.e. reaction-diffusion models.



Spatio-temporal pattern of turbulence in a fluid moving between two plates is pictured. At low speeds (top) turbulence is strictly confined to localized patches. At high speeds (bottom) on the other hand flows are turbulent throughout. In the paper we describe how turbulence is transformed from a local excitation into an expanding state that aggressively invades its surrounding. Credit: © IST Austria, 2015

The model created by the team depicts an initial steady state that remains as such when Reynolds numbers are small—as the Reynolds numbers are increased and eventually grow larger than a certain threshold, the outcome is an excitable state with major perturbations that that evolve into stable "puffs" that Graham describes as akin to nerve impulses. Bumping the Reynolds number higher causes the system to become unstable eventually leading to turbulence.

More information: Dwight Barkley et al. The rise of fully turbulent flow, *Nature* (2015). DOI: 10.1038/nature15701

Abstract
Over a century of research into the origin of turbulence in wall-bounded shear flows has resulted in a puzzling picture in which turbulence appears in a variety of different states competing with laminar background flow. At moderate flow speeds, turbulence is confined to localized patches; it is only at higher speeds that the entire flow becomes turbulent. The origin of the different states encountered during this transition, the front dynamics of the turbulent regions and the transformation to full turbulence have yet to be explained. By combining experiments, theory and computer simulations, here we uncover a bifurcation scenario that explains the transformation to fully turbulent

pipe flow and describe the front dynamics of the different states encountered in the process. Key to resolving this problem is the interpretation of the flow as a bistable system with nonlinear propagation (advection) of turbulent fronts. These findings bridge the gap between our understanding of the onset of turbulence7 and fully turbulent flows.

Citation: Model shows key features of transition of liquid from smooth to turbulent flow in a pipe (2015, October 22) retrieved 27 June 2024 from https://phys.org/news/2015-10-key-features-transition-liquid-smooth.html