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PHYSICAL REVIEW LETTERS

Origin of the Sharkskin Instability: Nonlinear Dynamics

Numerical simulations reveals the intrinsic mechanism for the onset of the sharkskin instability in polymer extrusion process

In this paper, we have studied polymer extrusion, an important process in plastics manufacturing. Often the final material's surface is rough with semi regular grooves resembling the skin of a shark. This phenomenon, known as sharkskin instability, has intrigued the scientific and industrial communities for over 60 years. We have reported the results of a simple physical model which explains the underlying mechanism that causes the sharkskin instability. We simulated the flow of polymer melts being squeezed through a slit and observed that the stretched polymer chains are stretched toward the exit, then recoiled as they moved further away, causing a swell and forming waves. These waves became the familiar sharkskin grooves on the surface of the melt.

The Fluids Lab, Department of Chemical Engineering, University of Patras

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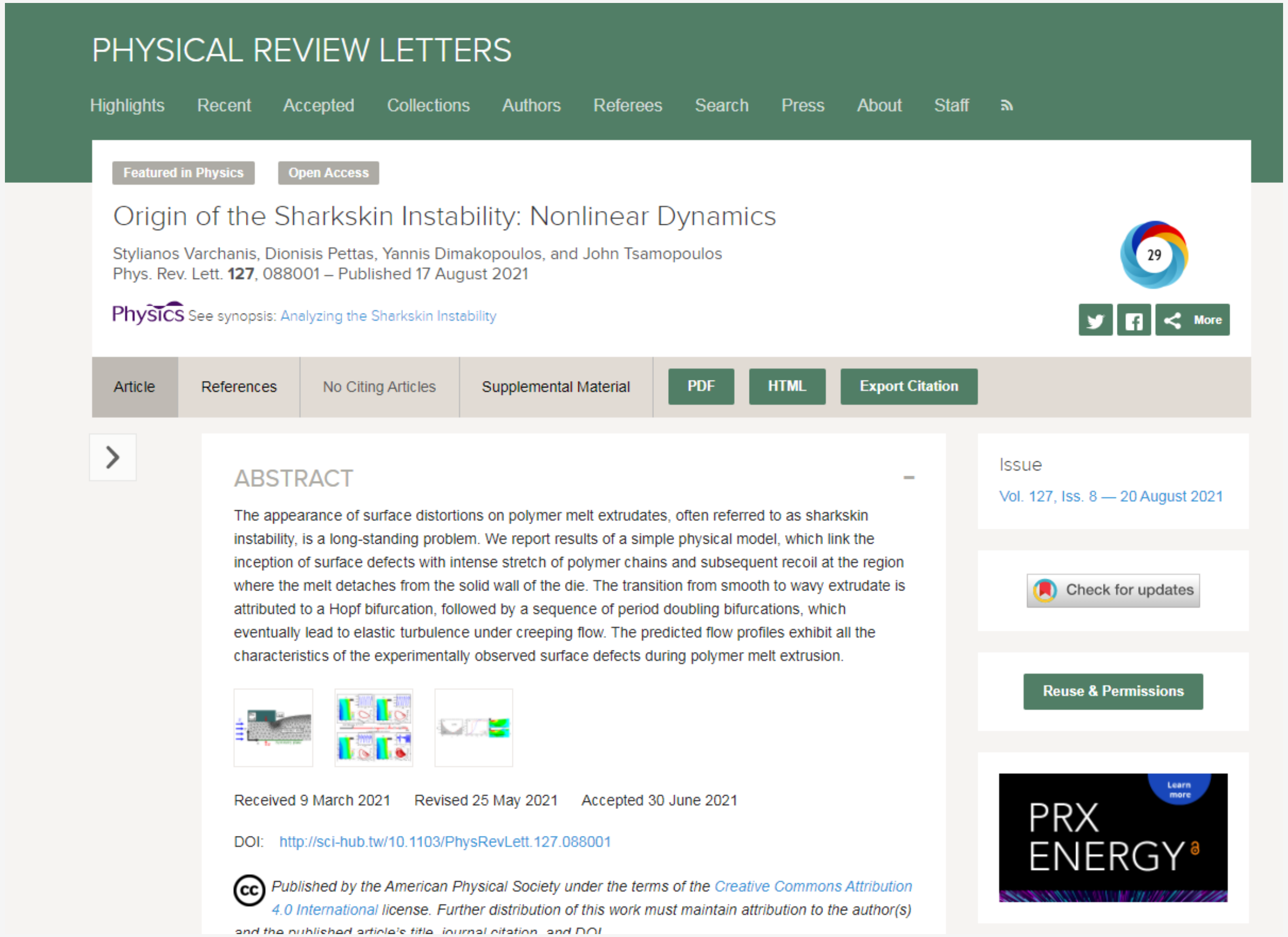

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Origin of the Sharkskin Instability: Nonlinear Dynamics

Stylianos Varchanis, Dionisis Pettas, Yannis Dimakopoulos, and John Tsamopoulos

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Physics See synopsis: Analyzing the Sharkskin Instability

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ABSTRACT

The appearance of surface distortions on polymer melt extrudates, often referred to as sharkskin instability, is a long-standing problem. We report results of a simple physical model, which link the inception of surface defects with intense stretch of polymer chains and subsequent recoil at the region where the melt detaches from the solid wall of the die. The transition from smooth to wavy extrudate is attributed to a Hopf bifurcation, followed by a sequence of period doubling bifurcations, which eventually lead to elastic turbulence under creeping flow. The predicted flow profiles exhibit all the characteristics of the experimentally observed surface defects during polymer melt extrusion.

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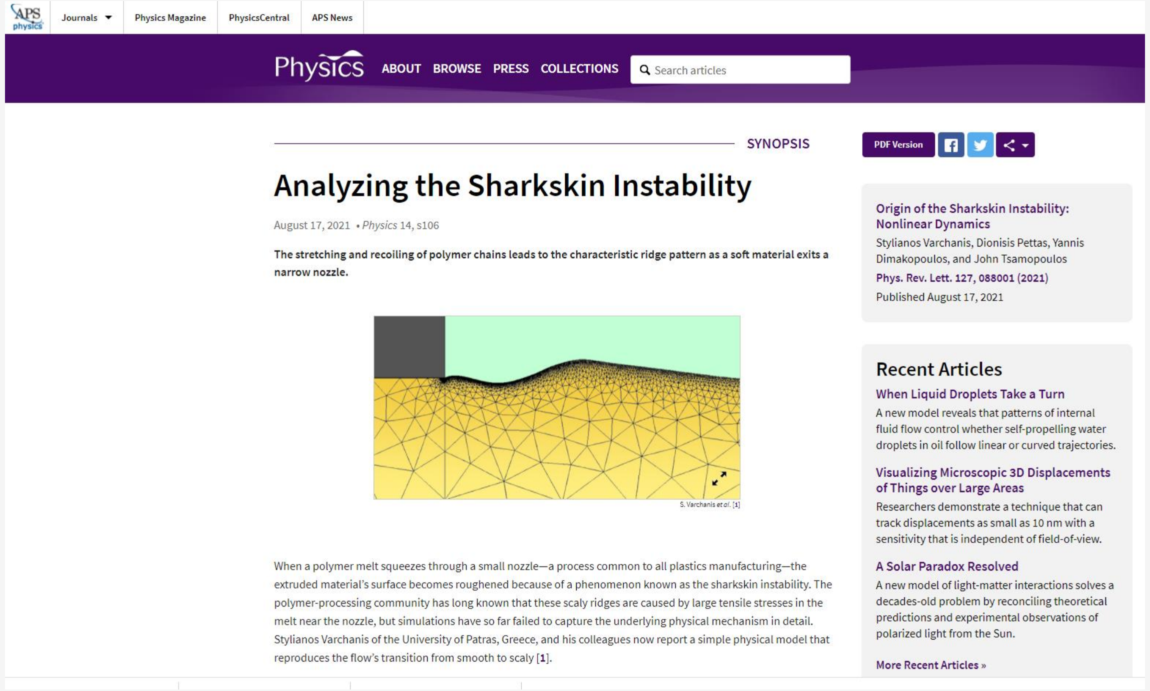

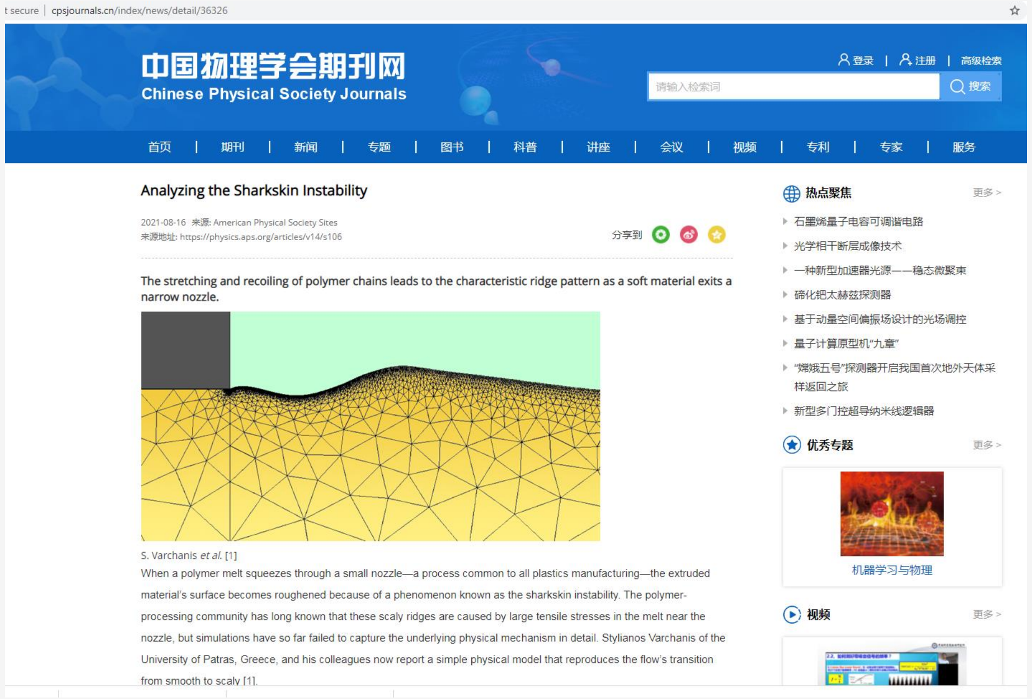

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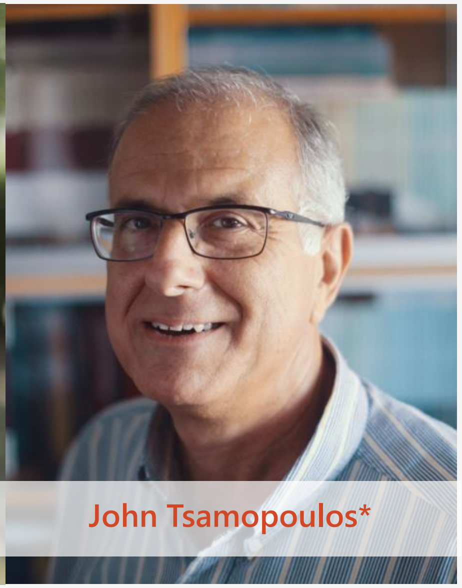
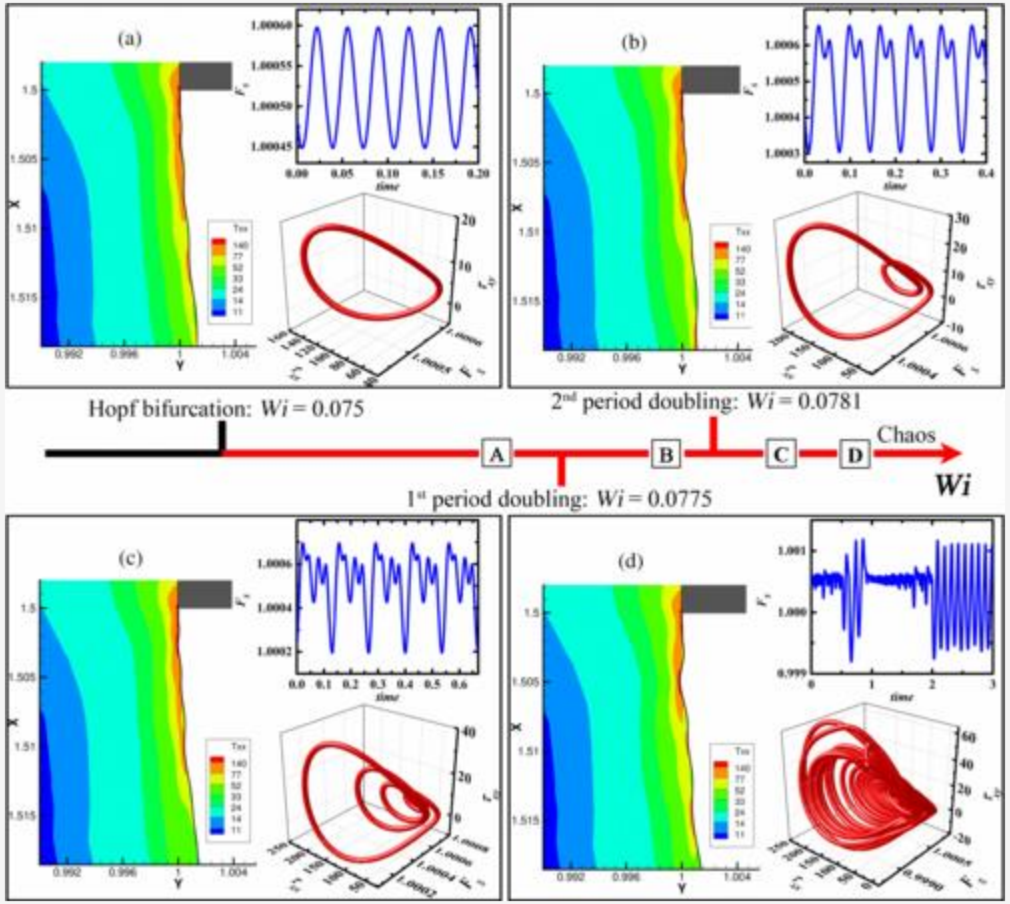


Laboratory of Fluid Mechanics and Rheology,
University of Patras, Greece

*Corresponding Author

Full Story

The appearance of surface distortions on polymer melt extrudates, often referred to as sharkskin instability, is a long-standing problem. We report results of a simple physical model, which link the inception of surface defects with intense stretch of polymer chains and subsequent recoil at the region where the melt detaches from the solid wall of the die. The transition from smooth to wavy extrudate is attributed to a Hopf bifurcation, followed by a sequence of period doubling bifurcations, which eventually lead to elastic turbulence under creeping flow. The predicted flow profiles exhibit all the characteristics of the experimentally observed surface defects during polymer melt extrusion.



The route to elastic turbulence

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