An exploration of tipping in complex systems

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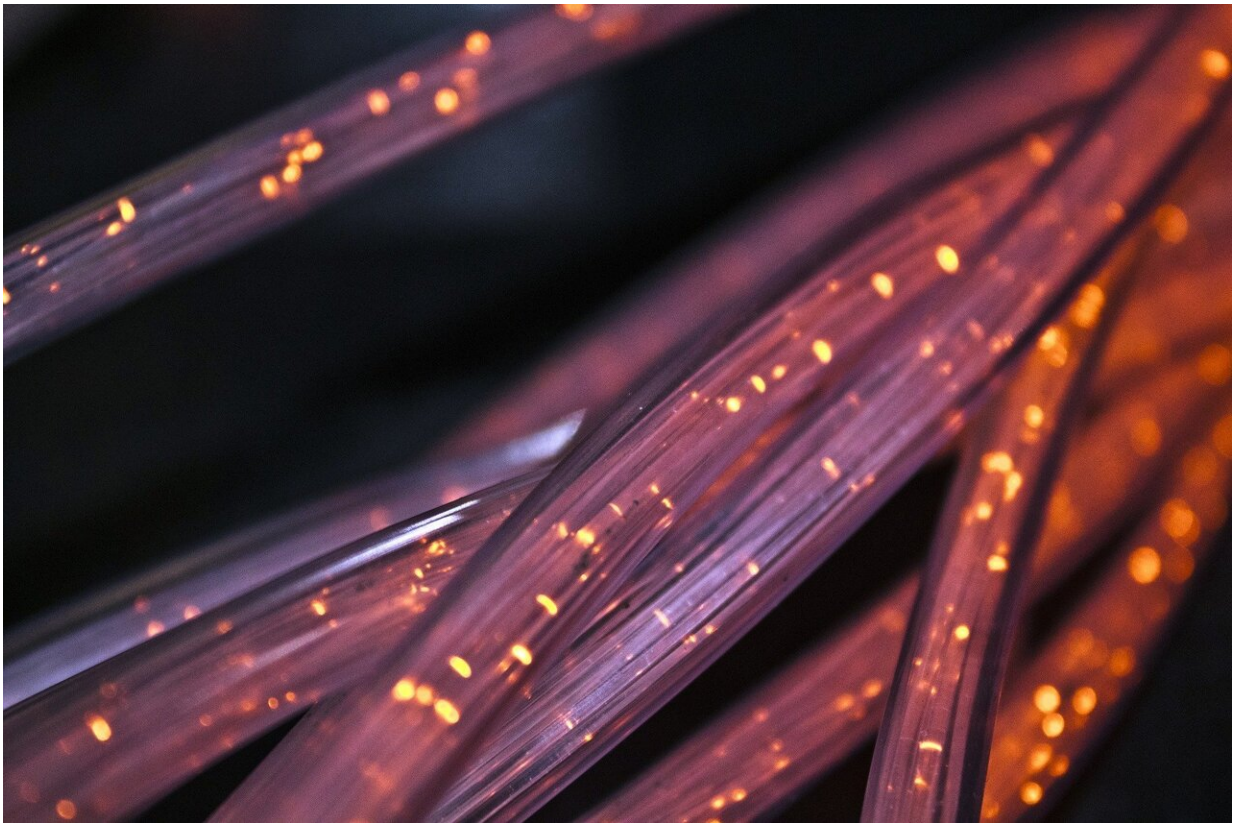

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Complex systems can be found in a diverse array of real-world scenarios, but are unified by their ability to suddenly transition between drastically different patterns of behavior. Known as 'tipping,' this type of transformation is generally triggered by small changes in the parameters of individual systems—whose effects can rapidly cascade to alter entire

networks of interacting subsystems. In this special issue, *EPJST* explores the nature of tipping in complex systems through 21 new articles. Together, the studies reveal recent trends and directions of research within the field, and highlight the pressing challenges it will face in the future.

The relevance of tipping pervades many different areas of modern research: from environmental factors, including climate change, ecology, and seismology to socioeconomic areas, including psychology, social networks, and financial markets. The articles presented in this special issue are split into three broad areas: in the first part, they focus on the mechanisms that can induce tipping between different states. The second group of papers explores the measures that characterize tipping phenomena, and suggests strategies that could be used to control them. The final part presents several specific case studies of tipping in complex systems, such as traffic flows, precipitation patterns, and dust cloud instabilities.

The special issue ends by reviewing the potential applications of tipping in different contexts. Here, it examines how the effect could be harnessed for more efficient logic operations, while highlighting how measurements of fluctuations within stable systems could provide essential early warning systems—helping to avoid and mitigate the often-damaging consequences of tipping. Together, the 21 studies draw together many of the latest mathematical and computational methods used to capture the complexity of numerous interacting subsystems. Ultimately, they highlight a shift within the field towards a more collaborative landscape, combining the latest data-driven techniques of dynamical systems theory, adaptive and multilayer networks, and machine learning.

More information: G. Ambika et al, Tipping in complex systems: theory, methods and applications, *The European Physical Journal Special*

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