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The Fragility of Interdependency: Coupled Networks Switching Phenomena[1]

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Recent disasters ranging from abrupt financial "flash crashes" and large-scale power outages to sudden death among the elderly dramatically exemplify the fact that the most dangerous vulnerability is hiding in the many interdependencies among different networks. In the past year, we have quantified failures in model of interconnected networks, and demonstrated the need to consider mutually dependent network properties in designing resilient systems. Specifically, we have uncovered new laws governing the nature of switching phenomena in coupled networks, and found that phenomena that are continuous "second order" phase transitions in isolated networks become discontinuous abrupt "first order" transitions in interdependent networks [S. V. Buldyrev, R. Parshani, G. Paul, H. E. Stanley, and S. Havlin, "Catastrophic Cascade of Failures in Interdependent Networks," Nature 464, 1025 (2010); J. Gao, S. V. Buldyrev, H. E. Stanley, and S. Havlin, "Novel Behavior of Networks Formed from Interdependent Networks," Nature Physics 8, 40 (2012). We conclude by discussing the network basis for understanding sudden death in the elderly, and the possibility that financial "flash crashes" are not unlike the catastrophic first-order failure incidents occurring in coupled networks. Specifically, we study the coupled networks that are responsible for financial fluctuations. It appears that "trend switching phenomena" that we uncover are remarkably independent of the scale over which they are analyzed. For example, we find that the same laws governing the formation and bursting of the largest financial bubbles also govern the tiniest finance bubbles, over a factor of 1,000,000,000 in time scale [T. Preis, J. Schneider, and H. E. Stanley, "Switching Processes in Financial Markets," Proc. Natl. Acad. Sci. USA 108, 7674 (2011); T. Preis and H. E. Stanley, "Bubble Trouble: Can a Law Describe Bubbles and Crashes in Financial Markets?" Physics World 24, No. 5, 29 (May 2011)].

[1]This work was carried out in collaboration with a number of colleagues, including T. Preis, J. J. Schneider, S. Havlin, R. Parshani, S. V. Buldyrev, J. Gao, and G. Paul–see "When Networks Network," Science News, 22 Sept. 2012.