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Order-to-chaos transition in the hardness of random Boolean satisfiability problems MELINDA VARGA, Department of Physics, University of Notre Dame, ROBERT SUMI, MARIA ERCSEY-RAVASZ, Faculty of Physics, Babes-Bolyai University, Romania, ZOLTAN TOROCZKAI, Department of Physics, University of Notre Dame — Transient chaos is a phenomenon characterizing the dynamics of phase space trajectories evolving towards an attractor in physical systems. We show that transient chaos also appears in the dynamics of certain algorithms searching for solutions of constraint satisfaction problems (e.g., Sudoku). We present a study of the emergence of hardness in Boolean satisfiability (k-SAT) using an analog deterministic algorithm. Problem hardness is defined through the escape rate κ, an invariant measure of transient chaos, and it expresses the rate at which the trajectory approaches a solution. We show that the hardness in random k-SAT ensembles has a wide variation approximable by a lognormal distribution. We also show that when increasing the density of constraints α, hardness appears through a second-order phase transition at α_c in the random 3-SAT ensemble where dynamical trajectories become transiently chaotic, however, such transition does not occur for 2-SAT. This behavior also implies a novel type of transient chaos in which the escape rate has an exponential-algebraic dependence on the critical parameter. We demonstrate that the transition is generated by the appearance of non-solution basins in the solution space as the density of constraints is increased.

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