Physical aging and emerging long-period orbits in deterministic classical oscillators

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Physical aging is understood as the breaking of time translation invariance in the measurement of autocorrelation functions and long intrinsic time scales. In previous work [1] we had shown physical aging of repulsively coupled classical oscillators under the action of noise. Noise led to the migration of oscillator phases through a rich attractor space. To explore the role of stochastic fluctuations in physical aging, we here replace noise by a quenched disorder in the natural frequencies. Again we identify physical aging, now in a deterministic system of repulsively coupled Kuramoto oscillators, where the attractor space is explored quite differently. Tracing back the origin of aging, we identify the long transients that it takes the deterministic trajectories to find their stationary orbits in the rich attractor space. The stationary orbits show a variety of different periods, which can be orders of magnitude longer than the periods of individual oscillators. The smaller the width of the distribution about the common natural frequency is, the longer are the emerging time scales on average. Among the long-period orbits we find self-similar temporal sequences of temporary patterns of phase-locked motion on different time scales. The ratio of time scales is determined by the ratio of widths of the distributions about the common natural frequency, as long as the width is not too large. The effects are particularly pronounced if we perturb about a situation in which a self-organized Watanabe-Strogatz phenomenon is known to happen, going along with a continuum of attractors and a conserved quantity. We expect similar phenomena in coupled FitzHugh-Nagumo elements with a certain disorder in the model parameters and antagonistic couplings as guarantee for a rich attractor space.

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