BP 56: Aging in Physical and Biological Systems (focus session, joint DY/BP)

Physical aging is known from a number of complex systems such as spin glasses or materials like polymer glasses, colloids and gels. On the other hand, biological aging refers to the increase in mortality and the associated loss of functions with age that occurs (almost) universally across the kingdoms of life. This focus session aims to confront these different manifestations of aging in order to identify possible conceptual and methodological interrelations between two largely disjunct fields of research.(Organizers J. Krug and H. Meyer-Ortmanns)

Time: Friday 9:30–12:00 Location: BH-N 334

Invited Talk BP 56.1 Fri 9:30 BH-N 334

Demographic perspectives on the evolution of senescence — •Annette Baudisch — University of Southern Denmark, Campusvej 55, 5230 Odense M

Senescence, the physiological decline that results in decreasing survival and/or reproduction with age, remains one of the most perplexing topics in biology. Most theories attempting to explain the evolution of senescence (i.e. antagonistic pleiotropy, mutation accumulation, disposable soma) were developed several decades ago. Confronted with empirical patterns of survival and reproduction, predictions of the theories do not hold. New theory is needed to shed light on the determinants of patterns of birth and death. At this point it might be feasible and instructive to broaden perspectives by cutting across disciplinary boundaries and seek for a general theory of determinants of birth and death patterns, i.e. life course trajectories, pertaining to animate or inanimate objects on any scale of observation.

Invited Talk BP 56.2 Fri 10:00 BH-N 334

Biological mechanisms of aging — •Björn Schumacher — CECAD Research Center, University of Cologne

The Biology of aging has long been a descriptive research discipline. Only in the past 20 years mechanisms of aging have been uncovered through research in genetic model systems. A number of distinct an interconnected pathways that regulate longevity have been identified. However, the complexity of the aging process remains a challenge to modern aging research. Integration of quantitative data linking the age-dependent accumulation of harmful damage to macromolecules - particularly the genetic material- to the regulation of longevity assurance pathways have begun to unravel a more integrated and complete understanding the biological mechanisms of aging.

Invited Talk BP 56.3 Fri 10:30 BH-N 334

Aging in out-of-equilibrium systems: an overview — •Jean-Philippe Bouchaud — Capital Fund Management, 75007 Paris, France

Aging is a particular type of out-of-equilibrium dynamics that is observed in a variety of systems, from glassy systems to atomic cooling and blinking dots, etc. I will review several distinct mechanisms that can lead to aging, discuss their theoretical underpinning and their experimental relevance.

Invited Talk BP 56.4 Fri 11:00 BH-N 334

Aging in coarsening systems with non-algebraic growth laws — •Michel Pleimling — Virginia Tech, Blacksburg, VA, USA

Physical aging is generically encountered in systems far from equilibrium that evolve with slow dynamics. Well known examples can be found in structural glasses, spin glasses, magnetic systems, and colloids. Recent years have seen major breakthroughs in our understanding of aging processes in non-disordered systems characterized by an algebraic growth of the domains. Progress in understanding aging in systems with more complicated growth laws has been much slower though. After a brief introduction into the phenomenology of aging in simple coarsening systems, I discuss in this talk non-equilibrium relaxation and aging processes in systems characterized by a non-algebraic growth of the ordered domains. Disordered ferromagnets provide interesting examples where the relaxation process is dominated by a slow crossover from an algebraic-like regime at early times to the slower asymptotic growth that prevails for large times. In order to study aging processes deep inside an anomalously slow growth regime we turn to different versions of the ABC model where the biased exchanges of particles of different types yield domains that only grow logarithmically with time.

This work is supported by the US Department of Energy through grant DE-FG02-09ER46613.

BP 56.5 Fri 11:30 BH-N 334

Aging of Classical Oscillators during a Noise-Driven Migration of Oscillator Phases — •Hildegard Meyer-Ortmanns and Florin Ionita — Jacobs University Bremen, 28759 Bremen

We consider classical nonlinear oscillators like rotators and Kuramoto oscillators on hexagonal lattices of small or intermediate size. When the coupling between the elements is repulsive and the bonds are frustrated, we observe coexisting states, each one with its own basin of attraction. For special lattices sizes the multiplicity of stationary states gets extremely rich. When disorder is introduced into the system by additive or multiplicative Gaussian noise, we observe a noise-driven migration of oscillator phases in a rather rough potential landscape. Upon this migration, a multitude of different escape times from one metastable state to the next is generated. Based on these observations, it does not come as a surprise that the set of oscillators shows physical aging. Physical aging is characterized by nonexponential relaxation after a perturbation, breaking of time-translation invariance, and dynamical scaling. When our system of oscillators is quenched from the regime of a unique fixed point toward the regime of multistable limit-cycle solutions, the autocorrelation functions depend on the waiting time after the quench, so that time translation invariance is broken, and dynamical scaling is observed for a certain range of time scales. It is an open question as to whether physical aging as we have studied here, is also responsible for biological aging in these excitable or oscillatory systems in biological realizations.

F. Ionita, H. Meyer-Ortmanns, Phys. Rev. Lett. 112, 094101 (2014).

BP 56.6 Fri 11:45 BH-N 334

Parametrization and interaction analysis of survival curves — Ivan G. Szendro[1], Rahul Marathe[2], Yidong Shen[3], Adam Antebi[3], and •Joachim Krug[1] — [1]Institute for Theoretical Physics, University of Cologne, Germany — [2]Department of Physics, IIT Delhi, India — [3]Max Planck Institute for Biology of Ageing, Cologne, Germany

A key signature of biological aging is the increase of mortality with age. Age-dependent mortality can be extracted from the survival curve, which monitors the surviving fraction of a population of individuals as a function of time. Experiments on longevity-related mutations and interventions in model organisms typically focus on mean life span only, thus neglecting much information contained in the shapes of survival curves. Here we present an exploratory study aimed at parametrizing experimental survival curves obtained for the nematode Caenorhabditis elegans. To this end, we fit survivorship data to models of varying complexity, including the classical Gompertz law as well as models based on reliability theory. We also analyze the multidimensional interactions between different interventions and mutations, using a published data set that contains all combinations of two interventions (dietary restriction and temperature) and two genetic mutations (daf-2 and clk-1).