Leopoldina
Nationale Akademie
der Wissenschaften

NOVA ACTA LEOPOLDINA

Neue Folge | Vorabdruck | Nummer 425

Time in Nature and Culture

Programme and Abstracts of the Lectures held at the Annual Assembly 20th to 21st September 2019 in Halle (Saale)

Published by Jörg Hacker, President of the Leopoldina

German Academy of Natural Scientists Leopoldina–
National Academy of Sciences, Halle (Saale) 2019

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Abhandlungen der Deutschen Akademie der Naturforscher Leopoldina

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Editorial Office: Dr. Michael Kaasch, Dr. Joachim Kaasch and Norman Heenemann

The journal Nova Acta Leopoldina is published by the Wissenschaftliche Verlagsgesellschaft Stuttgart, Birkenwaldstraße 44, 70191 Stuttgart, Germany.

The journal is supported by the Federal Ministry of Education and Research and the Ministry of Economy, Science and Digitalization, Land of Saxony-Anhalt.

Cover: Adobe Stock | Bill45

ML stands for member of the German Academy of Sciences Leopoldina.

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Printed in Germany 2019

Published by Prof. Dr. Dr. h. c. mult. Jörg Hacker,
President of the German National Academy of Sciences Leopoldina
Typesetting: unicom Werbeagentur GmbH
Printing: *Druck-Zuck* GmbH Halle (Saale)
Printed on paper bleached in a chlorine-free process.

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Thanks

We would like to thank the Alfried Krupp von Bohlen und Halbach-Stiftung for generous support to the Annual Assembly.

Alfried Krupp von Bohlen
und Halbach-Stiftung

We would like to thank the Wilhelm and Else Heraeus Foundation for the generous support to implement a program for students which – in collaboration with the Gesellschaft Deutscher Naturforscher und Ärzte (GDNÄ) – allows selected secondary school students to attend the Leopoldina Annual Assembly.

Wilhelm und Else Heraeus Stiftung

We would like to thank the Leopoldina Akademie Freundeskreis e.V. (Friends of the Leopoldina Academy) for financing the Leopoldina Prizes for Junior Scientists.

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FREUNDESKREIS

Programme

The language of the Opening Ceremony is German. Simultaneous translation into English will be provided.

Friday, 20th September 2019

9:00 – 11:00 | Ceremonial Opening

Musical Prelude

Welcoming Speech
Ulla Bonas ML, Halle (Saale)
Vice-President of the Academy

Awarding Prizes

Cothenius-Medal
Carus-Medal
Schleiden-Medal
Mendel-Medal
Leopoldina Prize for Junior Scientists
Georg-Uschmann-Award for the History of Science

Opening Speech
Jörg Hacker ML, Halle (Saale)
President of the Leopoldina

Welcoming Addresses
Thomas Rachel
Parliamentary State Secretary at the
Federal Ministry of Education and Research

Reiner Haseloff
Minister President of Saxony-Anhalt

Keynote Lecture
Freedom of Science and Responsibility for Science
Reinhard Merkel ML, Hamburg

11:00 – 11:30 | Lunch Break

11:30	**|**	**Introduction**
		Jörg Hacker ML *President of the Leopoldina*
		Inaugural Lecture **Life in the Digital Time Machine** *Helga Nowotny, Vienna (Austria)*
12:15 – 14:00	**|**	**Lunch Break**
Session I	**|**	**Time in Physics**
		Moderation: *Gunnar Berg ML, Halle (Saale)*
14:00 – 14:45		**Attoclock and Tunneling Time:** **Time Measurement in Quantum Mechanics** *Ursula Keller ML, Zurich (Switzerland)*
14:45 – 15:30		**Embarking on a Journey through** **Time to the Big Bang** *Felicitas Pauss ML, Geneva (Switzerland)*
15:30 – 16:15		**The Arrow of Time** *Wolfgang P. Schleich ML, Ulm*
16:15 – 16:45	**|**	**Break**
Session II	**|**	**Time in Chemistry and Biology**
		Moderation: *Martin Quack ML, Zurich (Switzerland)*
16:45 – 17:30		**Time and the Origins of Biological Complexity** *Paul P. Rainey, Plön*
17:30 – 18:15		**Multi-Resolution and Timescale Simulation of Biomolecular Systems: A Review of Methodological Issues** *Wilfred F. van Gunsteren, Zurich (Switzerland)*
20:15	**|**	**Evening Lecture**
		Moderation: *Ulla Bonas ML, Halle (Saale)*
		Rhythm, Timing, and Movement: **How the Brain Responds to Musical Rhythm** *Jessica Grahn, London (Ontario, Canada)*

Saturday, 21st September 2019

Session III	**|**	**Philosophy and Psychology**
		Moderation: *Frank Rösler ML, Hamburg*
9:00 – 9:45		**Time in the Head: Rhythms of Speech and Rhythms of the Brain** *David Poeppel, Frankfurt (Main)*
9:45 – 10:30		**Time Philosophy** *Norman Sieroka, Bremen*
10:30 – 11:00	**|**	**Break**
Session IV	**|**	**Time in Mathematics and Mathematics of Time**
		Moderation: *Thomas Lengauer ML, Bonn*
11:00 – 11:45		**Mathematics, Computer Science, and Time** *Martin Grötschel ML, Berlin*
11:45 – 12:30		**Chimaras in Physics and Biology: Synchronization and Desynchronization of Rhythms** *Eckehard Schöll, Berlin*
12:30 – 14:00	**|**	**Lunch Break**
Session V	**|**	**Chronobiology und Chronomedicine**
		Moderation: *Horst-Werner Korf ML, Frankfurt (Main)*
14:00 – 14:45		**Clocks in Translation: Circadian Rhythms in Health and Disease** *Steve A. Kay, Los Angeles (CA, USA)*
14:45 – 15:30		**Light, Sleep and Circadian Interactions: Biology to New Therapeutic Targets** *Russell G. Foster, London (UK)*
15:30 – 16:15		**Chronomedicine** *Charles A. Czeisler, Boston (MA, USA)*

16:15 – 16:45	**|**	**Break**
Session VI	**|**	**Time in Life**
		Moderation: *Regina Riphahn ML, Nuremberg*
16:45 – 17:30		**Global Environmental History of the Industrial Revolution, 1780 – now** *John McNeill, Washington D.C. (USA)*
17:30 – 18:15		**How We Use Time, and Why** *Daniel Hamermesh, Austin (TX, USA)*
18:15 – 19:00		**Time to Live, Time to Die. On the Association between Seasons, Birth, Health, and Death*** *Gabriele Doblhammer, Rostock*
19:00	**|**	**Closing Remarks**
		Thomas Lengauer ML *Member of the Presidium of the Leopoldina*
20:00 – 22:00	**|**	**Conference Dinner** (by separate invitation)

Abstracts of the Presentations

Inaugural Lecture

Helga Nowotny, Vienna (Austria)

Live in the Digital Time Machine

The convergence between abundant data, unprecedented computational power and algorithms trained through Deep Learning boosts the current digital transformation which pervades our societies and economies and upsets the world order. It alters our individual and collective temporalities by radically changing the temporal structures and relationships between humans and machines. The digital time machine(s) currently in the making are based on AI functioning as prediction machines which will make decisions (and data) cheaper and the economy more efficient. But living with and inside prediction machines implies living in a deterministic world, in which time-to-X appears as preformed and automated. Digital time machines are set to deepen further the digital divide, fragmenting societies into parallel worlds with people living in data-rich and data-poor time zones. Life chances will be even more unequally distributed if these time-zones are temporally non-interoperable.

How will the dynamics of digital temporalities unfold seen in the light of co-evolution between humans and machines? Can we infuse a humanistic dimension into the Digital Time Machine, the *Eigenzeit* for the digital age?

Evening Lecture

Jessica Grahn, London (Ontario, Canada)

Rhythm, Timing, and Movement: How the Brain Responds to Musical Rhythm

Moving to music is an instinctive, often involuntary activity, experienced by those in all cultures. The talk will take a neuroscientific perspective on why humans may move to music, and how the brain's movement centers light up in response to music and rhythm, even when we are not moving a muscle. Do those individuals who have trouble moving to the beat still feel compelled to move to it? We will discuss individual variation, and the importance of considering the individual when exploring the exciting potential held by some musical interventions for those with degenerative neurological diseases such as Parkinson's disease.

Session I – Time in Physics

Ursula Keller ML, Zurich (Switzerland)

Attoclock and Tunneling Time: Time Measurements in Quantum Mechanics

How long is a tunnel or an ionization event? While this question sounds simple, one has to clearly define what one means by “how long” or “how fast” to prevent misunderstandings. Tunneling and ionization is inherently a quantum mechanical process, and quantum mechanics gives us statistical or probabilistic descriptions. Therefore, a rate can be easily determined and has a clear meaning. With regards to the specific time delay of a single process there remains a heated debate. With some arguing that because time is not an observable in quantum mechanics such questions are not allowed to be asked. Others, on the other hand, argue that we should simply follow the electron wavepackets, and their group delays will determine the ionization delay. The latter is not always true and can lead to misleading results because there is no “conservation law” for the peak or the center of the wavepacket. The time-dependent Schrödinger Equation (TDSE) in most cases cannot be solved without approximations. Semi-classical models, on the other hand, seem to explain surprisingly well many current attosecond measurements. This talk will review the recent progress in attosecond measurements in quantum mechanics with regards to tunneling and ionization time delays.

Felicitas Pauss ML, Geneva (Switzerland)

Embarking on a Journey through Time to the Big Bang

Our journey through time to the Big Bang – an archaeology of the universe – takes us from the cosmic infinitely large dimensions of our visible universe to the infinitely small dimensions at the very first moments after the Big Bang.

Particle accelerators such as the Large Hadron Collider (LHC) at CERN, located at the Swiss-French border close to Geneva, are super-microscopes that allow us to explore the microcosm. With the LHC we study in-depth the interactions between the basic building blocks of matter. Furthermore, the important questions of new forms of matter and new symmetries can also be investigated. However, the LHC is also a "time machine" that enables us to study the physical laws of the first moments after the Big Bang.

The lecture will shed light on the current status and future prospects of this fascinating research. The connection between basic research and innovation plays just as important a role as the interplay of major international collaborations.

Wolfgang P. Schleich ML, Ulm

The Arrow of Time

Many fundamental equations of physics such as Newton's law of classical mechanics or Maxwell's equations of electrodynamics are time invariant. Indeed, a movie showing a phenomenon from these fields when run backwards will also be consistent with these laws. However, in daily life we feel time always progresses forward, and we cannot travel back into the past. This fact is summarized by the phrase *arrow of time.*

In this talk we present several suggestions for arrows of time and then turn to the Gödel universe. Stimulated by discussions with Albert Einstein the mathematician Kurt Gödel discovered in 1949 an exact cosmological solution of Einstein's field equations of gravitation with closed world lines. Therefore, general relativity does not exclude time travel, and one could in principle go back into one's own past. We use computer animations to illustrate this unusual universe.

Session II – Time in Chemistry and Biology

Paul P. Rainey, Plön

Time and the Origins of Biological Complexity

Life is hierarchically structured, with replicating entities nested within higher order self-replicating structures. Take, for example, multicellular life: the multicellular entity replicates, as do the cells that comprise the organism. Inside cells are mitochondria that also have capacity for autonomous replication; the same is true of chromosomes within the nucleus, and of genes that comprise chromosomes. Such hierarchical structure reflects a series of major evolutionary transitions in which lower order self-replicating entities became subsumed within higher order structures. Crucial for each transition was the establishment of conditions that allowed selection to operate over timescales longer than the replication rate of lower level particles. Giving prominence to often overlooked ecological factors, I will discuss how timescales of relevance to evolution arise, and the impacts of multiple timescales on the evolution of life's complexity, including its hierarchical structure.

Wilfred F. van Gunsteren, Zurich (Switzerland)

Multi-Resolution and Timescale Simulation of Biomolecular Systems: A Review of Methodological Issues

Theoretical-computational modelling with an eye to explaining experimental observations in regard to a particular chemical phenomenon or process requires choices concerning essential degrees of freedom and types of interactions and the generation of a Boltzmann ensemble or trajectories of configurations. Depending on the degrees of freedom that are essential to the process of interest, for example, electronic or nuclear versus atomic, molecular or supramolecular, quantum- or classical-mechanical equations of motion are to be used. In multi-resolution simulation, various levels of resolution, for example, electronic, atomic, supra-atomic or supra-molecular, are combined in one model. This allows an enhancement of the computational efficiency, while maintaining sufficient detail with respect to particular degrees of freedom. The basic challenges and choices with respect to multi-resolution modelling will be reviewed.

Session III – Philosophy and Psychology

David Poeppel, Frankfurt (Main)

Time in the Head: Rhythms of Speech and Rhythms of the Brain

Music is rhythmic (this is clear to everyone), speech is rhythmic (a little less apparent) – and the brain is also rhythmic (practically unknown). New neurobiological and psychological research shows that the temporal structure of language and music as well as the temporal organization of different brain structures and processes are systematically coordinated. The role that brain rhythms – neuronal oscillations – play in perception and recognition is explained by experimental studies using various methods. A selection of intuitively simple, entertaining and surprising results shows how the temporal structure underlies such perceptual experiences. From recognizing speech and melodies to building abstract mental representations, cognitive neuroscience reveals how neurobiological mechanisms provide different temporal building blocks for cognition.

Norman Sieroka, Bremen

Time Philosophy

Time is a fundamental dimension for humans, independently of whether they are considered primarily as biological-physical or as mindful beings. Accordingly, a broad range of academic disciplines investigates questions about time in its different manifestations: as physical time, as geologic or deep time, as individually experienced or psychological time, as socio-intersubjective time, as historical time, etc. However, the commonalities, differences, and connections between these manifestations are rarely discussed. At this point, philosophy can take on an important coordination task; and this is exactly what the present lecture is meant to illustrate. Starting from a few conceptual distinctions – most importantly that between different basic types of time order – individual aspects from some of the other lectures will be revisited and related to each other. This also provides insights into the relationship between questions of a more scientific and theoretical nature, such as the directedness of physical time or questions of chronobiology, and questions of social and ethical concern, such as transitional justice or specific forms of chronopolitics. It turns out that significant differences in attitudes and over disciplines often go hand in hand with a difference in how one thinks about the existence of the three different modalities of time – that is, whether or to what extent one assumes that the past and the future exist alongside the present.

Session IV – Time in Mathematics and Mathematics of Time

Martin Grötschel ML, Berlin

Mathematics, Computer Science, and Time

In 1908 Hermann Minkowski, introducing his lecture "Space and Time" on the revolutionary concept of spacetime, formed one of the most poetic sentences, which can be found in mathematical and natural-science literature:

"Henceforth, space by itself, and time for itself, are doomed to fade away into mere shadows, and only a kind of union of the two will preserve an independent reality."

Today, the approach is more sober – time is simply regarded as a variable, which has to be taken into account in the mathematical modelling of processes in nature, technology, or society. Mathematics and computer science do not ask what time actually is. The focus is pragmatic and lies on the interdependency between time and other variables. Whether time is considered continuous or discrete, depends on the respective application. Today, the issue "runtime" (of computer algorithms) plays an increasingly important role, especially in computer science. Terms such as *online algorithms* and *real time* have meanwhile found their way into everyday language. In my lecture, I will look into the aspects of time indicated above in a generally understandable manner.

Eckehard Schöll, Berlin

Chimeras in Physics and Biology: Synchronization and Desynchronization of Rhythms

Rhythms influence our life in various ways, e.g., through heart beat and respiration, oscillating brain currents, life cycles and seasons, clocks and metronomes, pulsating lasers, transmission of data packets, and many others. The physics of complex nonlinear systems has developed methods to describe and analyse periodic oscillations and their synchronization in complex networks, which are composed of many components. Synchronized oscillations as well as completely asynchronous chaotic oscillations play a major role in many networks in nature and technology. For instance, the synchronous firing of all neurons in the brain represents a pathological state, like in epilepsy or Parkinson's disease, and should be suppressed, as well as the synchronous mechanical vibration of bridges. On the other hand, synchronization is desirable for the stable operation of power grids or in encrypted communication with chaotic signals. In networks composed of identical components, intriguing hybrid states ("chimeras") may form spontaneously, which consist of spatially coexisting synchronized and desynchronized domains, i.e., seemingly incongruous parts. This might be of relevance in inducing and terminating epileptic seizures, or in unihemispheric sleep which is found in certain migratory birds and mammals, or in cascading failures of the power grid.

Session V – Chronobiology and Chronomedicine

Steve A. Kay, Los Angeles (CA, USA)

Clocks in Translation: Circadian Rhythms in Health and Disease

Our laboratory studies the composition and architecture of circadian networks in plants and animals. These networks provide adaptive advantages to organisms and are now known to be pervasive in their integration with many other regulatory modules in multiple cell types. We employ high throughput genomic and chemical biology pipelines to identify network components and apply mechanistic approaches to understand their detailed function and interactions. In both plant and animal systems, we have found that circadian networks are hierarchical and composed of regulatory layers that act at the transcriptional and post-transcriptional levels. Increasingly we are finding that circadian regulation is tightly integrated with metabolic networks and operate with reciprocal regulatory interactions.

Now that we have a reasonably robust knowledge base at hand, we can exploit our understanding of the composition and dynamics of clock proteins for specific translational use in agricultural biotechnology in crop species and drug discovery in humans. Specific examples of such knowledge translation will be presented.

Russell G. Foster, London (UK)

Light, Sleep and Circadian Interactions: Biology to New Therapeutic Targets

By studying how circadian rhythms and sleep are regulated (entrained) by the dawn/dusk cycle we demonstrated the existence of a “3rd class” of photoreceptor within the eye and showed that these new photoreceptors comprise a small number of photosensitive retinal ganglion cells (pRGCs) that utilize the blue light sensitive photopigment melanopsin (OPN4). Whilst there has been remarkable progress in understanding the complex intracellular mechanisms that generate circadian rhythms, the molecular pathways whereby the pRGCs entrain circadian biology has remained poorly understood.

The suprachiasmatic nuclei (SCN) are the site of the primary circadian pacemakers within the mammalian brain, and until recently, the model for entrainment involved a simple linear pathway whereby glutamate release from the pRGCs resulted

in Ca^{2+} influx and raised intracellular cAMP in SCN neurones. This in-turn resulted in CREB phosphorylation leading to increased transcription of two key clock genes, *Per1* and *Per2*, which either advanced or delayed the molecular clockwork. However, an important feature of entrainment is that circadian responses to light are limited – as typified by jet lag. Full recovery from jet lag requires a day for every time-zone crossed. We addressed this issue and have identified and characterized a key role for Salt Inducible Kinase 1 (SIK1) and the CREB-regulated transcription co-activator 1 (CRTC1) in clock re-setting. In addition, our more recent and unpublished findings have shown that light entrainment also involves the parallel activation of a Ca^{2+}-ERK1/2-AP-1 signaling pathway. Thus, both CRE and AP-1 regulatory elements drive light-induced clock gene expression.

These findings then led to a new understanding of how sleep/wake behavior modulates the effects of light upon the molecular clockwork. Adenosine builds within the brain during wake and dissipates during sleep, effectively encoding sleep/wake history. Pharmacological and genetic approaches demonstrated that adenosine also acts upon the circadian clockwork via A_1/A_{2A} signaling through the activation of the Ca^{2+}-ERK1/2-AP1 and CREB/CRTC1-CRE signaling pathways to regulate the clock genes *Per1* and *Per2*. We show that these signaling pathways converge upon and effectively inhibit the same pathways activated by light. Thus, the resulting phase shift of the circadian clock is the integrated product of sleep/wake history (via adenosine) and light.

Finally, the presentation will explore how such signaling mechanisms provide a potentially new and exciting target for the regulation of circadian rhythms and the "pharmacological" replacement of light for sleep/wake re-setting in individuals lacking eyes or in individuals with severe circadian rhythm disruption as seen in schizophrenia and dementia.

Charles A. Czeisler, Boston (MA, USA)

Chronomedicine

No abstract available.

Session VI – Time in Live

John McNeill, Washington D.C. (USA)

Global Environmental History of the Industrial Revolution, 1780 – now

This lecture explores the ecological impacts upon Asia, Africa and the Americas of mobilizing ever larger quantities of ores, fibers, and lubricants, among other materials required in industrialization. It introduces the concept of ecological teleconnections' as a way to understand the relationship between industrialization in Britain, Europe, and eastern North America and the lands and peoples that supplied lead, tin, copper, wool, cotton, leather, whale oil, palm oil, gutta-percha, ivory, and dozens of other materials taken more or less directly from the natural world. It also suggests the concept of ecological teleconnections in time as well as in space, using the example of carbon dioxide concentrations in the atmosphere and climate change.

Daniel Hamermesh, Austin (TX, USA)

How We Use Time, and Why

Economists have done immense amounts of research on work time; but they have done very little research on how time is spent outside of paid work. With non-work time accounting for 20 hours each day for the average adult in Western economies, this neglect is remarkable. Using data from the US, France, Germany and the UK, this lecture examines how time is divided among various activities, including sleep and television-watching, the first and third most important uses of time. It shows how all of these uses differ among demographic groups and studies the effects of economic incentives – income and wage rates – on them. It examines how time zones affect our spending of time; it demonstrates how the stress that people feel about time is affected by their economic circumstances. It concludes by considering how changes in economic policy can lead people to alter their activities in order to generate a less stressful life in which time is balanced more evenly over their lives.

Gabriele Doblhammer, Rostock

Time to Live, Time to Die.
On the Association between Seasons, Birth, Health, and Death

Health and mortality are determined by the interplay between nature and nurture. During the last 150 years this interplay has resulted in an ever increasing life expectancy and more active years in good health. How can this interplay be imagined? Seasonal variations influence not only the number of births, but also health from birth on, as well as the timing of death. The number of births differs by seasons, albeit in Germany the seasonal pattern has changed over the last decades. To what extent cultural patterns and/or biological factors are responsible is still lively debated. The risk of suffering from diabetes, chronic cardio-vascular diseases, and dementias depends on the month of birth, which is also true for life expectancy at old age. The pattern differs between the northern and the southern hemisphere and is still present among centenarians. Seasonal patterns in infections and diet are discussed as possible causes. Mortality depends on ambient air temperature, and extreme weather constellations result in mortality peaks. Improvements in public health, medical care, care provision, and a healthy life style can modify and counterbalance external influences by “nature”. Still they have the capacity to affect our health and life expectancy.

Venue

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