Time	Symposium 100 Years Nobel Prize for Albert Einstein Abstracts
10.15 – 11.00	**100 years ago: Nobel Prize for Physics goes to Albert Einstein** *Hans Rudolf Ott, ETH Zürich* Within a few months in the first half of the *annus mirabilis* 1905, Einstein submitted 3 articles to the Annalen der Physik. In retrospect each one of them had the quality to justify a nomination for the Nobel Prize in Physics, annually awarded by the Royal Swedish Academy since 1901. For various reasons it took more than 15 years until Einstein was chosen to be a recipient of this prestigious award. First, the scientific background of his light quantum hypothesis that resulted in the formulation of the *law of the photoelectric effect* for which he actually was honoured, is briefly reviewed. It is followed by remembering some of the highlights of his scientific career up to 1921. Considering the current flawless procedure of the prize reception, the circumstances under which he eventually received the insignia of the prize were quite unusual and deserve to be recalled. Finally some insight concerning the financial aspects of the prize and their impact on Einstein's private life will be provided.
11:00 – 11:30	**From Einstein's explanation of the photoeffect to high-resolution spectroscopy of matter** *Jürg Osterwalder, Universität Zürich* Experiments at the end of the 19th century showed that UV light can eject electrons from solid surfaces into vacuum. A puzzling observation was that the intensity of the light determines the number of emitted electrons but not their velocity. Einstein's revolutionary concept of light quanta solved this problem and allowed him to make predictions about the kinetic energy of the emitted electrons that were later confirmed experimentally by Millikan. While the first electron spectrometer was demonstrated as early as 1914, applications of photoelectron spectroscopy for studying electronic properties of matter began only in the second half of the 20th century. They evolved separately along two lines, x-ray photoelectron spectroscopy (XPS) for the study of core levels and ultraviolet photoelectron spectroscopy (UPS) for valence band studies. The former has developed into a widely used method for chemical surface analysis, while the latter has been extended into a most powerful method for the mapping of energy bands and the study of manybody effects in solids. The availability of new types of light sources and vast improvements of electron spectrometers have brought amazing progress in recent years. An overview will be given about the latest developments, including several variants of these spectroscopies.
11:30 - 12:00	**Integrated devices for controlling light by electrons** *Rachel Grange, ETH Zürich* Nonlinear and electro-optic devices are present in our daily life with many applications: light sources for eye surgery, green laser pointers, or modulators for telecommunication. They mainly use bulk materials such as glass fibres or crystals, hardly integrable due to low signal and difficult fabrication. Here I will show several strategies to enhance optical signals by engineering metal-oxides at the nanoscale with the goal of developing nonlinear and electro-optic photonics devices for a broad spectral range and over large surface area. We use metal-oxides such as barium titanate and lithium niobate as a platform for integrated photonics. I will present innovative fabrication approaches of metal-oxides materials that are very different from standard semiconductors or metals. Recently, we developed a waveguide Fourier transform spectrometer. We achieved a much broader bandwidth than typical commercial systems by using the electro-optic effect in lithium niobate. This concept of compact, broadband spectrometer without any moving parts is of interest for applications where flexibility and versatility are key, like in spaceborne spectroscopy, remote sensing or integration in mobile devices.
12:00 – 13:00	Lunch
13:00 – 13:45	**"Light quanta" – how was this concept & mental model understood since 1905?** *Klaus Hentschel, Universität Stuttgart* What happened after Einstein published his paper on the photoelectric effect (the only one he ever called "revolutionary") in 1905? The early reception of his new concept of "light quanta" was highly critical, even from those who normally supported Einstein. For example, Planck who tried everything to minimize the conflict with classical electrodynamics, v. Laue or Lorentz who opposed light quanta with reference to interference phenomena indicating an extended, non-pointlike structure of light. Experimentalists such as Millikan or Compton had their own, misleadingly naïve understanding of light quanta as "light atoms" or "bullets" and the only supporter early on was Johannes Stark who later became Einstein's severest antisemitic critic. Einstein himself intensely searched for a clear understanding of what light quanta are. In 1951 he admitted that fifty years of searching had not brought him any closer to any deeper understanding. I will compare different mental models of light quanta since 1905, or "photons" as they have been usually called since 1926.
13:45 – 14:30	**Single photons, entangled photon pairs and optimal cloning of qubits** *Nicolas Gisin, Université de Genève* Single photons and entangled photon pairs are todays routinely produced in many labs all around the world. Both single-photons and entangled photon pairs can be used to violate some Bell inequality, thus demonstrating the non-local character of quantum physics that Einstein accused of "spooky action at a distance". Einstein was worried that quantum non-locality was, on the one hand side, reintroducing Newton's gravitation non-locality into physics, and, on the other side, allowing for arbitrarily fast signaling, hence violating his beloved relativity theory. Today, the quantum information community understands that these legitimate worries are circumvented by, first, the randomness of the outcomes of quantum measurements, i.e. by non-local randomness, and, secondly, by the impossibility of perfectly cloning quantum states. Interestingly, optimal quantum cloning lies precisely at the limit imposed by no signaling, i.e. no spooky action at a distance. Moreover, optimal quantum cloning relates exactly to Einstein's A and B coefficients of spontaneous and stimulated emissions. It would be fascinating to ask Einstein what he thinks of today's understanding of his worries and whether he would, today, accept quantum non-locality?

14:30 – 15:15	**New frontier in physics: time in quantum mechanics** *Ursula Keller, ETH Zürich* With progress towards ever shorter laser pulses we have developed many different pump-probe techniques to access fast dynamics with the time resolution approximately given by the duration of the laser pulse. With the discovery and understanding of high-harmonic generation (HHG) we were able to move into the attosecond domain. The orbital period of an electron in ground-state hydrogen in Bohr's model amounts to 150 as. The attosecond is therefore the typical time scale for electronic motion on an atomic scale in quantum mechanics. We have invented the attoclock as an alternative measurement technique with attosecond time resolution to address very fundamental questions in quantum mechanics such as tunneling time, time delays between electrons in double ionization, and momentum transfer to photoelectron in multi-photon ionization. For example quantum tunneling time is a highly debated topic – we explain why. We discuss the attoclock technique to extract tunneling delays with regards to the typical approximations such as the dipole approximation, non-adiabatic effects, photoelectron momenta at the tunnel exit, electron correlation and exit coordinate. We can confirm that the He attoclock measurement is in agreement with two theoretical predictions: the Larmor time, and the probability distribution of tunneling times constructed using a Feynman Path Integral (FPI) formulation. Still there is an ongoing debate and we are in the process of building up an attoclock experiment with atomic hydrogen.
15:15 – 15:45	**Coffee Break**
15:45 – 16:15	**From light to electricity: New materials in electronics** *Natalie Banerji, Universität Bern* Organic conjugated materials have many favourable properties that make them interesting for a variety of electronic applications. The aim of my group is to understand the fundamental processes underlying their functionality. We use ultrafast spectroscopic techniques, such as transient absorption (TA) and time-domain terahertz (TD-THz) spectroscopies, to investigate charge carriers in organic semiconductors. While femtosecond TA measurements bring insights to the nature and evolution of the photoexcited species, we use TD-THz spectroscopy to gain information about the charge transport properties on the nanoscale. After presenting an overview of our experimental techniques, I will show results about charge generation in highly efficient solar cell materials based on organic polymer:non-fullerene blends. The photophysical properties of doped organic semiconductors are then discussed, as well as their applications to bioelectronic devices such as organic electrochemical transistors (OECTs). Finally, ways to explore ultrafast spectroscopy to study such devices in situ are presented.
16:15 – 16:45	**When the photoeffect becomes destructive: Lasers as tools in material processing** *Thomas Feurer, Universität Bern* When light is incident on a metal surface, electrons are emitted from (or within) the material. This phenomenon is called external (or internal) photoelectric effect. The internal photoelectric effect is relevant for the working of solar panels, but in case of high power photon sources can become destructive and is used for material processing. The physical processes associated to the redistribution of the energy added to the material via the internal photoelectric effect are diverse and strongly correlated. For instance, light-matter interaction becomes nonlinear, heat conduction competes with a sequence of phase transitions, ultimately resulting in material ejection, and hydrodynamic instabilities in the liquid phase of the material strongly influence the quality of material processing. All of these processes happen on similar time scales and make a formal description difficult. During the talk I will elaborate on these phenomena and show that a clever combination of analytical and numerical models can correctly describe such processes, is in agreement with experiments, is accurate enough to guide process and machine design, and can be used to train machine learning algorithms.
16:45 – 17:15	**High precision tests of QED** *Aldo Antognini, ETH Zürich und PSI Villigen* Laser spectroscopy is a powerful technique that allows precise measurements of atomic transitions. In this talk we focus on laser spectroscopy of muonic atoms, hydrogen-like atomic systems formed by a negative muon and a nucleus. Because the muon mass is 200 times larger than the electron mass, the atomic wave-functions of muonic atoms are strongly overlapping with the nucleus. The resulting sensitivity of the 2S-2P energy splitting in muonic atoms to nuclear structure effects has been recently exploited to extract precise values of the proton, deuteron and He-nucleus charge radii. These radii serve as benchmarks for modern approaches to the internal structure of these nuclei that still remains challenging despite the several decades of investigations. Moreover, the precise values of these radii open the way for highly accurate comparison between theory and experiments in the most simple "atomic" system such as H, He, HD^+ and He^+ leading to bound-state QED (quantum-electrodynamics) tests to an unprecedented level of accuracy. Because QED is the relativistic quantum field theory of electrodynamics, a precisions test of bound-state QED automatically implies a precision test of relativity and a precision test of photon-charged-particles interaction, both at the core of Einstein's legacy.
17:15	***END***