Public Symposium:
Louis de Broglie: 100 years of wave / particle dualism
& Public Lecture

Monday, 09.09.2024, Room ETA F 5

Time	ID	**LOUIS DE BROGLIE:** **100 YEARS OF WAVE / PARTICLE DUALISM** *Chair: Teresa Montaruli, Université de Genève*
14:30	6	**Matter and Light: Louis de Broglie and our current understanding of physics** *Friedrich-Karl Thielemann, Universität Basel and GSI Helmholtz Center for Heavy Ion Research; Darmstadt* Today's understanding of physics is not possible without the concept of quantum mechanics, but how did it all come about? Light had been understood in terms of waves since Huygen's wave interpretation in 1690 (and Fresnel's extension in 1818), but Planck (in 1900) and Einstein (in 1905) postulated particle behaviors (photons), where the frequency or wavelength of photons was related to their energy or momentum, confirmed by Compton's experiments in the early 1920s. The Bohr model of the atom (1913) still considered electrons as particles, but with quantized angular momentum. In 1924 de Broglie introduced the theory of electron waves, before understood as particles, and proposed (more generally) that particles are wave packets which move with group velocity, having an effective mass. Following de Broglie's proposal, leading to the wave-particle duality of electrons, modern quantum mechanics was born when in 1925 Werner Heisenberg, Max Born and Pascal Jordan developed matrix mechanics and Erwin Schrödinger invented wave mechanics as solutions of the Schrödinger equation in 1926. From the wider acceptance at the Fifth Solvay Conference in 1927 to further refinements and unified formalizations by David Hilbert, Paul Dirac, and John von Neumann until1930 only a few years had passed. Bohr won the Nobel prize in 1922, de Broglie in 1929, Heisenberg in 1932, Schrödinger in 1933, followed by many other quantum physicists since then. My colleagues in this symposium will discuss modern research and advances in this field, I focus on the role of de Broglie, a few main aspects and the history behind it.
		Chair: Johan Chang, Universität Zürich
15:15	7	**Waves of Quantum Matter** *Tilman Esslinger, ETH Zürich* The wave nature of matter materializes in interference experiments with Bose-Einstein condensates. Correspondingly, the particle nature can be made observable by detecting individual atoms. Yet, it is the interactions between the atoms and between atoms and light that give rise to intriguing phenomena and a multitude of phases, including superfluid, supersolid, Mott-insulating and topological phases. I will provide a perspective on quantum gas experiments and show how we can synthetically create quantum many-body systems with tailored interactions and topology. I will highlight recent experiments in which we investigate the interplay between non-trivial topologies and strong interactions.
16:00		***Coffee Break***

Time	ID	*Chair: Michel Calame, Empa & Universität Basel*
16:30	**8**	**Wave-particle duality in atom interferometers: precision measurements at the quantum limit** *Philipp Treutlein, Universität Basel* Atom interferometers are among the most precise measurement devices for inertial forces, electromagnetic fields and fundamental interactions. Their working principle is a beautiful embodiment of deBroglie's wave-particle duality of matter: while the wave nature of atoms gives rise to interference of the different paths through the interferometer, their particle nature gives rise to fundamental quantum noise in the detection of the resulting interference pattern. For uncorrelated atoms, this results in the so-called standard quantum limit of interferometric measurement, which is reached by today's best instruments. Surprisingly, another quantum phenomenon - entanglement - can be harnessed to overcome this limit. I will give an overview of the operating principle, applications and fundamental quantum limits of atom interferometers and show how we can use many-particle entangled states to improve their sensitivity, which promises significant advances for science and technology.
		Chair: Christof Fattinger
17:15	**9**	**Single electron imaging vs. coherent electron beam diffraction: Optimization of image contrast in cryo-electron microscopy** *Henning Stahlberg, Laboratory of Biological Electron Microscopy, EPFL and University of Lausanne* Cryo-transmission electron microscopy (cryo-EM) or tomography (cryo-ET) of frozen hydrated specimens is an efficient technique for analyzing the structure of proteins or tissue sections. However, both methods face challenges due to their very low signal-to-noise ratio. Efforts to enhance their efficacy focus on minimizing the initial damage caused by the electron beam on the sample and maximizing the recovery of phase contrast signal from electrons interacting with the sample. We are exploring whether employing stroboscopic imaging with individual electrons passing through the sample at precise nanosecond intervals could potentially reduce damage for a cryo-EM sample compared to a similarly intense barrage of electrons arriving randomly, a concept previously proposed for samples at room temperature. We are further advancing convergent beam electron diffraction with a probe aberration-corrected Titan Krios and an ultra-fast pixelated detector (4D-STEM), evaluating the data with ptychography and other data analysis methods, in order to maximize phase contrast signal recovery from a frozen hydrated cryo-EM specimen. Progress in these two approaches will be presented.
18:00		***END, Break***
		Public Lecture *Chair: Lukas Gallmann, ETH Zürich*
18:30	**10**	**The route to attosecond pulses** *Anne l'Huillier, Lund University Sweden, Nobel Laureate 2023* When an intense laser interacts with a gas of atoms, high-order harmonics are generated. In the time domain, this radiation forms a train of extremely short light pulses, of the order of 100 attoseconds. Attosecond pulses allow the study of the dynamics of electrons in atoms and molecules, using pump-probe techniques. This presentation will highlight some of the key steps of the field of attosecond science.
19:45		***END***