Abstracts of talks for the history of science conference,
One hundred years of the Bohr atom,
Tuesday 11 to Friday 14 June 2013.
Alphabetically by names of speakers.

Finn Aaserud, Niels Bohr Archive, Denmark

Love and physics: Margrethe Nørlund and Niels Bohr's creativity, 1910−1913

Niels Bohr and Margrethe Nørlund were engaged in August 1910, less than a year before Bohr completed his doctoral work. He then went to Cambridge and Manchester to continue his studies with J.J. Thomson and Ernest Rutherford, respectively. Niels and Margrethe married on Niels's return to Copenhagen in August 1912. Bohr's stay in England was an immensely creative period in his life, as confirmed by the intensive correspondence with his fiancée, who stayed behind in Denmark. The letters shed new light on this crucial period of Bohr's career. They document the importance not only of Margrethe, but also of his family in Denmark, for Bohr's early development as a scientist and human being.

Theodore Arabatzis and **Despina Ioannidou**, University of Athens, Greece

The role of analogies in the development of the Bohr atom

Analogies are widely used in the development of scientific models and theories. Modern scholarship on analogy takes as its point of departure the work of Mary Hesse. Hesse pointed out the existence of negative analogies between two different physical systems, that is, those respects in which the two systems clearly differ. However, she underappreciated the role of negative analogies in model-building.

In our presentation we will stress the significance of negative analogy in the development of Bohr’s atom. We will argue that it was the negative, rather than the positive, analogy between intra-atomic electrons and the constituents of a planetary system that motivated Bohr to adopt and develop Rutherford’s atomic model. The development of the negative analogy led to the conclusion that the electron could move only in certain discrete orbits and its energy and angular momentum were accordingly restricted. Furthermore, the analogy between planets and revolving electrons played a significant role in Bohr’s subsequent articulation of the model. On the one hand, the positive analogy suggested that electrons (like planets) revolved around the center of mass of the atom (solar system). On the other hand, the extremely high speed of electrons (unlike that of planets) suggested that relativity be brought into the picture.

Luis Boya, University of Zaragoza, Spain

Arnold Sommerfeld and Niels Bohr: comparison of the schools at Munich and Copenhagen at the time of the Old Quantum Theory

A comparative study is presented of the two main centres in which the Old Quantum Theory, 1913–1925, was developed: the Munich school with A. Sommerfeld and the Copenhagen school with N. Bohr. The later was mainly based in the correspondence principle, the second on application of strict mathematical quantization rules; the comparison covers several items, including selection rules for forbidden lines.

Enric Pérez Canals and **Blai Pie Valls**, University of Barcelona, Spain

Ehrenfest's adiabatic hypothesis in Bohr's quantum theory

It is widely known that Paul Ehrenfest formulated and applied his adiabatic hypothesis in the early 1910's. Niels Bohr, in his first attempt to construct a quantum theory in 1916, used it for fundamental purposes in a paper which he decided not to publish after having received the new results by Sommerfeld in Munich. Two years later, Bohr published *On the Quantum Theory of Line Spectra*. There, the adiabatic hypothesis played an important role, although it appeared with another name: the *principle of mechanical transformability*. In subsequent variations of his theory, Bohr never suppressed this principle completely; in the final version before the rise of Quantum Mechanics, in a paper of 1924, it was called *principle of the existence and permanence of the quantum numbers*.

In our paper we will describe and analyze the role of Ehrenfest's principle in the work of Bohr, before the emergence of Quantum Mechanics. We will also consider how Ehrenfest faced Bohr's uses of his most celebrated contribution to quantum theory, as well as its wide distribution after Bohr's intervention.

N.D. Hari Dass, Chennai Mathematical Institute; CQIQC, IISc, India

The Superposition Principle in Quantum Mechanics – did the rock enter the foundation surreptitiously?

The superposition principle forms the backbone of Quantum Theory. The resulting linear structure of quantum theory is structurally so rigid that tampering with it has serious, seemingly unphysical, consequences. This principle has also met the stringent tests at the highest available accelerator energies. Is this aspect of quantum theory forever then ?

The present work is an attempt to understand the attitude of the founding fathers towards this principle. It appears as if they accepted it without debating to the same excruciating degree as they did many interpretational aspects.

As a first attempt, I am looking carefully into the proceedings of the 1927 Solvay Meeting. In my talk I shall present these aspects along with some speculations about possible ways of escaping linearity.

Jeroen van Dongen, Utrecht University, Holland

Communicating the Heisenberg relations: Niels Bohr and the forgotten Einstein-Rupp experiments

In 1926, Albert Einstein collaborated with Emil Rupp on a set of experiments that were to probe the wave versus particle nature of light. The experiments have now been forgotten, even though their history is quite surprising: after it was established that Rupp had committed fraud, they have been eradicated from the collective memory of the physics community. Niels Bohr is one of the physicists who was closely following the development of these experiments, and proposed his own interpretation of them to Einstein using Heisenberg's new relations; yet, he would not mention them in his later reminiscenses on discussions with Einstein. In this talk, I will discuss the Einstein-Rupp experiments, their interpretationby Bohr and their role in the discussions between Bohr and Einstein.

Anthony Duncan, University of Pittsburgh and **Michel Janssen**, University of Minnesota, U.S.A.

Stark contrasts between the old and the new quantum theory

We compare the treatments of the Stark effect in hydrogen in the old and the new quantum theory as given by Kramers in his 1919 dissertation and by Schrödinger in the third of his 1926 papers on wave mechanics, respectively. The two derivations are very similar, reflecting the close connection between the Schrödinger equation and the classical Hamilton-Jacobi equation central to the old quantum theory. Yet there are also important differences. In addition to the Bohr-Sommerfeld quantum conditions, the old quantum theory requires some artificial and physically not well motivated further restrictions on which orbits and which transitions between orbits are allowed. In wave mechanics, the quantum conditions emerge naturally and there is no need for any further special assumptions. We investigate which elements of the old quantum theory survived in the transition to the new quantum theory and which elements did not.

Michael Eckert, Deutsches Museum, Germany

Extending Bohr: Sommerfeld's early atomic theory, 1913-1916

Arnold Sommerfeld's response to Bohr's atomic model is reviewed from the perspective of Sommerfeld's personal research agenda. He admired Bohr's derivation of the Rydberg formula for hydrogen but was otherwise critical about the model. In 1913, Sommerfeld attempted to explain the recently discovered Paschen-Back-effect by generalizing Lorentz's classical theory of the Zeeman effect. The discovery of the splitting of spectral lines in an electric field (Stark effect) entered his agenda as another challenge. In both cases the classical approaches finally failed, so that Sommerfeld resorted to Bohr's model as an alternative. He extended Bohr's model by quantizing both the azimutal and radial motion of the electron around the nucleus. In the non-relativistic case he recovered Bohr's Rydberg formula (now with a sum of two quantum numbers instead of a single one as in Bohr's model); in the relativistic case he obtained what became known as the fine-structure-formula. Although the development from the Bohr- to the Bohr-Sommerfeld-theory has been the subject of detailed historical accounts, the dynamics of this process appears in a new light when described mainly from the perspective of Sommerfeld's private and professional correspondence.

Ernst Peter Fischer, Heidelberg, Germany

A Romantic Understanding of Atoms: Bohr's success in a new perspective

Bohr´s conception of an atom contains elements that philosophers refer to as romantic and this will come as a surprise for scientists. For the romantics who responded to the ideas of enlightment around 1800 there is no structure of things. For them there is only a field of action. The potential is considered more real than the actual and romantic scientists generate their own vision of the universe and its constituents exactly as artists create a piece of art. A romantic can mould things as he likes and they come into being as a result of his artistic activity. Romantics are opposed to any view which tries to represent reality as having some kind of form which can be studied, written down and communicated to others. From the romantic point of view Nature has to be given a form to be understood. If one adds all this up it becomes obvious that Bohr´s atom is a romantic creation something that should be taken into account when writing the history of science.

Karl Grandin, Royal Academy of Science, Sweden

Niels Bohr as seen from a Swedish perspective

Niels Bohr made several crucial contributions to the development of physics in the 20th century, not only through his scientific publications but also through establishing the important environment for international collaboration at the institute at Blegdamsvej. In this talk I will investigate Bohr's activities from a Scandinavian perspective, especially Bohr as seen from the Swedish perspective. Besides all his other important activities Bohr took an active interest throughout his career in the local promotion of the physical sciences. Bohr as seen from a Swedish perspective might then not only satisfy the local historical interest in the matter, but also add elements to the understanding of Bohr's work by taking the Scandinavian connection into consideration. There is a story from the Second Scandinavian Congress of Mathematicians in Copenhagen in 1911, when the Swedish theoretical physicist C.W. Oseen came into contact with Niels Bohr and subsequently supported Bohr in obtaining a professorship and discussing how to strengthen physics in Denmark and Sweden. Later on Bohr was even offered to become a member of the physics Nobel committee. The Scandinavian element is even more pronounced after the war through for instance discussions of the peaceful uses of nuclear energy with the Swedish Prime Minister Tage Erlander and the establishment of Nordita.

Thiago Hartz and **Olival Freire Jr**., Federal University of Bahia, Brazil

Uses and appropriations of Niels Bohr's ideas about quantum field measurements (1935–1965)

Niels Bohr and Léon Rosenfeld published in 1933 a renowned article showing the consistency of the quantum theory of the electromagnetic field. This article was largely analyzed in the history of science literature; however, this literature broadly fails in noticing the existence, between 1935 and 1965, of many debates occurred outside Copenhagen which were completely influenced by Bohr's 1933 ideas.

In our work, we analyze two of these debates. The first one, happened in 1938, was triggered by Matvei Bronstein and Jacques Solomon's attempts to extend Bohr's ideas to the gravitation field case. The resistance they found was related to the legitimacy of Bohr's approach to quantum field theory. On the other hand, the second debate, happened in 1962, at a moment when Bohr's ideas were already firmly established, was a dispute about the appropriation of Bohr's ideas by Bryce DeWitt and other young physicists, and Rosenfeld's reaction in defense of Bohr's original purposes. In these debates, there were uses, defenses, criticisms, and appropriations of Bohr's ideas, and there was no general agreement. Thus, controversies were engendered. In describing and analyzing them we are interested in outlining the large influence of Bohr's ideas in the history of quantum field theory.

PUBLIC LECTURE LAUNCHING THE CONFERENCE

J.L. Heilbron, emeritus professor of history at the University of California, Berkeley

“My courage is ablaze so wildly”: Niels Bohr en route to his quantum atom

Among Einstein’s reactions to Bohr’s quantum atom was amazement at the courage of the young man who put it forward. Material from the Bohr family archives soon to be published indicates the psychological source of his courage and the support system that maintained it. Of special value are the many letters to his fiancée, Margrethe Nørlund, dating from Bohr’s postdoctoral sojourn in England in 1911/12, during which he began his struggle to quantize Rutherford’s nuclear model. The new material also helps to explain why Bohr felt it desirable, and even necessary, to ground the quantum condition defining his atom in four conflicting ways. The explanation invokes considerations outside of physics and invites a deeper inquiry into Bohr’s unusual mental makeup.

Dieter Hoffmann, Max Planck Institute for History of Science, Germany

The relationship between Niels Bohr and Max Planck

For Niels Bohr Max Planck was not only “the scientist who has created the foundation on which we all are working”, but also a man, “who has always shown [me] warm friendship”. Both were for Bohr “one of the richest sources of pleasure und encouragement” during his whole life. The personal relationship between Bohr and Planck started just after WWI, when Bohr congratulated his Berlin colleague for winning the Nobel prize, and lasted until Planck’s death in 1947.Their discussions focused less upon specific scientific problems than upon a wide range of general questions, in particular the procedure by which the Planck Medal was awarded. The talk will give a detailed description of the relations between these two pioneers of quantum theory, embedded in the scientific and social developments of the times.

Giora Hon, University of Haifa, Israel, and **Bernard R. Goldstein**, University of Pittsburgh, U.S.A.

Constitution, Structure, System, and Model: Imagining the Atom – An Early Twentieth-Century Story

We focus on Niels Bohr's use of the term "model" in 1913. The title of his trilogy, "On the Constitution of Atoms and Molecules", contrasts with that of Ernest Rutherford's experimental paper of 1911, "The Scattering of alpha and beta Particles by Matter and the Structure of the Atom", and that of Joseph J. Thomson's theoretical paper of 1904, "On the Structure of the Atom." Yet, in the very opening paragraph of his trilogy, Bohr identified what he called Rutherford's theory with an "atom-model". We ask, how does this usage differ from previous usages of model and other similar terms such as those that were invoked by Joseph Larmor ("model", 1900), Jean Perrin ("constitution", and "hypothèse", 1901), Ludwig Boltzmann (essay on "model", 1902), Lord Kelvin ("model", 1904), Hantaro Nagaoka ("system", and "mechanical analogy", 1904)? We compare these usages with those of leading physicists in the late nineteenth century. The historical evidence indicates that Bohr's usage in 1913 was unusual at the time (and unexplained), but his invocation of model had far-reaching consequences for the introduction of modeling into science in general and physics in particular. We examine the different usages of "constitution", "structure", "system", and "model" in describing the atom, and consider their philosophical presuppositions.

Martin Jähnert, Max Planck Institute for the History of Science, Berlin.

The Correspondence Principle in Practice: Its Spread and Use in the Old Quantum Theory

Writing to Arnold Sommerfeld in 1922 Niels Bohr complained that: „[i]n the last years […] my attempts to develop the principles of quantum theory […] were met with very little understanding.“ Looking for the correspondence principle as one of these principles in papers submitted by physicists outside of Copenhagen, one finds indeed that prior to 1922 physicists made little use of Bohr's idea. From 1922 onwards, however, the principle dispersed into the wider networks of quantum theory. Physicists in research centers in Europe and the US started to incorporate Bohr's principle into their work and used the principle in different ways, sometimes far removed from Bohr's use of it in atomic spectroscopy.

In my talk I will discuss how physicists suddenly became interested in this idea, which Bohr's writings had been promoting publicly since 1918. I will show how they came to an understanding of the correspondence principle in its core elements, while introducing it to new research fields and developing it in different directions depending on their research strategies. I will study this process by looking in particular at the work of James Franck and Friedrich Hund on the Ramsauer effect in 1922, which shows the complex interrelation of the developing understanding of a new phenomenon and the use of the correspondence idea in a new conceptual context.

Shaul Katzir, Tel Aviv University, Israel

Manchester at war: Rutherford, Bohr, submarine detection and atomic spectra

In October 1914 Bohr arrived for a second long stay in England, this time as a reader in Rutherford's physics department at Manchester University. While Bohr continued with his theoretic research on the atom, Rutherford had to virtually stop his experimental research on the subject. Instead he dedicated his time for searching means to detect submarines. With former (British) students he carried out classified research in a water tank at the basement of the physics building. Bohr, a neutral citizen, could hardly miss the war research, but did not participate. He, rather, formed a bridge between Rutherford and German scientists informing the former about developments in the study of the atom. Using Rutherford's classified correspondence, I will discuss his work during Bohr's two years tenure in Manchester, Bohr's role at the place, and Rutherford's ambivalence towards the war research. On the one hand he regretted that British scientists could not devote their "attention to the pure science problems." On the other he acknowledged the potential contribution of scientists to the war effort, and helped in their mobilization.

Henrik Knudsen, University of Aarhus, Denmark

Pursuing common cultural ideals: Niels Bohr, neutrality, and international scientific collaboration during the inter-war period

During the 1920s Niels Bohr's new institute of theoretical physics in Copenhagen rose to prominence as an international center of excellence attracting many of the finest talents from the new generation of young physicists. The talk addresses Bohr's ideals and ideas about international scientific collaboration, and links them to the internationalist policy of science and culture that was cultivated and spearheaded by the Danish government and the country's social-liberal intellectual elite in the wake of the First World War. This new policy of science was institutionalized in 1919 with the creation the Rask-Ørsted Foundation and carefully designed to help bridge the emerging cultural divide between the victors and losers of the war and to rebuild the traditions of international scientific collaboration. Bohr's attempts to counter the totalitarian threats of the 1930's by interpreting the cultural and intellectual history of Denmark on the basis of these internationalist cultural ideals are also discussed. Parallels are drawn between these efforts to construct an anti-totalitarian, open-minded, and pluralist cultural-political identity and Bohr's own successful practice as a transnational institution builder.

Helge Kragh, University of Aarhus, Denmark

The Many Faces of the Bohr Atom

The atomic model that Bohr proposed in 1913 constituted a break with all earlier models of the atom. Keeping to the theory's basic postulates, he conceived the model as preliminary and immediately began developing and modifying it. Strictly speaking there was no "Bohr atom" but rather a series of different models sharing some common features. There is a great deal of difference between the 1913 Bohr "pancake model," the 1922 many-quantum orbital model, and the more symbolic and unvisualizable 1924 model associated with the Bohr–Kramers–Slater theory. I shall pay particular attention to the second of these models which Bohr ambitiously used in describing the electron configurations of all elements in the periodic table. It is still something of a mystery how he arrived at these configurations and how seriously he took the model as a realistic picture of the atom.

Michiyo Nakane, Kawasaki, Japan

Bohr's Introduction to Action-Angle Variables in a 1918 Paper

Action-angle variables provide one of the most important mathematical techniques for quantum theory. These variables originated in Charlier's books on celestial mechanics published in 1902 and 1907. Charlier performed a canonical transformation defined by a particular generating function and attained new canonical variables constructed by angle variables and action integrals. Noting Charlier's argument, Schwarzschild defined action-angle variables and used them for an explanation of Stark effects in 1916. However, he did not present action variables in the form of $I_i=\int p_i dq_i$, but he noted variables that have the same dimension as the action integrals that construct canonical variables together with angle variables, $\omega_i=n_i t+\beta_i$, where t is time, n_i is the mean motion, and β_i is the initial value of the angle. In a 1918 paper entitled "On the Quantum Theory of Line-Spectra," Bohr mentioned that Kramers showed him a way to make I_i and ω_i canonical conjugates. An origin of formation of action-angle variables that we find in textbooks of mechanics today first appeared here. Then, Bohr developed his idea of a conditionally periodic system using the action variables I_i.

Michael Nauenberg, University of California, Santa Cruz

What happened to the Bohr-Sommerfeld elliptic orbits in Schrödinger's wave mechanics?

No abstract as yet provided.

Jaume Navarro, University of the Basque Country, Spain

Plum puddings and Bohr's atom

Folk history of science speaks about a plum pudding atomic *model*, formulated by J.J. Thomson with the use of his corpuscles (electrons), which was largely abandoned after Ernest Rutherford's experiments and Niels Bohr's quantum atom. In this paper I explore two related issues: to what extent should we understand Thomson's views as a *model* for the atom, and what happened with this *model* in the years after 1913. I will argue that J.J. Thomson did not formulate a consistent atomic *model* with electrons as the main building block, since his views on electricity, matter and radiation always relied on what he called "Faraday tubes". These consisted of ether vortical tubes whose properties were meant to explain the mass and electrification of the corpuscles and of the atoms. They also became the physical structures underpinning any explanation of quantum phenomena like atomic spectra, the emission of light and, later on, in the late 1920s, electron diffraction. Thus, the only *model* he consistently defended were these Faraday tubes rather than a plum pudding atom.

Kristian H. Nielsen, University of Aarhus, Denmark

The Bohr atom bound in cloth: comparing popular books about atomic physics in Germany, Britain, and Denmark, 1918−1927

The rise of quantum theory in the early decades of the twentieth century sparked numerous popular books, all of which presented in words, and a few in images, new scientific ideas about the structure of the atom to the general public. In Germany, physicists Leo Gratz and Arnold Sommerfeld published Die Atomtheorie (1918) and Atombau und Spektrallinien (1919), respectively; US physicist and inventor Albert Crehore criticized Bohr's theory in his The Atom (1919); British physicist Edward Andrade and Norman Robert Campbell in separate books elucidated The Structure of the Atom (both 1923); and in Denmark popular science writer Helge Holst and Dutch physicist Hendrik A. Kramers co-authored a book about Bohr's theory of the atom (1922) that was later translated into English, German, Spanish, and Dutch. This paper compares these and other contemporary "atomic books" with respect to their cultural context, publication history, authorship, intended readers, analogies used to explain in words the new atomic physics, and iconography. It will be argued that these books served a range of purposes from plain popularisation to scientific contemplation.

Gábor Palló, Budapest University of Technology and Economics, Hungary

The Bohr model's early reception in Hungary: Hevesy and Bohr

The Bohr model arrived in Budapest very soon, in November 1913, almost simultaneously with the publication of the last paper of Bohr's trilogy. This fast reception is not unique as we can learn from Helge Kragh's study on the British and German case. Hungary, however, did not excel with front line researches in the field of atomic structure. The later famous nuclear physicists like Leo Szilard, Eugene Wigner or Edward Teller were still too young to contribute to the reception of the Bohr model. The main actor of the reception was George Hevesy, Bohr's friend and colleague. Their close relation explains that Hevesy understood Bohr's theory in statu nascendi. Besides speaking about the Bohr – Hevesy relationship, the paper tries to provide a picture on the open mindedness of a traditionally thinking peripheral scientific community that faced with disturbing new ideas and gave impetus to young people who became successful some decades later.

Peter Robertson, University of Melbourne, Australia

Birthplace of a New Physics – The Early History of the Niels Bohr Institute

The foundation in 1921 of the Niels Bohr Institute in Copenhagen was to prove an important event in the birth of modern physics. From its modest beginnings as a small three-storey building and a handful of physicists, the Institute underwent a rapid expansion over the following years. Under Bohr's leadership, the Institute provided the principal centre for the emergence of quantum mechanics and a new understanding of Nature at the atomic level. Over sixty physicists from 17 countries came to collaborate with the Danish physicists at the Institute during its first decade. The Bohr Institute was the first truly international centre in physics and, indeed, one of the first in any area of science. The Institute provided a striking demonstration of the value of international cooperation in science and it inspired the later development of similar centres elsewhere in Europe and the United States. In this talk I will discuss the origins and early development of the Institute and examine the reasons why it became such an important centre in the development of modern physics.

Robert Rynasiewicz, Johns Hopkins University, U.S.A.

The(?) Correspondence Principle

One finds, even in texts by distinguished physicists, diverse enunciations of the correspondence principle. Typical is that quantum mechanics should agree with classical mechanics in some appropriate limit. Most commonly, the limit specified is that of high quantum numbers, or of large masses and orbits of large dimensions. But sometimes it is specified as mean behavior when large numbers quanta are involved, or sometimes even as just the average of quantum mechanical variables. Sometimes, the principle is even taken as a prescription for replacing each classical dynamical observable with an appropriate mathematical operator. In 1918, however, Bohr proposed what he would later call the correspondence principle as a way of deriving amplitudes and polarizations of emitted and absorbed spectral lines. I will begin with Bohr's principle and trace the evolution of correspondence considerations through the 1920's, with a view as to whether in each case it is supposed to play the role of a theorem, an adequacy constraint, an inductive hypothesis or a heuristic.

Arne Schirrmacher, Humboldt University, Germany

Models at an Exhibition. The Planetary Atom on Display in Europe and What this Meant for Science

As far as it is known, Bohr himself only produced more or less schematic drawings of his atomic model, which can be found in his notes, letters and manuscripts or which have been produced for him to be used in his lectures. Others, however, in particular in Germany and Britain built real three-dimensional physical models, which found their way into prominent museums and big exhibitions. My talks reconstructs the trajectories Bohr's ideas took in disciplinary and popular spaces and analyzes the motivations for physicists like Arnold Sommerfeld, Wolfgang Pauli, Lawrence Henry Bragg or Douglas Hartree to step out of modest theory into proposals of atomic iconography. Unlike later objects that were directly manufactured for schools or museums the early physical wood-and-brass interpretations were part of a process of scientific reflection and interpretation of Bohr's atomic model, and a epistemological means to extend his findings in order to explain problems like shape, bonding and stability of atoms and molecules. In this way they represented procedures of approximation, computational strategies as well as descriptive vocabulary in the same way as they provided a popular image of modern physics. This peculiar spell they exerted on many viewers, even physicists could not evade. Lawrence Bragg noted on a visit of Bohr at the London Science Museum in 1946, where models of the early 1920s were still on display, that he “even found Bohr himself gazing at them in a fascinated way ...”

Shan Gao, University of Sydney, Australia and Chinese Academy of Sciences, China

How do electrons move in atoms? − From the Bohr model to quantum mechanics

Niels Bohr proposed what is now called the Bohr model of the atom in 1913. He suggested that electrons are particles and they undergo two kinds of motion in atoms; they either move continuously around the nucleus in certain stationary orbits or discontinuously jump between these orbits. The Bohr model was latterly replaced by quantum mechanics, in which the physical state of an electron is described by a wave function. What, then, does the wave function truly represent? Exactly what are electrons? And how do they move in atoms? In this talk, I will show that a deep analysis of protective measurements and the mass and charge distributions of a single quantum system may provide the answers. It turns out that microscopic particles such as electrons are indeed particles, while their motion is not continuous but essentially discontinuous and random, displaying wave-like behavior. Moreover, the wave function represents the state of random discontinuous motion of particles, and in particular, the modulus square of the wave function gives the objective probability density of the particles being in certain locations. In some sense, this new picture of quantum reality can be regarded as a certain extension of Bohr's discontinuous quantum jumps.

Brigitte Van Tiggelen, Catholic University of Louvain, Belgium, and **Annette Lykknes**, Norwegian University of Science and Technology, Norway

Ida Noddack and the fission proposal: the actor's perspective

The establishment of Bohr's atomic model changed the way the Periodic Table of Elements was used, in particular when it comes to the search and the discovery of missing elements, which is the context within which the discovery of fission took place. When in 1934 Ida Noddack suggested the possibility that the nucleus might break up into several large fragments during nuclear reactions, she was commenting Enrico Fermi's claim of having produced element 93 by bombarding uranium with slow neutrons. Her criticism and suggestion however went unnoticed

The case only resurfaced in history of science several decades later and the fact that Ida Noddack's proposal was ignored has been interpreted in a wide variety of frameworks: gender, politics, disciplinary boundaries between chemistry and physics, authority loss, prematurity in scientific discovery etc. Some of these interpretations have failed to provide the context and the expertise on which Ida Noddack relied when criticizing the way new elements were allegedly produced, yielding sometimes anachronistic claims she never made herself. In this paper we draw on previously unused archival material to provide the actors' perspective. Among others, we will contrast the views of Meitner and Noddack on matter, the periodic table, and the manufacture of missing elements.

Henrik Zinkernagel, University of Granada, Spain

Are we living in a quantum world? Bohr and quantum fundamentalism

Quantum fundamentalism is the view according to which everything in the universe (if not even the universe as a whole) is fundamentally quantum and ultimately describable in quantum mechanical terms. Bohr's conception of quantum mechanics has historically been seen as opposed to such a view – not least because of his insistence on the necessity of classical concepts in the account of quantum phenomena. Recently, however, a consensus seems to be emerging among careful commentators on Bohr to the effect that he – after all – did subscribe to some version of quantum fundamentalism. Against this consensus, I will defend a variant of the more traditional reading of Bohr in which the answer to what an object is (quantum or classical) depends on the experimental context. Inspired by Bohr, I will moreover sketch some principal problems for quantum fundamentalism in contemporary physics and philosophy.