CHAPTER 4.3

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

*Gábor Palló**

Abstract

The Bohr model arrived in Budapest very early, in November 1913 almost simultaneously with the publication of the last paper of Bohr's trilogy. This fast reception was not unique but Hungary did not excel with front line researches in the field of atomic structure. 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 in the reception was George Hevesy, Bohr's Hungarian friend and colleague. Instead of research programs, a special genre, philosophical reflections on science provided context for the reception. This context interpreted the Bohr atom differently from the research context.

Key words: Bohr atom; Georg von Hevesy; science in Hungary; philosophical reflections.

SCI.DAN.M. I · ONE HUNDRED YEARS OF THE BOHR ATOM: PROCEEDINGS FROM A CONFERENCE
THE ROYAL DANISH ACADEMY OF SCIENCES AND LETTERS · 2015

The Bohr atom was first mentioned and explained publicly in a lecture in November, 1913 in Hungary. This took place almost simultaneously with the appearance of the last part of Bohr's trilogy, "On

* Budapest University of Technology and Economics, Visual Learning Lab. E-mail: gabor.pallo@ella.hu.

the Constitution of Atoms and Molecules." According to the printed version, the lecture provided a state-of-the-art report, including X-ray spectroscopy, the Geiger-Marsden experiment, the nucleus, and Rutherford's planetary model and its stability problem. This problem was solved by Bohr on the basis of the quantum hypothesis which also explained various spectroscopic results and the periodic system.[1]

As we can learn from Helge Kragh, among others, Bohr discussed his ideas with some colleagues, like Rutherford, Ehrenfest or Sommerfeld earlier in 1913. But as a public reaction to Bohr's ideas, the lecture in Budapest seems to be one of the earliest.[2] This was a public event rather than a discourse of esoteric specialists.

The scientific community of Budapest was not known as a center of research on atomic structure; in fact, it was peripheral. Hence, the Budapest reception might show another side of Bohr's atomic model than that seen by specialist experts.

1. George Hevesy in 1913

The speaker was a twenty-eight-year old chemist, Hevesy György, or as he became known in international science, Georg von Hevesy or George de Hevesy. About a year before his Budapest talk, in 1912, he had met Bohr in Rutherford's Manchester laboratory and they became friends. Previously, Hevesy worked in electrochemistry and inorganic chemistry. In Manchester he learned to handle short half-life radioactive materials and he learned about all the exciting ideas born there, including the structure of the atom and the problem of placing radioactive elements in the periodic system. He often discussed all these matters with Bohr, who, according to Hevesy's account, devised his main ideas in 1912. The writing took a year for Bohr.[3] Yet, in a letter dated from Budapest on 15 January 1913 Heve-

1. The lecture was delivered in the session of the Mathematical Physical Society in November 1913, but its text was published somewhat later: Hevesy (1914) and (1915).

2. Kragh (2012).

3. Kuhn, Segré, and Heilbron (1963).

sy asked Bohr about the questionable stability of Rutherford's atomic model.[4] In his reply on February 7, Bohr explained his basic ideas concerning the structure of atoms.[5] "Taking Planck's theory of radiation into account," Bohr wrote that "we can in a simple way get an answer of our questions" and he summarized his views on the volume of atoms in relation to the chemical bond, the interpretation of the periodic system, his "hope of a detailed understanding of what we may call the 'chemical and physical' properties of matter" and some other points, but without any technical details and much physical argumentation that could be incomprehensible to a chemist.

All these appeared fully convincing to Hevesy, who became one of the early supporters of the Bohr atom. It helped him interpret his research subject related to the periodic system. In 1913 Hevesy was extremely busy. He established close contact with the well-equipped Viennese Radium Institute, in particular with the director, Stefan Meyer, and Fritz Paneth, a physical chemist of Hevesy's age. Hevesy worked hard on the exploration of the physicochemical and electrochemical properties of radioactive elements, such Actinium, Polonium, Thorium-D, Radium D, E, F, Ionium, and on their chemical separation. He took part in establishing the displacement law, and speculated about the radioelements' places in the periodic table. Gradually, he came to the conclusion together with others, like Fleck, Russell, Darwin and Soddy, that some radioactive elements are chemically inseparable from each other. Relying on inseparability, Hevesy and Paneth worked out the radioactive indicator method in 1913.[6] Hevesy, however, did not work in spectroscopy.

He lived in Budapest, started to work at the University of Budapest, and recruited some collaborators, like Elisabeth Rona, Laszlo Zechmeister and Gyula Gróh. He habilitated to become *Privatdozent*

4. Hevesy wrote Bohr: "Lately I have studied Rutherford's atomic model, in particular its handling the problem of stability and noticed the difficulties in case of heavy atoms compared with light atoms, such as H atom that contains one electron only." Hevesy to Bohr, 15 January 1913. Niels Bohr Archive (NBA), Niels Bohr Scientific Correspondence.

5. Bohr to Hevesy, 7 February 1913. NBA. George Hevesy Scientific Correspondence.

6. Paneth and Hevesy (1913).

of chemistry in early 1913 with a lecture titled "The features of electron and the constitution of the atom," published in a Hungarian chemical journal.[7] In this text among many other things Hevesy wrote about Rutherford's model but did not mention Bohr's theory, which he only mentioned later in 1913.

Meanwhile, Hevesy commuted between Budapest and Vienna to enjoy the favourable research conditions and to collaborate with Paneth. Their voluminous correspondence shows that Hevesy circulated Bohr's idea in Austria also. In August 1913, Hevesy thanked Paneth for informing Paneth's boss, Stephan Meyer, about the system of Bohr.[8] In September, after meeting Einstein in Austria, Hevesy sent the often cited letter to Rutherford about his conversation with Einstein, who said that "this is an enormous achievement. The theory of Bohr must be then wright [*sic*]."[9] Hevesy was an early propagator of the Bohr atom.

2. Problematic reception: Research

Based on the early presence of the Bohr atom, it could be assumed that science was very lively in Hungary in the early 20th century. This period brought up an extremely successful generation of scientists, including George Hevesy and his later assistant at the Budapest University, physical chemist Michael Polanyi. The younger generation, such as Eugene Wigner, John von Neumann, Leo Szilard, Edward Teller, and others who later in their life contributed significantly to various parts of physics related to or originated in the Bohr atom. They were, however, mere high school students in 1913. It could be supposed that science was as lively in Budapest as music, producing Bartok, philosophy, producing Lukács and Mannhe-

7. Hevesy (1913).

8. In German: „Ich denke dir dass du Prof. Meyer über das Bohrsche System informiert hast." Hevesy to Paneth, 11 August 1913. This correspondence is stored in Berlin: Fritz Paneth Papers, Archiv zur Geschichte der Max-Planck-Gesellschaft, Berlin-Dahlem. I am grateful to Siegfried Niese for generously presenting me with copies.

9. Hevesy to Bohr 23 September, 1913. NBA George Hevesy Scientific Correspondence.

im, or the internationally less well-known poetry. This is why Bohr's model found its way to the local researchers very soon after its creation.

However, this was not the case. The early presence of the Bohr atom in the Hungarian press does not mean that it immediately became part of the local research programs. The audience for Hevesy's lectures and articles obtained information about the Bohr model, but there is no sign of any reaction to it, not to mention any influence on research or teaching in the next couple of years, including the First World War and the subsequent radical political events. The sociological and cognitive context might explain the neutrality of researchers.[10]

In principle, the Bohr atom could be received both by the physics and the chemistry community. However, the small group of physicists was dominated by Loránd Eötvös who was sixty five, head of department since 1878. For several decades he concentrated on the extremely precise measurement of the gravitation constant and his assistants had to help him in this. A notable exception was Győző Zemplén, who was expelled to the Technical University, the only other university in Budapest. Zemplén worked in thermodynamics and published results concerning the theory of shock waves. Unlike Eötvös' group, Zemplén was open to the latest results of physics, including radioactivity, the theory of relativity, and the quantum hypothesis. Although he did not do any research related to these subjects, he wrote about them in his popular articles. He did not, however, write about Bohr's theory.

Because of the research subjects of this community, the Bohr model and atomic structure in general were not relevant. Researches in spectroscopy started in the 1930s at the Technical University.

On the other hand, the chemistry community organized a small radioactivity institute. It was connected to the II. Institute of Chemistry, headed by the sixty-nine years old Béla Lengyel, who died in 1913. As a student of Robert Bunsen, Lengyel used the spectroscope

10. The historical contetxt, the history of institutions and activities of the scientists mentioned in this section are detailed in Szabadváry and Szőkefalvi-Nagy (1972) and in Palló (1992).

as a device in his work in analytical chemistry, without engaging in the physical theory of spectroscopy.

His relationship with radioactivity was similar. Lengyel was the first doing research in radioactivity in Hungary in the last years of the 1890s, but the radioactivity institute was directed by his adjunct, Gyula Weszelszky. Lengyel's institute worked in inorganic chemistry and chemical analysis. Radioactivity seemed to them a new property that helped them to find new chemical components in the local ores and water of springs and in Lake Balaton. They worked out measurement methods, and constructed devices for measurements, but they did not immerse themselves in the relevant theoretical complexity of the phenomena. This was a natural historical research program, which aimed to map and to describe local surroundings, to which the Bohr atom did not seem to add new perspectives. Hevesy could have established a connection between this group and the front line of researches, but he had no contact with the radioactivity institute.

Hevesy worked at the III Institute of Chemistry, which was under organization by Gusztáv Buchböck, a physical chemist and disciple of Wilhelm Ostwald and Walter Nernst. This was the first institution of physical chemistry in Hungary. The forty-four years old Buchböck was a specialist of reaction kinetics, ion hydration and electrochemistry, but without any connection to the subject of atomic structure. As a relatively young person, he was thought to be open-minded, and he was friendly and supportive of Hevesy, a young expert in electrochemistry. Some years later, Buchböck successfully nominated Hevesy to be appointed to a full professorship.

In short, neither in physics nor in chemistry could research provide any context for the reception of the Bohr model because the subjects and the approaches avoided the theoretical issues that Bohr touched upon.

3. Natural philosophy

There was, however, another genre of scientific literature that did in fact provide context to the reception of the Bohr model. This was the writings of scientists and science writers on large historical and philosophical issues related to their fields. This cannot be called popular science, because the aim was not to provide information about some results in a non-technical simplified way to a non-professional audience. The authors of this genre did not use strict philosophical or scientific language and argumentation; rather they provided their own reflections on the state of the wide area of their interest. Many journals in Hungary published natural philosophical articles in Hungary and other European countries, including professional periodicals and the journals that spoke to a wider, educated audience.

In Hungary, the authors were mostly recruited among university and high school teachers, but many articles of this type were translations of texts published in foreign, mostly German, journals.

Many natural philosophical articles addressed the issue of "matter." They spoke about the origin of matter, primordial matter, changes of matter, atomism, Prout's hypothesis, the electron, the new alchemy and so on. Some of them connected matter with radiations, like X-rays, radioactive rays, N-rays and other mysterious radiations. The existence of atoms was also a recurrent subject. New scientific results often enlarged the framework. The decaying atom, the structure of the atom, and the changing chemical elements belonged to the subject.

The pattern was exemplified by Ödön Székely's article, titled "Newer theories about the structure and evolution of matter".[11] The paper started with atoms and molecules as building blocks of matter. The electron was even smaller; it did not have mass, only electromagnetic features. Then followed cathode rays, X-rays, and radioactive rays, proving that matter tends to dematerialize. The investigation of uranium, thorium and actinium showed the decay of matter. Referring to the popular French amateur physicist, Gustave Le Bon, Székely explained that ether and matter were two extreme poles in the world. Atoms consised of electric vibrations and they were also little solar systems – concluded Székely without referring to Rutherford.

This narrative provided context for the Bohr atom. Matter could

11. Székely (1913).

be shown as distributed unevenly in the universe, exhibiting a particular structure that was manifested in the large solar systems and in the construction of the atom. In this approach the Sun corresponded to the nucleus, while the planets to the electrons. Hence, in the late 1910s Rutherford's model attracted more interest in this literature than the Bohr atom which appeared to be a somewhat refined variant of the Rutherford model without changing its essence.

Hevesy's lecture, delivered in 1913, can be considered as a popularization, i.e., a simplified and confident summary of scientific results, including the Bohr atom, although he started with the statement that atoms exist and they are not the smallest particles. By 1916, however, he found his way to the natural philosophical genre.[12] In a paper, Hevesy discussed the changing meaning of the term "chemical element". He started with Boyle's and Dalton's terms, and showed the difficulties caused by the phenomena of isotopy, changes of elements, the displacement law, X-ray spectroscopy and the problem of placing the elements in the periodic system . Based on the Rutherford-Bohr model, "chemical element" needed a clear definition that helped to interpret these phenomena. Hevesy suggested accepting Fritz Paneth's views, published in a philosophical study on "element," saying that an "element" is a chemically indivisible body.[13]

Hevesy disseminated Bohr's ideas in several talks in various scientific societies without any sign of intellectual resistance of his audience.

In 1915 and 1917, another author, Jenő Mende, a high school teacher, referred to the "Rutherford-Bohr" model in popular science articles without a detailed explanation, and by the 1920s the Bohr atom became an often-occurring item both in popular science and in the reflective philosophical genre.[14]

12. Hevesy (1916).

13. Paneth (1916). Paneth published a seminal philosophical paper on the issue of chemical elements: Paneth (1931). English translation as Paneth (1962). This study is part of the current debates in the philosophy of chemistry. See in particular the writings of Eric Scerri (2007).

14. Mende (1915). Mende (1917).

4. Conclusions

The Bohr model provided coherent picture of a number of theoretical problems emerging in various research laboratories, related mainly to spectroscopy and the interpretation of the periodic system. However, to a community or a culture that was not committed to these subjects, the Bohr atom might say something else than to those communities that were engaged in the related subjects. The Hungarian researcher groups both in physics and chemistry belonged to the former type. The appearance of the Bohr model was slow because of the fervent local research interest in non-related subjects, even though George Hevesy, a collaborator and friend of Bohr, happened to work in Budapest in 1913 and informed the local community about the developments in this field. This information, however, did not turn the Hungarian research programs toward Bohr's theoretical problems.

The reinterpretation of Bohr's model occurred in another genre, the historical and philosophical reflection on scientific fields. This kind of writings was widespread in the non-specialist scientific literature. It absorbed the Bohr atom without any resistance. In these articles, the Bohr model was embedded into a different context from its original scientific one. The articles painted large pictures about the universe, in which the new atomic model interestingly resembled to the solar system. Hence, writers used the expression "Rutherford-Bohr" model. From their viewpoint, Bohr only a little bit modified Rutherford's exciting macrocosmos – microcosmos idea, revealing the fundamental structure of the universe. The usage of quantum might appear a technical detail of secondary importance.[15] By this the Bohr atom received a metaphysical significance instead of a physical one and this metaphysics pointed to the harmony of the universe, in which small things worked the same way as large things.

15. These conclusions are in harmony with Arne Schirrmacher's views related to the reception of the Bohr model, see Schirrmacher (2009).

People liked to talk about these issues in the Budapest coffee houses. The fast developing city loved modernity: electric lights, the telephone, car, X-ray, radium, Freud, and relativity. The planetary atomic model was one of these incomprehensible wonders.

BIBLIOGRAPHY

Hevesy, György (1913). "Az elektron tulajdonságai és az atom konstitucziója." *Magyar Chemiai Folyóirat* 19, 53-59, 69-74, 88-94.

Hevesy, György (1914). "Az atómok szerkezetéről. I." (About the structure of atoms.) *Mathematikai és Physikai Lapok* 23, 192-207.

Hevesy, György (1915). "Az atómok szerkezetéről. II." *Mathematikai és Physikai Lapok* 24, 1-16.

Hevesy, György (1916). "Az elem fogalma az újabb kutatások fényében." (The concept of element in the light of new researches.) *Magyar Chemiai Folyóirat* 22, 145-148.

Kragh, Helge (2012). *Niels Bohr and the Quantum Atom: The Bohr Model of Atomic Structure 1913-1925.* Oxford: Oxford University Press.

Kuhn, Thomas, Emilio G. Segré, and John L. Heilbron (1963). Interview with Dr. Georg von Hevesy at Hevesy's apartment, Stockholm, Sweden, 4 February. <http://www.aip.org/history/ohilist/4670_2.html> Downloaded: May 15, 2013.

Mende, Jenő (1915). "Radioactiv eredetű hydrogen." (Hydrogen produced by radioactivity). *Uránia* 16, 426-427.

Mende, Jenő (1917). "Röntgen sugarak interferenciája szabálytalanul elhelyezkedő részecskéken."(X-rays interference on irregularly placed particles.) *Természettudományi Közlöny* 49, 186-187.

Palló, Gábor (1992). *Radioaktivitás és a Kémiai Atomelmélet: Az Anyagszerkezeti Nézetek Válsága a Magyarországi Kémiában.* Budapest: Akadémiai Kiadó.

Paneth, Friedrich (1916). "Über den Element-und Atombegriff in Chemie und Radiologie." *Zeitschrift für physikalische Chemie* 91, 171-198.

Paneth, Friedrich (1931). "Die erkenntnistheoretische Stellung des chemischen Elementbegriffs." *Schriften der Königsberger Gelehrten Gesellschaft, Naturwissen-schaftliche Klasse* 8, Heft 4, 101-125.

Paneth, Friedrich (1962). "The epistemological status of the chemical concept of element." Parts I and II, translated by H. R. Paneth [Heinz Post] in *British Journal for the Philosophy of Science* 13, 1-14, 144-160.

Paneth, Fritz and George Hevesy (1913). "Über Radioelemente als Indikatoren in der analytischen Chemie." *Mitteilungen aus dem Institute für Radiumforschung*, no. 43.

Scerri, Eric (2007). *The Story of the Periodic System: Its Development and Its Significance.* New York: Oxford University Press.

Schirrmacher, Arne (2009). "Bohr's atomic model." 58-61 in Daniel Greenberger, Klaus Hentschel, and Friedel Weinert, eds., *Compendium of Quantum Physics. Concepts, Experiments, History and Philosoph.* Berlin, Heidelberg: Springer-Verlag,.

Szabadváry, Ferenc and Szőkefalvi-Nagy Zoltán (1972). *A Kémia Története Magyarországon.* Budapest: Akadémiai Kiadó.

Székely Ödön (1913). "Újabb elméletek az anyag szerkezetéről és fejlődéséről." (Recent theories on the structure and evolution of matter.) *Magyar Mérnök- és Építészegylet Közlönye* 47, 560-563.