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Editors

The Rudolf Mössbauer Story

His Scientific Work and Its Impact on Science and History

Springer

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ISBN 978-3-642-17951-8 e-ISBN 978-3-642-17952-5
DOI 10.1007/978-3-642-17952-5
Springer Heidelberg Dordrecht London New York

Library of Congress Control Number: 2011944215

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Rudolf Mössbauer

Dedicated in sincere gratitude to our colleague and friend Rudolf Mössbauer.

Foreword

Before the Second World War, Göttingen and Berlin were the German hubs of physics. Munich also had a very good reputation for physics, thanks to Conrad Röntgen and Max von Laue, and this was enhanced by Arnold Sommerfeld's famous school, from which a number of Nobel Laureates emerged. Munich had also had an excellent reputation for chemistry for a long time. In 1875, Adolf von Baeyer was appointed to Munich as the successor to Justus von Liebig, although to the sister university. Nevertheless, it was the appointment of scientists such as Liebig and von Baeyer to Munich which turned Munich into a Mecca for chemistry alongside Heidelberg and later Berlin.

Our university, then still known as the "Technische Hochschule München," excelled in the decades before the Second World War, primarily thanks to its chemistry. Two Nobel Laureates held professorships here – the organic chemists Heinrich Otto Wieland and Hans Fischer. This proud tradition continued with the awarding of Nobel Prizes to the metal-organics chemist Ernst Otto Fischer (1973) and the biochemist Robert Huber (1988).

After 1945, science in Germany stood on the threshold of a new beginning. Munich succeeded in attracting important physicists, including such illustrious names as Werner Heisenberg and Heinz Maier-Leibnitz. Outstanding scientists also helped the physics at the TH München in achieving an international reputation. The Professor for Technical Physics, Walther Meissner, carried out pioneering work in low temperature research and in 1946 – only 1 year after the war ended – he set up a commission of the Bavarian Academy of Sciences and Humanities with associated research institute. This is where "magnetic flux quantization" was observed for the first time. The Walther Meissner Institute for Low Temperature Research has maintained its close links with the TUM's physics department to this day.

Heinz Maier-Leibnitz, who was appointed Meissner's successor in 1952, was a student and colleague of the Nobel Laureates James Franck and Walther Bothe. In the USA, he was able to acquire crucial experience. Maier-Leibnitz introduced a new, promising discipline to the Institute for Technical Physics at our university: Applied nuclear physics. In 1957, he was also able to start up the first research reactor at a German university in Garching. Consequently, his Institute had an excellent research and experimental facility for nuclear physics, neutron physics, and solid state physics at its disposal.

Maier-Leibnitz gave his diploma and doctoral students topics which led to the development of measuring methods. He tried to apply these new methods to a wide range of research fields. Improvisation was required, given the limited equipment at his Institute. The students had to work in cramped laboratory space, share measurement equipment with each other, and even build it themselves in many cases.

One of the most gifted of Maier-Leibnitz' students was Rudolf Mössbauer, who was born in Munich in 1929. Like many of his contemporaries, he had to wait more than a year before he was admitted to the bomb-damaged technical university, only taking up his studies in the winter semester 1949/1950. He spent the time in between working in a laboratory at a company which manufactured optical lenses, Optische Werke Rodenstock, in Munich. His physics teachers at high school had been disappointing – and it was this that motivated him to turn to precisely this discipline at university and to investigate it further.

As Mössbauer later acknowledged, research at Professor Maier-Leibnitz' institute could be conducted "in an atmosphere of great freedom" – and this surely paved the way for his subsequent success. For his doctoral thesis, the young student investigated the "nuclear resonance fluorescence of gamma radiation in iridium 191." His meticulous way of working paid off, because for iridium 191, of all things, the measurement deviations were minimal. The doctoral student did not let himself be misled and did not write off his surprising observations as measurement errors.

Since the research possibilities in Munich were limited, Maier-Leibnitz made it possible for Mössbauer to work at the Max Planck Institute for Medical Research in Heidelberg. In 1957, this is where he made the unexpected discovery that the cross-section increases greatly with decreasing temperature, instead of decreasing as would have been expected. In a further experiment in Heidelberg, he succeeded in measuring the recoilless spectrum of the gamma-ray line directly. After successfully defending his thesis, Mössbauer was awarded his doctorate in January 1958 at the TH München and subsequently worked as a research assistant with his teacher Maier-Leibnitz.

The "Mössbauer effect" named after its discoverer enables researchers to measure the interaction of a nucleus with its environment and the gamma quantum with the gravitational field with great accuracy. It can be used for many different applications not only in nuclear physics and solid state physics, but also in chemistry, biomedicine, geology, mineralogy, and archaeology. The high-precision Mössbauer spectroscopy has even been used to prove predictions of Albert Einstein's General Theory of Relativity in the laboratory. A current example of its application is space research: The two Mars robots "Spirit" and "Opportunity" used this type of spectrometer to investigate the rocks on the red planet. It was thus possible to prove not only the earlier existence of water, but also that the atmosphere once contained much more oxygen than it does today. In 2013, when the Russian "Fobos Grunt" probe lands on Phobos, one of Mars' moons, a Mössbauer spectrometer will again be part of the instrumentation.

In autumn 1958, the newly qualified doctor of physics was full of anticipation as he presented his discovery at the Meeting of German Physicists in Essen, but his German colleagues showed only moderate interest. A year later, however, during a research colloquium at the University of Heidelberg, Mössbauer attracted the attention of the Swiss physicist Felix Böhm, who was teaching in California, and he informed his university, the "California Institute of Technology." Böhm's colleague Richard Feynman sent a wire: "Get this guy!." In Pasadena, CalTech provided Mössbauer with excellent research facilities, and in 1961 the 32-year-old scientist shared the Nobel Prize for Physics with Robert Hofstadter "for his researches concerning the resonance absorption of gamma radiation and his discovery in this connection of the effect which bears his name."

This was the first time that a doctoral thesis which originated from our university had been awarded a Nobel Prize. The smart young physicist was celebrated by the students in Germany like a pop star. The joy was mixed with melancholy on the "brain drain" to the USA, however.

It was almost a miracle that the Nobel Laureate could not only be persuaded to return to Germany, but to his Alma Mater in Munich as well, because a great many German universities and research facilities were competing for the highly talented young scientist. And he had his price. Mössbauer laid down conditions which the bureaucracy of the German Ministries found it hard to deal with, such as converting the classical university faculty into a "department" of professors on equal footing which was managed by an elected board of directors, 20 new chairs and world class research facilities. Mössbauer's demands were vigorously supported by his colleagues in Munich – Heinz Maier-Leibnitz, Nikolaus Riehl, Wilhelm Brenig, and Wolfgang Wild – and the farsighted assistant secretary of state Dietrich Bächler (now an honorary senator of the TUM). Even as late as April 1963, Mössbauer complained in a letter to his teacher Maier-Leibnitz after prolonged, laborious negotiations that the "attitude displayed so far" by the Bavarian Government still required a "drastic change." Finally, the Minister of Culture, Theodor Maunz, and Minister of Finance, Rudolf Erhard, were convinced after all.

The outcome of the negotiations was fantastic: 16 chairs were approved, and four more positions were funded like chairs; there were also hundreds of positions for academic staff. The new physics department in Garching was given an outstandingly well-equipped new building, designed by Professor Angerer, which even today is still setting standards. The press celebrated the "Second Mössbauer Effect."

This investment did actually bear fruit. Klaus von Klitzing, who taught at the TUM from 1980 to 1984 as Professor for Solid State Physics, was awarded the 1985 Nobel Prize for Physics for his discovery of the "quantum Hall effect." Erwin Neher studied physics at the TUM from 1963 to 1966 and was awarded the 1991 Nobel Prize for Physiology or Medicine jointly with Bert Sackmann for their discoveries regarding the function of individual ion channels in cells. Wolfgang Ketterle studied physics at the TUM from 1978 to 1982. In 2001, he shared the Nobel Prize for Physics with Eric A. Cornell and Carl E. Wieman "for the achievement of Bose-Einstein condensation in dilute gases of alkali atoms, and for early fundamental studies of the properties of the condensates."

Rudolf Mössbauer was a flagship of the TUM for decades with his teaching and research work and was deemed to be a brilliant teacher. Every year he travelled to the USA for 3 months to keep in touch with developments there. Countless conferences, working groups, and doctoral students worldwide were concerned with the application possibilities of Mössbauer spectroscopy.

In 1972 Rudolf Mössbauer took on a new challenge: For 5 years he was Director of the Institut Laue-Langevin (ILL) in Grenoble and its high-flux neutron reactor. During this period of time, he turned his attention to low-energy neutrino physics, another promising field of work. Mössbauer became a pioneer in this discipline. The discovery that these elementary particles have a rest mass after all could lead to the correction or even the complete replacement of standard models to explain the world.

Our Alma Mater can consider itself fortunate that Rudolf Mössbauer remained loyal to it for most of his years of active research: For almost four decades he worked here as a student, doctoral student, assistant, and professor. His meteoric rise to become a Noble Laureate at just 32 years of age is still an academic fairytale which enthuses and motivates. It is thanks to scholars like Rudolf Mössbauer that Munich of today is the outstanding German location for physics, and that Munich cannot be overlooked in the world of physics research and finally – that Munich now ranks among the global elite in more disciplines than ever before.

I am delighted that this anthology of renowned scientists and colleagues pays due recognition to the pioneering discovery of Rudolf Mössbauer in its multitude of applications and would like to thank all the authors and editors for their collaboration on this project.

Munich
August 2011

Wolfgang A. Herrmann