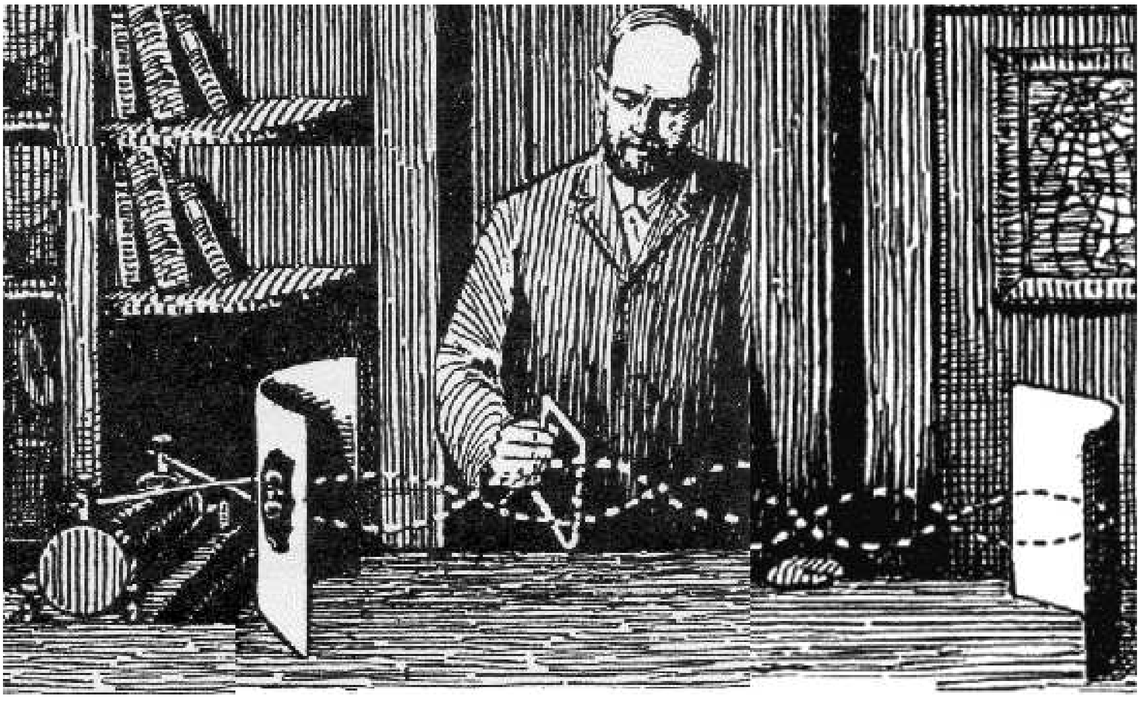
Gudrun Wolfschmidt (ed.)

Heinrich Hertz (1857–1894) and the Development of Communication

October 8-12, 2007

Booklet of Abstracts



Hamburg: Institute for History of Science
2007

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- Prof. Dr. Robert Klanner, Department Physik, Institut für Experimentalphysik, Universität Hamburg
- Prof. Dr. Hans-Joachim Braun, Universität der Bundeswehr Hamburg

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- Deutsche Forschungsgemeinschaft (DFG)
- Behörde für Wissenschaft und Forschung Hamburg

Web Page of the Symposium:
`http://www.math.uni-hamburg.de/spag/ign/events/hertz07.htm`

Prof. Dr. Gudrun Wolfschmidt
Koordinatorin

Schwerpunkt Geschichte der Naturwissenschaften
Department Mathematik
Fakultät für Mathematik, Informatik und Naturwissenschaften (MIN)
Universität Hamburg

Bundesstraße 55 Geomatikum
D-20146 Hamburg

Tel. +49-40-42838-5262
Fax: +49-40-42838-5260

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Inhaltsverzeichnis

Monday, 8. October 2007

1. Heinrich Hertz and the Development of Communication – Festakt

14 h	Geburtshaus von Heinrich Hertz in der Poststraße 20, 20354 Hamburg Enthüllung einer Gedenktafel (Patriotische Gesellschaft von 1765) Grußwort: Peter Klein Einladung zum Kaffee
16 h	Department Physik, Wolfgang Pauli Lecture Hall, Jungiusstraße 9, 20355 Hamburg Festakt zur Eröffnung der Tagung Organisation: Schwerpunkt Geschichte der Naturwissenschaften
	Grußwort von Prof. Dr. Arno Frühwald, Dekan der MIN-Fakultät (Dean of the Faculty of Mathematics, Informatics and Natural Sciences)
	Grußwort von Jens Struckmeier, Departmentleiter Mathematik
	Grußwort von Robert Klanner, Departmentleiter Physik
	Peter Heering, Universität Oldenburg: Wie der Funke in die elektrische Forschung kommt – Elektrische Experimente im 18. Jahrhundert – Experimentalvortrag
	Chor des Elektronen-Synchrotrons Hamburg unter der Leitung von Axel Schaffran: *„Viele verachten die edele Physik“* – Klänge zwischen Elementarteilchen und Außenwelt
	Martin Wegener, Universität Karlsruhe, Institut für Angewandte Physik: Wenn Funken Wellen schlagen – Die Hertzschen Experimente Experimentalvortrag
	Schlußworte: Gudrun Wolfschmidt
19 h	Senatsempfang anläßlich 150 Jahre Heinrich Hertz im Rathaus, Bürgermeistersaal - Grußwort Staatsrat Roland Salchow, Behörde für Wissenschaft und Forschung (BWF) (State Secretary of the Ministry of Science and Research) - Grußwort Roger H. Stuewer, University of Minnesota, Minneapolis, USA Empfang – Reception

Tuesday, 9. October 2007, 9 h
Geomatikum, Bundesstr. 55, D-20146 Hamburg

2. Heinrich Hertz (1857–1894) – Philosophy of Science

Chairman: Roger H. Stuewer,
University of Minnesota, Minneapolis, USA

09.00	Gregor Schiemann, Universität Wuppertal: The Loss of World in the Image. Origin and Development of the Concept of Image in the Thought of Hermann von Helmholtz and Heinrich Hertz
09.30	Claus Peter Ortlieb, Universität Hamburg, Department Mathematik: Hertz' Beitrag zum Konzept des mathematischen Modells
10.00	Allan Janik, „Brenner-Archiv", Universität Innsbruck: How Did Heinrich Hertz Influence Wittgenstein?
10.30–11.00	Coffee break
11.00	John Preston, The University of Reading, England: Hertz, Wittgenstein, and the Instrumentalist Turn in the Philosophy of Science
11.30	Rudolf Seising, Medical University of Vienna: „Bilder", „Beulen", Bänder and structures: Heinrich Hertz, communication technology and philosophy
12.00	Giora Hon, Department of Philosophy, Haifa University, Israel and Bernard R. Goldstein, University of Pittsburgh, USA: Hertz's methodology and its influence on Einstein
12.30–14.00	Lunch Break

Tuesday, 9. October 2007, 14 h
Geomatikum, Lecture Room (Hörsaal) 2

3. Electromagnetism and Electrodynamics – Theory and Experiment

Chairman: Robert Klanner,
Institut für Experimentalphysik, Universität Hamburg

12.30–14.00	Lunch Break
14.00 14.30	Olivier Darrigol, CNRS, Paris Hertz's stroke of genius of 1884: The principle of the unity of the electric force Karl Heinrich Wiederkehr, Hamburg, SPGN: Heinrich Hertz im Spannungsfeld von älterer Elektrodynamik und der Maxwellschen Theorie
15.00–	Coffee break

4. Heinrich Hertz – Principles of Mechanics

Chairman: Robert Klanner,
Institut für Experimentalphysik, Universität Hamburg

–15.30	Coffee break
15.30 16.00 16.30	Jesper Lützen, Universität Kopenhagen: Hertz and the Geometrization of Mechanics Alfred Nordmann, Institut für Philosophie, TU Darmstadt: Physics, Philology and Philosophy – A Tale of Hertz's Life-Long Struggles Peter Klein, Universität Hamburg, Didaktik der Mathematik und der Naturwissenschaften: Revision of Mechanics – Heinrich Hertz Preparing the Theories of Relativity
17.00	Possibility to visit the exhibition: „Physik mit Her(t)z" in the Landesinstitut für Lehrerbildung und Schulentwicklung in Hamburg, Felix-Dahn-Strasse 3, 20357 Hamburg (3rd floor) – in walking distance from the Geomatikum
19.00	Get together Party – Geomatikum

Wednesday, 10. October 2007, 9 h
Geomatikum, Lecture Room (Hörsaal) 2

5. The Discovery of Electromagnetic Waves – Heinrich Hertz's Experiments and Apparatus

Chairman: Jürgen Teichmann,
Deutsches Museum, München

09.00	Martin Henke, University of Hamburg: Berend Wilhelm Feddersen (1832–1918) und die Hertz-Kontroverse
09.30	Joachim Pelkowski (Ober-Mörlen) Hertz on Meteorology: A Lasting Contribution and a Remarkable Inaugural Lecture
10.00	Frank Dittmann, Deutsches Museum München: Heinrich Daniel Rühmkorff, Erfinder des Rühmkorffschen Funkeninduktors
10.30–11.00	Coffee break
11.00	Roland Wittje, Norwegian University of Science and Technology, Trondheim, Norway / Regensburg und Wolfgang Engels, Universität Oldenburg: What Went on in the Laboratory? Replicating the Early Hertz Experiments (experimental lecture)
12.00–14.00	Bus to Hamburg-Bergedorf Lunch Break

Wednesday, 10. October 2007, 15 h
Hamburger Sternwarte in Bergedorf,
Gojenbergsweg 112, D-21029 Hamburg

6. From Radar Technology to the Application of Electromagnetic Waves in Astronomy

Chairman: Gudrun Wolfschmidt,
SPGN, Universität Hamburg

14.15	Welcome by Peter Hauschildt, Observatory, Department of Physics, University of Hamburg
14.30	Albrecht Sauer, Deutsches Schiffahrtsmuseum Bremerhaven: Zur Einführung elektromagnetischer Kommunikations- und Navigations-Verfahren in der deutschen Schifffahrt
15.00	Richard Strom, ASTRON, Radiosterrenwacht Dwingeloo & Sterrenkundig Instituut 'A. Pannekoek', University of Amsterdam: Ir A. H. de Voogt's pioneering role as radio amateur and astronomer
15.30	Gudrun Wolfschmidt, Hamburg, SPGN: Development of Radio Astronomy in Germany until 1970
16.00–16.30	Coffee break
16.30	Norbert Junkes, MPI für Radioastronomie, Bonn: Radio Astronomy in Germany – Status and Future Developments – Entwicklung der Radioastronomie in Deutschland nach 1970
17.00	Zoltán Kolláth, Konkoly Observatory, Budapest, Hungary: Stellar music – detecting cosmic acoustic signals by electromagnetic waves (with Audio Examples)
17.30	Guided tour through Hamburg Observatory Reception
20.00	Back to the center of Hamburg by bus

Thursday, 11. October 2007, 9 h
Museum für Kommunikation,
Gorch-Fock-Wall 1, D-20354 Hamburg

7. The Birth of Radio – Wireless Telegraphy

Chairman: Fabio Bevilacqua,
Dipartimento di Fisica, Università degli Studi di Pavia

09.00	Die Karlsruher Experimente von Heinrich Hertz und die Rolle von Ferdinand Braun für die Entstehung der Radiotechnik in Theorie und Praxis in Deutschland und in Russland Vitaly G. Gorokhov, Institut für Philosophie der Russischen Akademie der Wissenschaften
09.30	Aleksandar Marincic, Serbian Academy of Sciences and Arts, Belgrade, Zorica Civric, Museum of Science and Technology, Belgrade Nikola Tesla's Contributions to Radio Developments
10.00	Richard Strom, ASTRON, Radiosterrenwacht Dwingeloo & Sterrenkundig Instituut 'A. Pannekoek', University of Amsterdam Highlights of amateur radio in the Netherlands to 1926
10.30–11.00	Coffee break
11.00	Wolfgang König, Technische Universität Berlin, Institut für Philosophie, Wissenschaftstheorie, Wissenschafts- und Technikgeschichte: Wilhelm II. und die Funktechnik
11.30	Horst A. Wessel, Mannesmann-Archiv und Universität Düsseldorf: Telegraphie ohne Drähte – Technische Voraussetzungen und wirtschaftliche Bedeutung der frühen Funktelegraphie
12.00–14.00	Lunch Break

Thursday, 11. October 2007, 14 h
Museum für Kommunikation,
Gorch-Fock-Wall 1, D-20354 Hamburg

8. Heinrich Hertz (1857-1894) – Life and Impact

Chairman: Claus Peter Ortlieb,
Department Mathematik, Universität Hamburg

12.00– 14.00	Lunch Break
14.00	Stefan Wolff, Deutsches Museum München: Die Familie Hertz – ein jüdischer Name
14.30	Frank Linhard, Universität Frankfurt: The Concept of 'Ether' in Hertz's Kiel Lecturesand its Meaning for the Concept of Space
15.00	James G. O'Hara, Gottfried Wilhelm Leibniz Bibliothek – Niedersächsische Landesbibliothek Hannover: Hertz's dilemma of the different velocities of transmission of electromagnetic waves in air and along wires. Why did he get the results he got?
15.30–	Coffee break

9. Development of Communication Technology

–16.00	Coffee break
16.00–	Oliver Rump, Director of the Museum: Guided tour through the Museum of Communication
18.00	Reception

Friday, 12. October 2007, 9 h
Museum für Kommunikation
Gorch-Fock-Wall 1, D-20354 Hamburg

10. Development of Communication Technology: From Tube to Digital Technology

Chairman: Hans-Joachim Braun,
Helmut-Schmidt-Universität/Universität der Bundeswehr Hamburg,
Professur für Neuere Sozial-, Wirtschafts-und Technikgeschichte

09.00	Hans-Joachim Braun, Universität der Bundeswehr Hamburg: Thereminvox: The Career of a Unique Electronic Musical Instrument (with Audio Examples)
10.00	Peter Donhauser, Technisches Museum Wien: Das Heinrich-Hertz-Institut und die Pionierzeit der „Elektrischen Musik” in Berlin
10.30–11.00	Coffee break
11.00	Joachim Goerth, HAW Hamburg: Development of electronic tubes
11.30	Renate Tobies, TU Braunschweig: Mathematics – for improving the construction of valves
12.00	Erika Linz, Universität zu Köln / Aachen: Society on the move: The success story of the mobile phone
12.30	Roger H. Stuewer, University of Minnesota, USA: Closing remarks

Enthüllung einer Gedenktafel am Geburtshaus von Heinrich Hertz in der Poststraße 20 – Patriotische Gesellschaft von 1765

An dieser Stelle stand das Haus,
in dem am 22. Februar 1857
Heinrich Hertz
Professor der Physik
geboren wurde, Sohn des Anwalts und
späteren Justizsenators Gustav Hertz.

Heinrich Hertz war einer der bedeutendsten Physiker.
Seine Entdeckung der Elektromagnetischen Wellen 1887/88
wurde zur Grundlage des Zeitalters
der elektronischen Massenmedien und
vollendete die Klassische Physik.

Als Pionier der Modernen Physik entdeckte er 1887 den
Photoeffekt, den ersten Quanteneffekt.
Seine „Prinzipien der Mechanik“ (1894) waren
Wegbereiter der Ideen der Relativitätstheorien.

Er starb in Bonn am 1. Januar 1894.

Patriotische Gesellschaft von 1765

Enthüllung der Gedenktafel, Poststraße 20,
am Montag, 8. Oktober 2007, 14 Uhr
Grußwort: Prof.Dr. Peter Klein

Einladung zum Kaffee
(Anmeldung erforderlich, Tel. 040-366619)

Festakt zur Eröffnung der Tagung

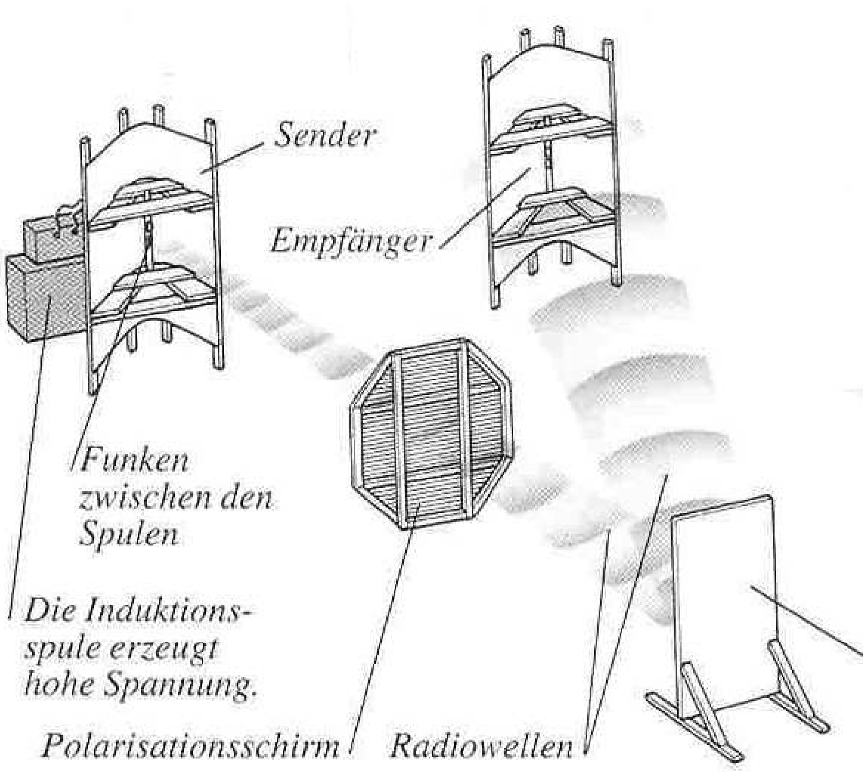

Abbildung 1.1:
Hertz' experiments

Wolfgang Pauli-Hörsaal (Lecture Hall)
Department Physik, Jungiusstraße 9, D-20355 Hamburg

1.1 Festakt zur Eröffnung der Tagung (mit musikalischer Umrahmung)

16 h - Department Physik, Wolfgang Pauli Lecture Hall,
Jungiusstraße 9, D-20355 Hamburg
(Underground U1 – stop "Stephansplatz"
or Underground U2 – stop "Messehallen")

- Organisation/Moderation: Gudrun Wolfschmidt,
  Schwerpunkt Geschichte der Naturwissenschaften, Mathematik und Technik

- Grußwort: Prof. Dr. Arno Frühwald, Dekan der MIN-Fakultät
  (Faculty of Mathematics, Informatics and Natural Sciences)
- Grußwort: Prof. Dr. Jens Struckmeier, Departmentleiter Mathematik
- Grußwort: Prof. Dr. Robert Klanner, Departmentleiter Physik

- PD Dr. Peter Heering, Universität Oldenburg:
  Wie der Funke in die elektrische Forschung kommt -
  Elektrische Experimente im 18. Jahrhundert
  (Experimentalvortrag)

- Chor des Elektronen-Synchrotrons Hamburg
  unter der Leitung von Axel Schaffran: :
  „Viele verachten die edele Physik" –
  Klänge zwischen Elementarteilchen und Außenwelt

- Prof. Dr. Martin Wegener,
  Universität Karlsruhe (TH), Institut für Angewandte Physik:
  Wenn Funken Wellen schlagen –
  Die Hertzschen Experimente
  (Experimentalvortrag)

- Closing remarks: Gudrun Wolfschmidt,
  Schwerpunkt Geschichte der Naturwissenschaften, Mathematik und Technik

1.2 Wie der Funke in die elektrische Forschung kommt – Elektrische Experimente im 18. Jahrhundert

PD Dr. Peter Heering

Arbeitsgruppe Didaktik und Geschichte der Physik, Institut für Physik, Carl-von-Ossietzky-Universität Oldenburg, D-26111 Oldenburg

peter.heering@uni-oldenburg.de

Elektrizität ist ein wesentliches Thema der Naturforschung im 18. Jahrhundert. Dabei wird in dieser Periode insbesondere die elektrische Entladung zu einem wesentlichen Zugang zur Fragestellung,was denn Elektrizität sei. Erst gegen Ende des 18. Jahrhunderts werden dann (letztlich auch kanonisierte) Experimente entwickelt, die auf die Erzeugung statischer elektrischer Effekte abzielen. Im Rahmen meines Vortrags werde ich ausgewählte Experimenten diskutieren und demonstrieren, um hierdurch einen Zugang zur experimentellen Praxis dieser Periode zu eröffnen.

Abbildung 1.2:
How the spark comes into the electrical research – Experiment 1744

1.3 Wenn Funken Wellen schlagen – Die Hertzschen Experimente

Prof. Dr. Martin Wegener

Universität Karlsruhe (TH), Institut für Angewandte Physik,
Wolfgang-Gaede-Straße 1, D-76128 Karlsruhe

martin.wegener@physik.uni-karlsruhe.de

Heinrich Rudolf Hertz wurde am 22. Februar 1857 geboren. Mit seinen Karlsruher Experimenten zu elektromagnetischen Wellen hat er im Jahr 1887 die Maxwellsche Theorie der Elektrodynamik bestätigt und zugleich den Grundstein für die heutige Informationsgesellschaft gelegt. Mit seinen Experimenten zum Photoeffekt aus dem gleichen Jahr hat Hertz – ohne dass ihm dies klar sein konnte – auch die Grenzen der Maxwellschen Theorie aufgezeigt und eine Tür zum Photon sowie zur Photonik geöffnet.

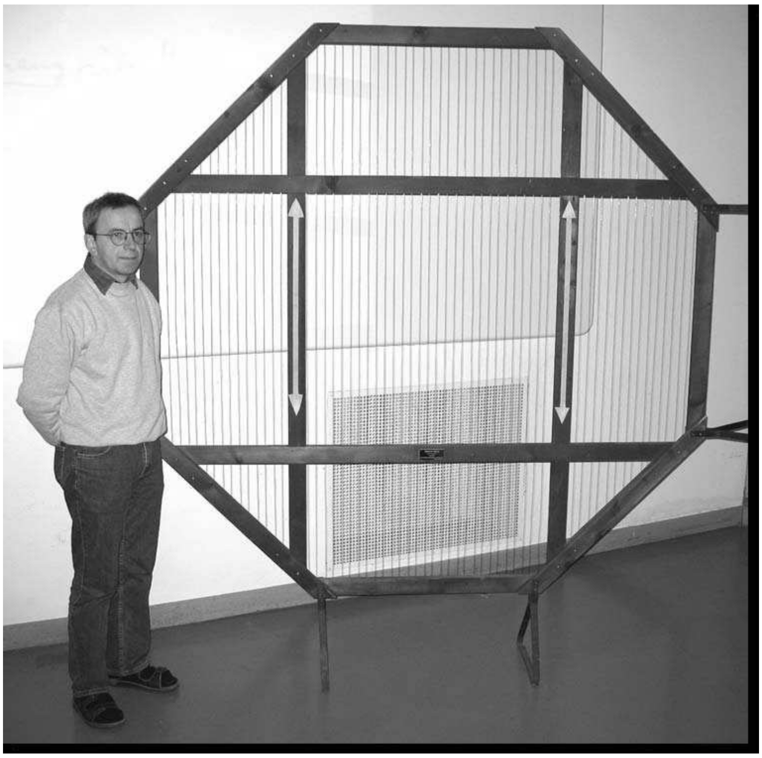

Abbildung 1.3:
Nachbau eines Hertzschen Drahtgitter-Polarisators

Senatsempfang anläßlich 150 Jahre Heinrich Hertz im Rathaus am 8. Oktober 2007, 19 Uhr

Rathaus, Bürgermeistersaal

`http://fhh.hamburg.de/stadt/Aktuell/senat/rathaus/start.html`

- Grußwort – Staatsrat Dr. Roland Salchow,
  Behörde für Wissenschaft und Forschung Hamburg (BWF)
  (State Secretary of the Ministry of Science and Research)
- Prof. Dr. Roger H. Stuewer,
  University of Minnesota, Minneapolis, USA

Empfang – Reception
(Einlaß nur mit Einladungskarte –
special invitation card necessary)

Figure 2.1:
Heinrich Hertz (1857–1894)

Heinrich Hertz (1857–1894) – Philosophy of Science

Chairman: Prof. Dr. Roger H. Stuewer

University of Minnesota, Program in History of Science and Technology,
Tate Laboratory of Physics,
116 Church Street SE, Minneapolis, MN 55455 USA
Phone Number: 612-624-8073, Fax Number: 612-624-4578

`rstuewer@physics.umn.edu`

Geomatikum, Lecture Room (Hörsaal) 2
Bundesstr. 55, D-20146 Hamburg

2.1 The Loss of World in the Image – Origin and Development of the Concept of Image in the Thought of Hermann von Helmholtz and Heinrich Hertz

Prof. Dr. Gregor Schiemann

Philosophisches Seminar / FB A, Bergische Universität Wuppertal, Gaußstr. 20, D-42119 Wuppertal

schiemann@uni-wuppertal.de

Searching for origins of the current conception of science in the history of physics, one faces a remarkable phenomenon. Typical for today is the notion that theoretical knowledge-claims have only relativized validity. This historical movement was supported by representatives of a conception of nature that is not at all typical today, by resprentatives of a mechanism whose objective it was to explain natural phenomena by the action of mechanically moved matter.

Hermann von Helmholtz and his pupil Heinrich Hertz were two of these representatives who contributed significantly to the modernization of the conception of science. Paradigmatic for their common contribution to this development is the way, in which they employed the concept of image. Considering the origin and the different meanings of this concept it is possible to trace a line of development which begins with Helmholtz's original claim that a universally and forever valid theory provides a unique representation of nature. It continues with the realization that the status of scientific knowledge is capable of revision; and it arrives at Hertz's admission that a variety of theories over a domain of objects is possible, at least at times.

Verlust der Welt im Bild – Ursprung und Entwicklung des Bildbegriffes bei Hermann von Helmholtz und Heinrich Hertz

Sucht man in der Physikgeschichte nach Ursprüngen heutiger Wissenschaftsauffassung, so stösst man auf ein bemerkenswertes Phänomen: Die für die Gegenwart typische Relativierung der Geltung theoretischer Erkenntnisansprüche wurde historisch massgeblich von Vertretern einer Naturauffassung eingeleitet, die heute in keiner Weise mehr als typisch gelten kann – von Vertretern des Mechanismus, deren Ziel es war, die Naturphänomene als Wirkung mechanisch bewegter Materie zu erklären. Hermann von Helmholtz und sein Schüler Heinrich Hertz waren zwei dieser Vertreter, die ganz entscheidend zur Modernisierung der Wissenschaftsauffassung beigetragen haben. Paradigmatisch für ihren gemeinsamen Anteil an dieser Entwicklung ist die auf sie zurückgehende wissenschaftstheoretische Verwendung des Bildbegriffes. Am Ursprung und an den unterschiedlichen Bedeutungen dieses Begriffes lässt sich eine Linie nachzeichnen, die vom Alleinvertretungsanspruch einer universell und ewig gültigen Theorie, wie Helmholtz ihn zunächst vertritt, über die Einsicht in den revisionsfähigen Status wissenschaftlicher Erkenntnis bis hin zum Eingeständnis von Hertz führt, dass zumindest zeitweise eine Vielfalt von Theorien eines Gegenstandsbereiches möglich sei.

2.2 Hertz' Beitrag zum Konzept des mathematischen Modells

Prof. Dr. Claus Peter Ortlieb

Universität Hamburg Department Mathematik, Zentrum für Modellierung und Simulation
Bundesstraße 55, D-20146 Hamburg

C.P.Ortlieb@t-online.de

The introduction to Heinrich Hertz' last work Die Prinzipien der Mechanik in neuem Zusammenhange dargestellt is a milestone on the long way from Galilei's opinion the *book of nature is written in the language of geometry* to the modern concept of the mathematical model. Hertz seems to have been the first, who has raised into consciousness the significance of the scientific development of the 19^{th} century for the role of mathematics in the knowledge of nature, and who has expressed the consequences considerably: There are different correct mathematical descriptions (and not the only one) of a field of physics, for example. Because of this, further criteria are to be added for the choice *"of the inner pretended pictures and symbols of the outer objects"* (in today's language: the mathematical models). Hertz designates as the three most important ones: Correctness, admissibility, usefulness. As an implication, mathematics and substantial sciences are falling apart, with consequences for the limits of the knowledge of nature, too. More than one hundred years later, they still are ignored frequently.

Die Einleitung zu Heinrich Hertz' letztem Werk Die Prinzipien der Mechanik in neuem Zusammenhange dargestellt ist ein Meilenstein auf dem langen Weg von Galileis Auffassung, das Buch der Natur sei *in der Sprache der Geometrie geschrieben*, zum modernen Konzept des mathematischen Modells. Hertz scheint der Erste gewesen zu sein, der die Bedeutung der naturwissenschaftlichen Entwicklung des 19. Jahrhunderts für die Rolle der Mathematik in der Naturerkenntnis ins Bewusstsein gehoben und die Konsequenzen deutlich ausgesprochen hat: Es gibt für einen Gegenstandsbereich etwa der Physik verschiedene richtige mathematische Beschreibungen und nicht nur die eine. Deswegen müssen für die Auswahl der "inneren Scheinbilder und Symbole der äußeren Gegenstände" (im heutigen Sprachgebrauch: der mathematischen Modelle) weitere Kriterien hinzu kommen. Hertz nennt als die drei wichtigsten: Richtigkeit, Zulässigkeit, Zweckmäßigkeit. Das damit verbundene Auseinanderfallen von Mathematik und Substanzwissenschaften hat Folgen auch für die Grenzen der Naturerkenntnis, die mehr als hundert Jahre später immer noch oft übersehen werden.

2.3 How Did Heinrich Hertz Influence Wittgenstein?

Univ.-Prof. Dr. Allan Janik

Forschungsinstitut "Brenner-Archiv", Universität Innsbruck
Josef-Hirn-Strasse 5, A-6020 Innsbruck

Allan.Janik@uibk.ac.at

Contrary to what is frequently asserted the notion of the proposition as "Bild" was not the primary point of influence of Hertz upon Wittgenstein; rather, the notion of "showing" the linguistic roots of metaphysical probelms on the basis of alternative representations of the problematic matter at hand was the crucial element in Wittgenstein's abiding Hertzian heritage, which influenced all of his thinking profoundly. Paradoxically, this was not a matter of Wittgenstein simply adopting something from Hertz but of re-thinking a fundamental notion in Hertz's philosophy of science such that he could claim to have understood Hertz better than Hertz himslef did, which explains why the importance of Herrtz for Wittgenstein's conception of philosophy has largely gone unrecognized.

2.4 Hertz, Wittgenstein, and the Instrumentalist Turn in the Philosophy of Science

Dr. John Preston, Senior Lecturer

Department of Philosophy, The University of Reading,
Reading RG6 6AA, England

j.m.preston@reading.ac.uk

Commentators often suppose that the remarks on science in Ludwig Wittgenstein's Tractatus Logico-Philosophicus are not only influenced by, but also fundamentally in line with the philosophical remarks on physics contained in Heinrich Hertz's book The Principles of Mechanics. I argue here that there are significant differences between their overall frameworks, their respective views on the status of the laws of physics, and in their resulting forms of anti-realism. Although Hertz presented his material in terms of a Kantian distinction which Wittgenstein was later to sharpen, Wittgenstein decisively rejected the conception of logic with which that distinction was then associated. And although Wittgenstein was of course familiar with Hertz's mechanics, and was undoubtedly influenced by Hertz in certain respects, he did not interpret that work, or other systems of mechanics, in the way that Hertz did.

I argue that Hertz's philosophy of science is best thought of as *epistemically* anti-realist, but *semantically* realist. There is not enough evidence to suppose that Hertz interpreted his own mechanics in anything other than a literal way, as making truth-valued *claims*. (So he is not rightly thought of as a kind of positivist). But Hertz departs from scientific 'realism' in insisting that our knowledge of nature can only go so far. (His view might thus profitably be compared to Bas van Fraassen's 'constructive empiricism').

Wittgenstein, however, took a turn which (with one possible but controversial exception) had not really taken before. The Tractatus' view of language forced him to consider the status of scientific propositions. I argue that the Tractatus, and some of Wittgenstein's subsequent productions, portray high-level theories and laws as *rule*-like, rather than claim-like. His view of the laws of science is a version of the 'inference-licence' view, otherwise known as *instrumentalism*. I distinguish between loose and strict kinds of instrumentalism, and I argue that his contemporaries, followers, and certain recent critics are right to understand him as an instrumentalist in this stricter (and more interesting) sense. I also suggest that Wittgenstein was innovative in this respect.

No doubt Wittgenstein was inspired by having read Hertz (this essay does not consider claims that Wittgenstein generalised Hertz's remarks on science to yield the Tractatus' 'picture theory' of language); nevertheless, the relationship between his philosophy of *science* and Hertz's is one of *creative misappropriation*.

2.5 Hertz's methodology and its influence on Einstein

Prof. Giora Hon[1], Prof. Bernard R. Goldstein[2]

1 University of Haifa, Department of Philosophy,
Mt. Carmel, 31905 Haifa, Israel

hon@research.haifa.ac.il

2 School of Arts and Sciences, University of Pittsburgh, USA

brg@pitt.edu

Hertz died at the early age of 37; nevertheless, in this short lifetime he became a leading classical physicist and an outstanding philosopher. In 1884 Hertz published a detailed and critical analysis of Maxwell's set of equations. This major undertaking, "Über die Beziehungen zwischen den Maxwell'schen elektrodynamischen Grundgleichungen und den Grundgleichungen der gegnerischen Elektrodynamik", preceded his famous *tour de force*: proving experimentally that electric waves exist. Hertz attempted in this paper to show the validity of Maxwell's set of equations even if one starts with the premises of opposing theories. He did not introduce the ether in his derivation of the equations, despite his belief in the reality of this hypothetical entity. He distinguished between the electric and the magnetic force, claiming, however, that each force is unified in the sense that different sources yield the same kind of force.

Hertz's influential papers, which Einstein reported reading, are based on the idea of interchangeability of electric and magnetic elements. Hertz explicitly characterized Maxwell's theory as asymmetrical, a feature with which he was not satisfied. He therefore proceeded to eliminate the asymmetry between the forces. Hertz manipulated the equations for the forces of electricity and magnetism mathematically, recasting them symmetrically, thus making the two descriptions of the forces interchangeable. However, in the wake of his experimental work on electric waves, Hertz no longer accepted the validity of his derivation of the equations; instead, he opted for the axiomatic approach, turning the equations into postulates.

Einstein's decision to postulate the two principles of his theory of relativity of 1905 (thus giving it an axiomatic basis) is reminiscent of Hertz's decision to postulate the equations. But this line of influence did not affect Einstein's view of asymmetry, for it has to be removed by physical arguments, not by mathematical manipulations as Hertz had done. For Einstein *indistinguishability* was the key concept, not *interchangeability*. Nevertheless, Hertz's pioneering attempt to grapple with the asymmetrical nature of Maxwell's theory formed the background against which Einstein clarified his thoroughly physical approach to the problem. Hertz was a most effective interlocutor for Einstein: in Hertz's work Einstein found the quintessence of 19th-century physics and it served as his point of departure for inaugurating the physics of a new era.

2.6 "Bilder", "Beulen", Bänder and structures: Heinrich Hertz, communication technology and philosophy

PD Dr. Rudolf Seising

Core Unit for Medical Statistics and Informatics,
Medical University of Vienna, Spitalgasse 23, A-1090 Vienna, Austria

rudolf.seising@meduniwien.ac.at

"Das Bild ist ein Modell der Wirklichkeit" (A picture is a model of reality), "Wir machen uns Bilder von den Tatsachen" (We picture facts to ourselves) and "Das Bild ist eine Tatsache" (A picture is a fact) asserted Ludwig Wittgenstein in his *Tractatus logico-philosophicus*, thereby confirming the influence on his thinking - which he himself acknowledged - of Heinrich Hertz's *Prinzipien der Mechanik* (Principles of Mechanics). In this contribution the "picture" concept, which has a long tradition in philosophy, serves as the starting point of an interpretation of the relationship between real systems and theoretical structures of modern science. In addition, the approach dubbed as the "structuralist" view of scientific theories in the 20^{th} century will be extended and enhanced by the concept of "fuzzy sets" and "fuzzy relations".

The gap between real systems and exact mathematical theories and the search for possible ways of bridging this gap led the electrical engineer Lotfi A. Zadeh in the 1960s to consider a "mathematics of cloudy or fuzzy quantities" and ultimately to establish the theory of *fuzzy sets and systems*. Starting with a mathematical theory of electrical filters, on the one hand, and, on the other, the impossibility of realizing ideal filters whose "passbands" ("Durchlassbänder") have exactly defined threshold frequencies, and bearing in mind the characteristics of actual electrical filters with their unsharp boundaries, Zadeh developed a mathematical theory of "membership functions" for classes with unsharp boundaries.

In the second half of the 20th century a great many scientific concepts, methods and theories were "fuzzified" – a transformation that can be reconstructed and reflected upon in a scientific manner by appropriately expanding the framework of the structuralist *view of scientific theories*: Fuzzy sets can then serve as a new modelling tool in scientific theory. With fuzzy sets it is possible to handle classes and structures with unsharp boundaries. They can enable us to break down the sharp boundaries of our concepts, which Gottlob Frege always demanded - with reference to the classic sorites paradox – as otherwise not only would the laws of classical logic be violated, but also false conclusions would be possible. Zadeh's fuzzy logic, his computing with words and his computational theory of perceptions constitute a methodological hierarchy that fits in between the level of real systems and that of theoretical structures, making it possible to represent human perceptions which cannot be represented with the sharp boundaries of classical logic. In this connection, Wittgenstein spoke of "bumps that the understanding has got by running its head up against the limits of language".

Figure 3.1:
James Clerk Maxwell (1831–1879)

Electromagnetism and Electrodynamics – Theory and Experiment

Chairman: Prof. Dr. Robert Klanner

Institut für Experimentalphysik, Universitaet Hamburg
Luruper Chaussee 149, D-22761 Hamburg
Tel. +49 40 8998 2558, Sekr. +49 40 8998 2208, Fax. +49 40 8998 2170

Robert.Klanner@desy.de

Geomatikum, Lecture Room (Hörsaal) 2
Bundesstr. 55, D-20146 Hamburg

3.1 Hertz's stroke of genius of 1884: The principle of the unity of the electric force

Prof. Olivier Darrigol

CNRS, Paris, Rehseis,
83 rue Broca, F-75013 Paris
Tel.: +33-1-45 87 03 94

darrigol@paris7.jussieu.fr

In 1884, Hertz identified the unity of the electric force as the most important advantage of Maxwell's theory over its continental competitors. Through extremely ingenious reasoning, he showed that this principle required a modification of the commonly accepted electrodynamics of closed currents in a way that led to Maxwell's equations. The main purposes of this talk are to analyze this approach, to trace its Helmholtzian origins, and to explore possible relations with Hertz's famous experiments on high-frequency oscillations. Strangely, Hertz never referred back to this remarkable memoir of 1884, even though it anticipated some basic features of his later reformulation of Maxwell's theory. Some guesses will be given about the reasons for this silence.

3.2 Heinrich Hertz between old electrodynamics and Maxwell's Theory

PD Dr. Karl Heinrich Wiederkehr

Institute for History of Science, Hamburg University
Bundesstrasse 55, D-20146 Hamburg, Germany

In the time of Heinrich Hertz two theories electricity and electrodynamics competed essentially. On the continent the „older" electrodynamics created by Wilhelm Weber and Franz Neumann with its distant effect laws prevailed. The anglosaxon sphere held up the Faraday-Maxwell conception. The ..older" electrodynamics assumed the existence of positive and negative electric particles, which should have a mass. Due to this concept an electric current in a wire had to be explained as a countercurrent of particles. The field theory of Faraday and Maxwell rejected the existence of atoms and particularly negated the existence of material electric particles. Its cardinal point was the electric polarization of space elements and hence electric current arose from the so-called „communication" of electricity from one space element of a conductor to another. Maxwell adopted the opinions of Faraday, however in his Treatise of 1873 he also gave tribute to opposing views. When Heinrich Hertz went to Berlin in 1878, he came under the influence of Helmholtz – a determined opponent of Weber. Helmholtz wanted to create clarity in the teachings of electricity electrodynamics. He sympathized with the Faraday-Maxwell field theory and based his own theory of electrodynamics on it. In a prize competition about the question whether the electric current is connected to a transport of mass Hertz proved, that the mass assumed had to be extremely small. Contrary to the expectation of Helmholtz Hertz did not take this argument as an opportunity to lead an attack against the proponents of the „older" electrodynamics. Helmholtz initiated another prize competition in the academy of sciences: Electrodynamic effects inside isolators that had been demanded by Faraday and Maxwell should be demonstrated. However Hertz could solve this problem only in 1887 with the help of his fast electrical oscillations.

In his extensive investigations on cathode rays Hertz was also strongly influenced by Helmholtz, who interpreted cathode rays as wave events in the ether and Hertz was therefore convinced that cathode rays have nothing to do with the electric discharge – a fundamental mistake. In his work over electricity and electrodynamics (1884) Hertz treated the opposing opinions in detail and concluded that precedence had to be given to Maxwell's Theory. He already indicated the first Maxwell equation in its symmetrical form for the ether – according to Planck a first rate achievement. After his pioneering experimental works on electrical oscillatians in his theoretical works Hertz showed himself as a more extreme field physicist than Maxwell. He interpreted the conservation of the electric charge as a mathematical constant. Still in his last experimental work about cathode rays penetrating metal foils he repeated his incorrect opinions about the nature of the cathode rays. After the discovery of the electron in 1897 these views were revised Lorentz' electron theory.

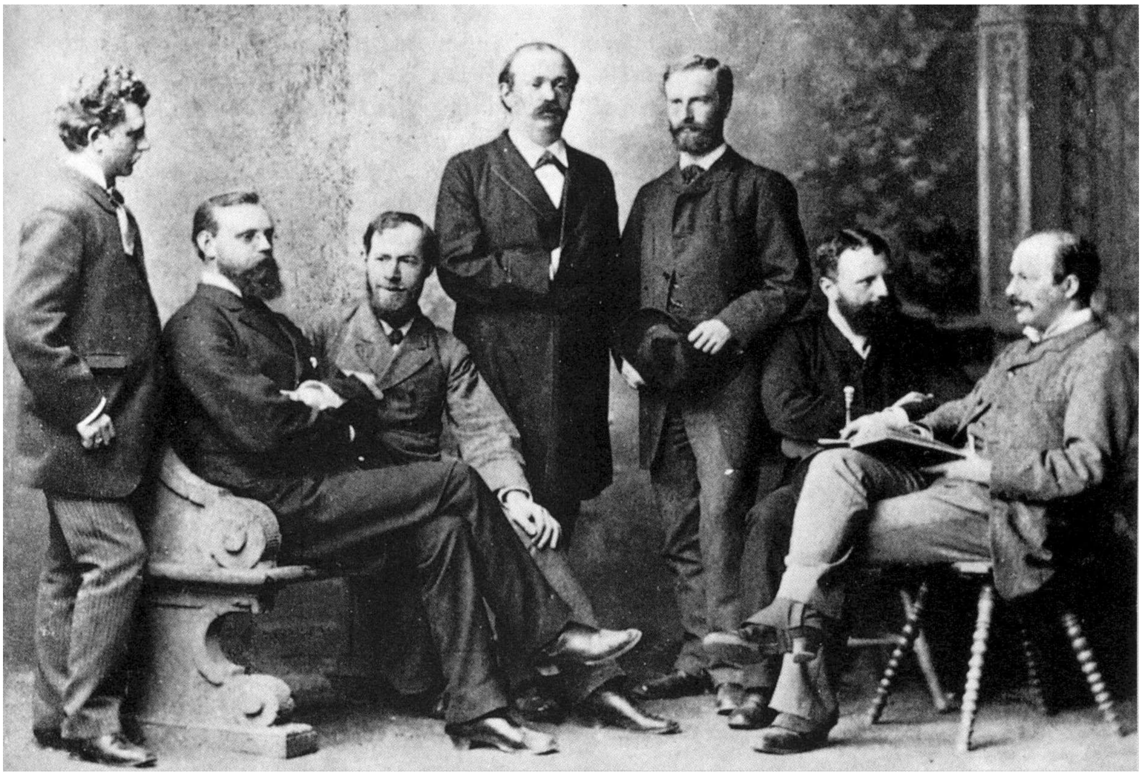

Figure 4.1:
Heinrich Hertz and his collegues

Heinrich Hertz – Principles of Mechanics
Heinrich Hertz – Prinzipien der Mechanik

Chairman: Prof. Dr. Robert Klanner

Institut für Experimentalphysik, Universitaet Hamburg
Luruper Chaussee 149, D-22761 Hamburg
Tel. +49 40 8998 2558, Sekr. +49 40 8998 2208, Fax. +49 40 8998 2170

Robert.Klanner@desy.de

Geomatikum, Lecture Room (Hörsaal) 2
Bundesstr. 55, D-20146 Hamburg

4.1 Hertz and the Geometrization of Mechanics

Prof. Dr. Jesper Lützen

University of Copenhagen, Institute for Mathematical Sciences,
Universitetsparken 5, DK-2100 Copenhagen, Denmark

lutzen@math.ku.dk

Hertz's posthumously published *Principles of Mechanics* is famous for its philosophical introduction and for its avoidance of force as a basic concept. In this talk I shall focus on a third innovative feature of Hertz's mechanics, namely its geometric form. Hertz chose to formulate his mechanical image of the physical world in terms of what he called a "geometry of systems of points", which we would now call a differential geometry of configuration space. He emphasized that the physical content of his image and the geometrical form he had chosen for its presentation were independent of each other but that they mutually assisted each other.

In the talk I shall present the basic features of Hertz's geometry of systems of points and analyze how it interacted with the physical content of the book. I shall compare his geometrization of mechanics with the earlier attempts by mathematicians such as his colleague in Bonn Lipschitz. Moreover I shall investigate how Hertz could both introduce his high dimensional non-Euclidean geometry of systems of points and at the same time claim that space is a priori three dimensional and Euclidean.

A much more comprehensive account of this and other aspects of Hertz's mechanics can be found in my book *Mechanistic Images in Geometric Form: Heinrich Hertz's Principles of Mechanics*, Oxford University Press, 2005.

4.2 Physics, Philology and Philosophy – A Tale of Hertz's Life-Long Struggles

Prof. Dr. Alfred Nordmann

Institut für Philosophie, TU Darmstadt,
Schloß. D-64283 Darmstadt

nordmann@phil.tu-darmstadt.de

Heinrich Hertz is known for his epistemological acuity. Both introductions to his major works (Electric Waves and Principles of Mechanics) point out that there can be competing theoretical representations of the same physical phenomena. Indeed, Hertz articulates a positivist stance according to which physics is severely limited in that it is "impossible to carry our knowledge of the connections of natural systems further than is involved in specifying models of the actual systems". The physicists' systems can agree with the real systems in nature only in one respect, namely "that the one set of systems are models of the other".

However, rather than settle comfortably into this positivist stance, Hertz struggled against it. The presentation will narrate this life-long struggle against the frustrations of philology which started in his student days. One highlight of this story is the time when he is "alone with nature", unfettered by "disputes about human opinions, views, and demands." At this point, "the philological aspect drops out and only the philosophical remains". Hertz can declare at this point that the "propagation in time of a supposed action-at-a-distance is for the first time proved. This fact forms the philosophical result of the experiments; and, indeed, in a certain sense the most important result."

4.3 Revision of Mechanics – Heinrich Hertz Preparing the Theories of Relativity

Prof. Dr. Peter Klein

Universität Hamburg, Didaktik der Mathematik und der Naturwissenschaften, Binderstr. 34 – Von-Melle-Park 8, D-20146 Hamburg

Klein@erzwiss.uni-hamburg.de

The title of Einsteins first paper on the Theory of Relativity Zur Elektrodynamik bewegter Körper obviously paraphrases Heinrich Hertz´ last one on electrodynamics. Yet, in the history of origins and influences of Einsteins works Hertz is rarely, and hardly sufficiently, mentioned. His works count as the very completion of classical physics by electrodynamics, which however (as Hertz himself explicitly noticed) had left open a set of problems Hertz obviously was unable to solve, instead turned to write a luxurious surplus (that nearly cost him his historical credit), the posthumously published Prinzipien der Mechanik, imposing and sophisticated, yet quite useless for concrete scientific work. Einstein, then, in his Theory of Relativity, was the first to demonstrate these problems as fundamental for physics at all, and who thereby also succeded to overcome them and bridge the gap.

I will show in this note that to a large extent Hertz already conceives and verifies Einsteins program: the introduction into his collected electrodynamical papers and the Prinzipien clearly expose the problems, demonstrate them as fundamental insufficiencies of mechanical methodology and develop principles for scientific work which, had he survived, would directly have guided Hertz to conceive a Theory of Relativity, most likely some five years before Einstein.

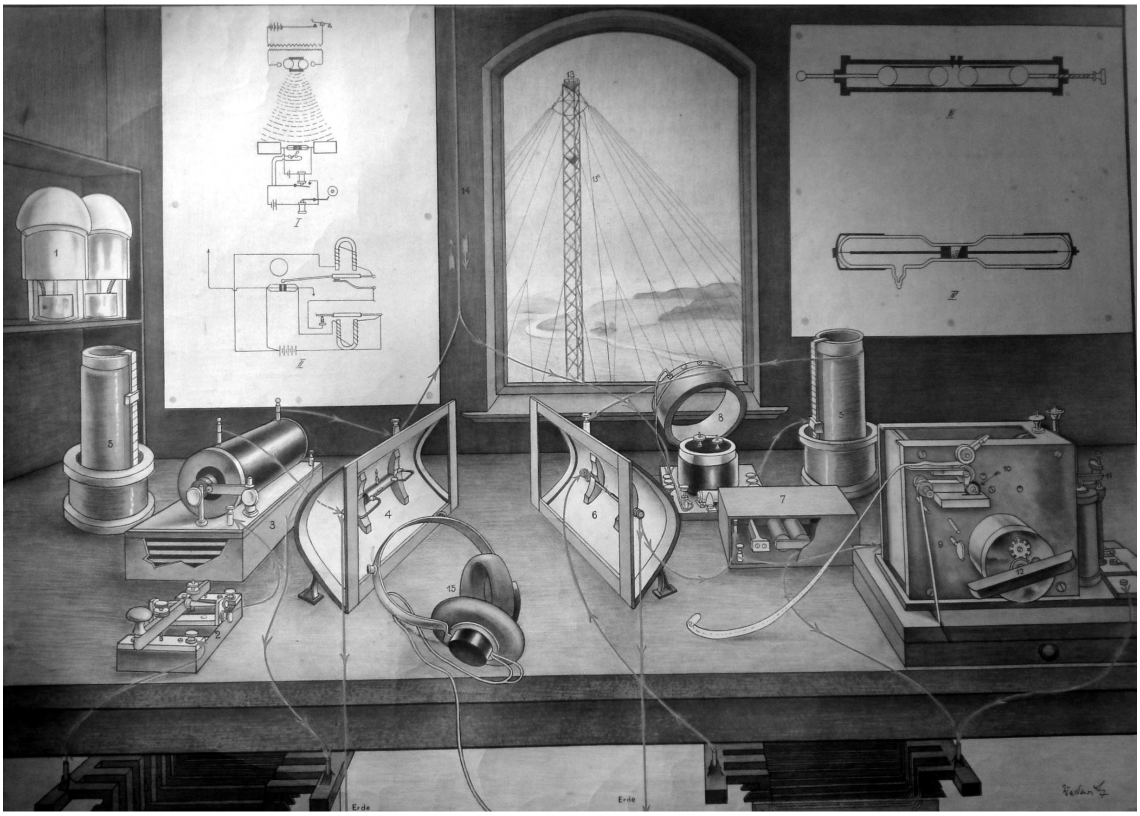

Figure 5.1:
Hertz' discovery of electromagnetic waves

Museum für Kommunikation – Foto: Gudrun Wolfschmidt

The Discovery of Electromagnetic Waves – Heinrich Hertz's Experiments and Apparatus

Chairman: Prof. Dr. Jürgen Teichmann

Ludwig Maximilians Universität München,
Deutsches Museum, Institut für Geschichte der Naturwissenschaften
D-80306 München, Germany
Tel: +49-89-2179538

j.teichmann@lrz.uni-muenchen.de

Geomatikum, Lecture Room (Hörsaal) 2
Bundesstr. 55, D-20146 Hamburg

5.1 Berend Wilhelm Feddersen (1832–1918) and the "Hertz – Controversy"

Dr. Martin Henke

University of Hamburg,
Address (private): Frühlingstrasse 34, D-22525 Hamburg

henke_m@gmx.de

Berend Wilhelm Feddersen is one of the pioneers of electrodynamics. Born in 1832 he studied Philosophy in Göttingen, Berlin and Kiel and completed 1857 his final thesis about the electrical discharge of Leidner bottles. On this subject he worked in the following five years. In 1862 he showed with a very sophisticated experiment that under certain conditions the current is not directly discharged as believed but it oscillates. After this discovery he stopped working on this matter and lived as a private man until he died in 1918 at the age of 86. As one of the early pioneers he experienced the impact of electrodymanic inventions which were connected to names like Hertz, Marconi, Branly but not to Feddersen.

When in 1909 the it Kieler Nachrichten published a dedication article for Feddersen's experiment they stated that it was Hertz, who had laid the foundation for wireless communication. Feddersen was really embarrassed. He immediately published a return saying that it was not Hertz but Branly, Marconi and himself who founded this discipline. To justify his view Feddersen initiated an international correspondence with several European experts. In letters to Chwolson (Russia), Bäcklund (Sweden), Branly (France), Bosscha (Netherlands), Zehnder (Swizzerland) and Zenneck (Germany) he asked for their view on the development of electrodynamics and who had given which impact. Their responses were quite heterogeneous: some saw Hertz without any doubt as founder, some fully deny this view. But the general opinion was that it is impossible to justify who the major contributor was. The evolution of electrodynamics was driven by different heads and their ideas and could only emerge in cooperation.

5.2 Heinrich Daniel Rühmkorff – Erfinder des Rühmkorffschen Funkeninduktors

Dr. Frank Dittmann

Deutsches Museum,
D-80306 München, Germany

f.dittmann@deutsches-museum.de

Im Jahre 1851 stellte Heinrich Daniel Rühmkorff mit seinem Funkeninduktor ein Gerät vor, mit dem man kontinuierlich Hochspannung erzeugen konnte. Bald gehörte der "Rühmkorff" zur Standardausstattung aller wissenschaftlichen Laboratorien in der Welt. Die Erzeugung von sehr hohen Spannungen war eine Voraussetzung für viele Entdeckungen in der zweiten Hälfte des 19. Jahrhunderts. Dies gilt für die Erforschung der Gasentladungsphysik oder der Kathoden- und Röntgenstahlen ebenso wie für die Entdeckung des Elektrons oder die Erzeugung von Funkwellen. Der Rühmkorffsche Hochspannungstransformator wurde auch außerhalb der Laboratorien in vielfältiger Weise verwendet, so zur Zündung von Explosivstoffen, als Zündspule für Verbrennungsmotoren oder in Schauversuchen, um Funken von spektakulärer Länge zu erzeugen. Nicht zuletzt trugen Beschreibungen in den Romanen des französischen Science-Fiction-Autors Jules Verne zur Bekanntheit des Namens bei.

Gleichwohl ist über Heinrich Daniel Rühmkorff wenig bekannt. Oft gibt es widersprüchliche Angaben, z. B. zu seinem Sterbedatum. Bisweilen wird auch der Name in der Literatur nicht korrekt geschrieben. Der Vortrag nimmt deshalb Leben und Werk dieses herausragenden Instrumentenbauers, der 1803 in Hannover geboren wurde, aber hauptsächlich in Paris wirkte, in den Blick.

5.3 What Went on in the Laboratory? Replicating the Early Hertz Experiments (experimental lecture)

Dr. Roland Wittje[1] und Wolfgang Engels[2]

1 Norwegian University of Science and Technology, Trondheim
Dep. of Physics, N-7491 Trondheim, Norway /
University of Regensburg

roland.wittje@phys.ntnu.no

2 Arbeitsgruppe Didaktik und Geschichte der Physik, Institut für Physik,
Carl-von-Ossietzky-Universität Oldenburg, D-26111 Oldenburg

wolfgang.engels@uni-oldenburg.de

More than ten years ago at the University of Oldenburg, Roland Wittje replicated Hertz's early experiments on the propagation of electric force. We will give a brief introduction to this replication and what we learned from it about the original experiments, as well as about experimental practices of the late 19th century. Main questions are: What was Hertz's starting point? How did his ideas and his experimental practices change? How do we read laboratory notes and publications differently if we actually want to do the experiment? And, not the least, which aspects of the experiment were part of common experimental practices and are therefore not made explicit in the written sources?

We will then demonstrate one of the replicated experiments. The audience will be able to get their own experience of how it sounded, smelled and looked. The original experiments are not especially suited for the lecture hall, but we believe that the audience will appreciate seeing for themselves the tiny sparks in the resonator. In addition, distinguished members of the audience will become an integral part of a very simple detector that is more suited for demonstration. Be prepared!

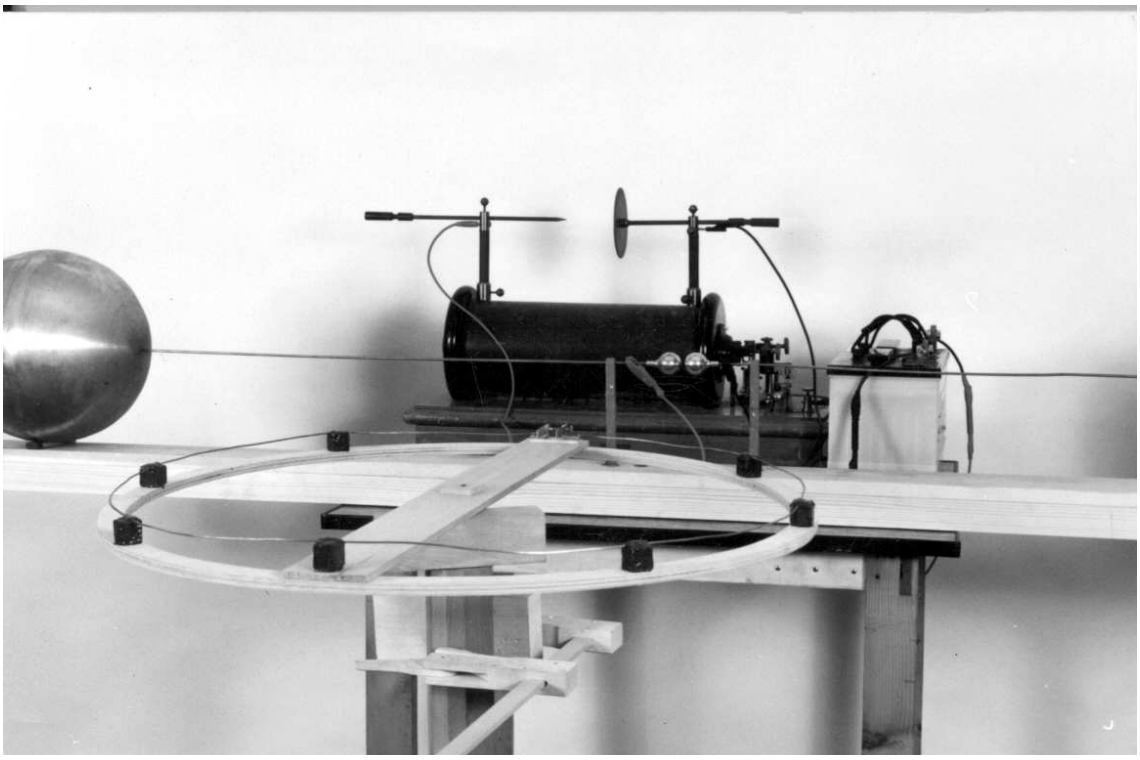

Figure 5.2:
Replicating the Early Hertz Experiments
Foto: Roland Wittje

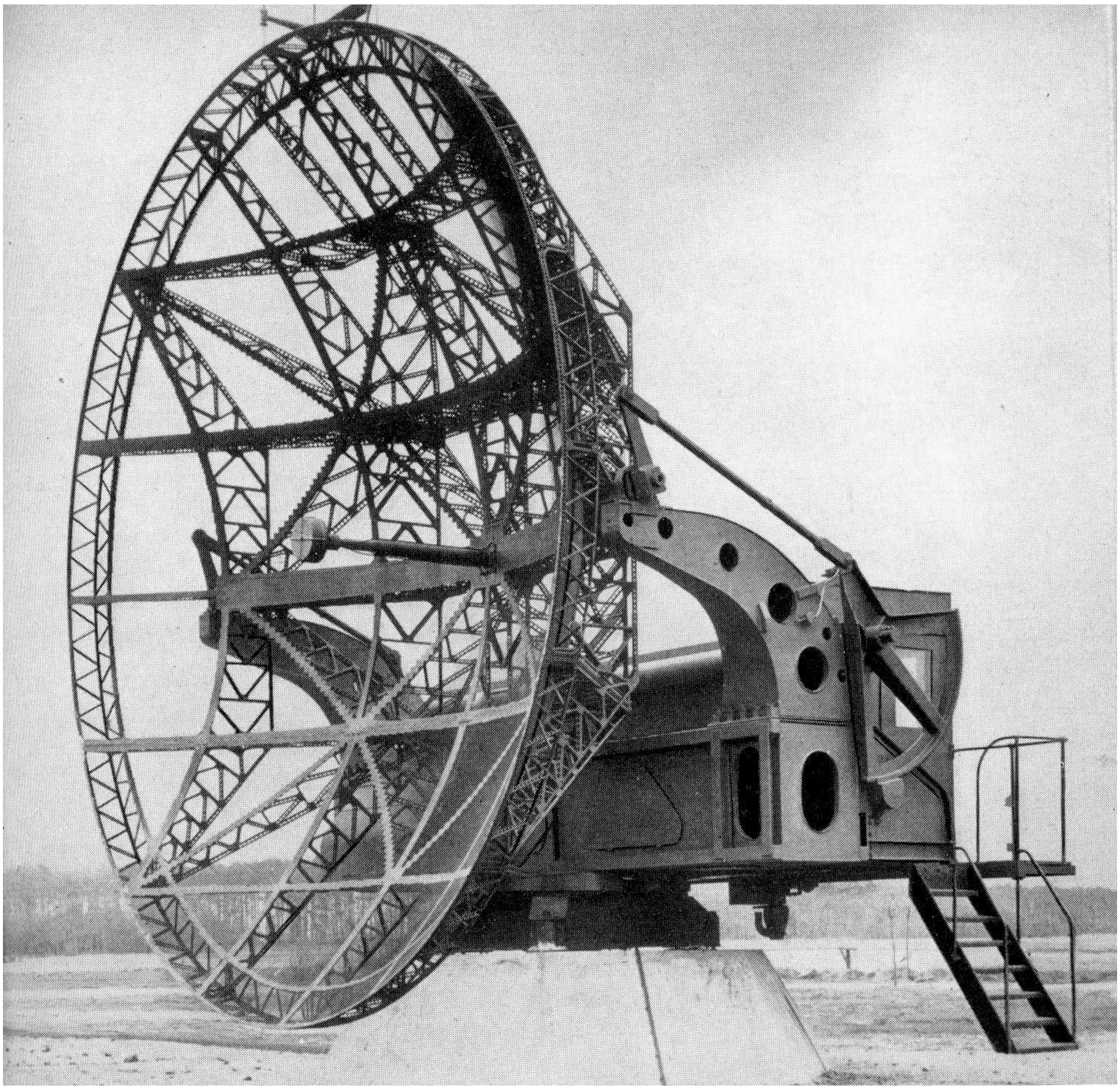

Figure 6.1:
Würzburg Riese, German radar system
used for radioastronomy after 1945

From Radar Technology to the Application of Electromagnetic Waves in Astronomy

Chairman: Gudrun Wolfschmidt

Universität Hamburg, SPGN

Hamburger Sternwarte in Bergedorf
Gojenbergsweg 112, D-21029 Hamburg

6.1 Zur Einführung elektromagnetischer Kommunikations- und Navigations-Verfahren in der deutschen Schifffahrt

Dr. Albrecht Sauer

Deutsches Schiffahrtsmuseum Bremerhaven,
Hans-Scharoun-Platz 1, D-27568 Bremerhaven,

sauer@dsm.de

Die Entdeckung elektromagnetischer Wellen und ihr technischer Einsatz führten auch in der Schifffahrt zu einer Reihe bahnbrechender Entwicklungen. Ein bald weltumspannender Seefunk revolutionierte die Kommunikation auf See – insbesondere die Versorgung mit aktuellen meteorologischen Informationen –, die Funknavigation mit ihren verschiedenen Verfahren erschloss neue wertvolle Möglichkeiten der Ortsbestimmung auch bei unsichtigem Wetter und die Entwicklung des Radars trug mittelfristig erheblich zur Kollisionsverhütung bei. Der Vortrag skizziert diese Entwicklungen in der Anfangszeit, sucht aber ebenso in zeitgenössischen Quellen nach Spuren der Rezeption dieser Neuerungen in der seemännischen Praxis.

6.2 Ir A.H. de Voogt's pioneering role as radio amateur and astronomer

Prof. Dr. Richard Strom

ASTRON, Radiosterrenwacht Dwingeloo &
Sterrenkundig Instituut 'A. Pannekoek,' University of Amsterdam
Postbus 2, NL-7990 AA Dwingeloo, The Netherlands

strom@astron.nl

By the age of 16, Anthonet Hugo de Voogt had developed a passion for amateur radio, which had probably been encouraged by his father. But whatever the spark, the flame of amateur radio burnt brightly for the young De Voogt. His hero was Marconi, but he was certainly aware of the work of Braun and others, as shown by a scrapbook of newspaper clippings. He undoubtedly knew of Hertz's achievements, but as the latter died when De Voogt was not yet 2, he would have been a less immediate figure for the young man. Amateur radio before 1910 was not for the faint hearted, but it quickly caught on (despite being illegal in the Netherlands), and De Voogt was in the vanguard of the movement. The accomplishments of the radio pioneers before 1920 (they increased public awareness, briefly had radio reception legalized before the 1914–18 war broke out, founded a society for radio telegraphy and held a hugely successful radio exposition in The Hague [even the queen attended!]) were considerable. Having obtained his electrical engineering degree (from Delft, 1916) and the 'Ir' title which went with it, De Voogt joined the Dutch PTT as an engineer, and moved steadily through the ranks to become head of the telephone district for Breda in 1939. A few weeks after the war in Europe ended in May, 1945, he was promoted to head the PTT's Radio Service. From this position in the upper echelons of the Post Office hierarchy, De Voogt's earlier passion (which had also included amateur astronomy) seems to have been rekindled, and he launched a number of initiatives to pursue radio astronomical research. The logic behind his action was that solar activity affects the ionosphere, which in its turn influences long distance radio communication. Radio observations, it was hoped, could help our understanding of, or at least be used to predict, the behavior of the active Sun. It was De Voogt who apprised Jan Oort of the possible use of an abandoned Würzburg Riese radar antenna in his search for the 21 cm H I line; it was also he who enabled Oort's nascent research group to borrow one from the PTT station in Kootwijk. One sees De Voogt's experience with early radio coming through in his initiative to protect the 21 cm hydrogen band from interference. In the end, the hydrogen observations proved far more significant than the solar work, and De Voogt's role can be seen as mainly a facilitator of research. It is somewhat ironical that it was not the solar research, with its potential application to improve radio communication, which proved successful, but rather the hydrogen work which was relevant only to pure science. One is reminded that Hertz's assessment of his own experiments is that they were "of no use whatsoever" - how difficult is it to outguess Dame Fortune!

6.3 Development of Radio Astronomy in Germany until 1970

Prof. Dr. Gudrun Wolfschmidt, Hamburg

Institute for History of Science, Hamburg University
Bundesstrasse 55, D-20146 Hamburg, Germany

wolfschmidt@math.uni-hamburg.de

After the discovery of electromagnetic waves by Heinrich Hertz (1857–1894) in 1887, one tried to find cosmic signals or extraterrestrial radio waves starting in 1896. In the 1930s, radio signals from the Milky Way and from the Sun were discovered with a system of antennas, or later with reflectors. A parabolic dish was used; in the focal point a vibration was induced in the dipole.

With the German "Würzburg-Riese" (7.5-m-reflector for RADAR), radio astronomy started after the war; especially in the Netherlands, UK and Australia. In Germany in the 1950s four centers were built up: Kiel (dipole antenna wall and 7.5-m-reflector), Freiburg (3-m-reflector and radiospectrograph), Berlin-Adlershof/GDR (36-m-transit telescope) and Potsdam/GDR (several antennas for solar radio astronomy).

Beginning in 1952, Friedrich Becker (1900–1985) started to plan a first large German radio telescope, a 25-m-reflector, Stockert, Eifel (1956). Shortly, together with Dwingeloo (25-m-reflector) it was the largest in the world. Shortly the development of amplifiers will be discussed (electronic tubes with Yagi antennas and parametric amplifiers since 1960; later Maser and transistors were introduced since the 1970s.

Very quickly the dimensions of radio telescopes were increased – a development in the direction of Big Science. Already in the 1960s one tried to get a new telescope: finally in 1971 the 100-m-diameter antenna was inaugurated (MPI for Radioastronomy, Bonn) – it was until 2000 the largest fully steerable radio telescope in the world.

6.4 Radio Astronomy in Germany – Status and Future Developments

Dr. Norbert Junkes

MPI für Radioastronomie, Bonn,
Auf dem Hügel 69, D-53121 Bonn

njunkes@mpifr-bonn.mpg.de

The development of radio astronomy in Germany in the last forty years is closely connected with the 100 m radio telescope near Effelsberg and the Max Planck Institute for Radio Astronomy (MPIfR) in Bonn. The telescope was built between 1968 and 1971 and performs radio observations in a wide wavelength range between 70,cm and 3 mm. In October 2006, the high accuracy of the observations, especially in the millimetre range, was further improved by a new secondary mirror with active surface elements.

Radio telescopes for even shorter wavelengths in the millimetre and submillimeter range were built by MPIfR, namely the 30 m IRAM telescope on Pico Veleta (Spain) and the 10 m Heinrich Hertz telescope on Mt. Graham (Arizona/USA). The latest instrument is the 12 m APEX telescope in the Chilean Atacama area, which started in 2005 with radio observations in the submillimeter regime. APEX is a precursor to the international ALMA project (Atacama Large Millimeter Array) for high-resolution studies in the highest radio frequencies accessible from ground.

The low-frequency regime in radio astronomy is covered by LOFAR, the "Low Frequency Array", a European radio telescope at meter wavelengths with a number of stations in different European countries connected via fast internet. The first German station with 96 dipole receivers was recently built at the Effelsberg site. LOFAR is the European precursor for the SKA ("Square Kilometer Array"), the international project for radio astronomy in the next decade.

6.5 Stellar music – detecting cosmic acoustic signals by electromagnetic waves (with Audio Examples)

Dr. Zoltán Kolláth

Konkoly Observatory of the Hungarian Academy of Sciences,
Konkoly Thege Miklós út 15–17, H-1121 Budapest
P.O. Box 67, H-1525 Budapest, Hungary

kollath@konkoly.hu

In radio broadcast, the modulation of radio waves by an acoustic signal is used to transmit music or speech. There exist natural processes that provide similar modulation of electromagnetic radiation. By detecting these signals and demodulating them, one can listen to cosmic acoustic signals. MHD waves in solar and planetary atmospheres provide such natural processes of radio emission. However, simple acoustic waves are also able to provide observable modulation of electromagnetic radiation, even in the optical range. Sounds can be detected from brightness variation of pulsating stars. Like earthquake vibrations, the acoustic oscillations of stars make it possible to perform seismic studies of the internal structure of heavenly bodies. We cannot hear these sounds directly, since sound does not travel in the vacuum of interstellar space, and the stellar humming is much deeper than the deepest bass tones humans can hear. By speeding up the observed light variation data, these distant infra-bass sounds become audible. The voices of stars are astonishingly interesting, providing a wide range of sounds from a simple buzz through colourful noises to strange, polyphonic booming. Going beyond just listening, these stellar audio sources can be treated as virtual musical instruments, giving a new sense to the Music of the Spheres.

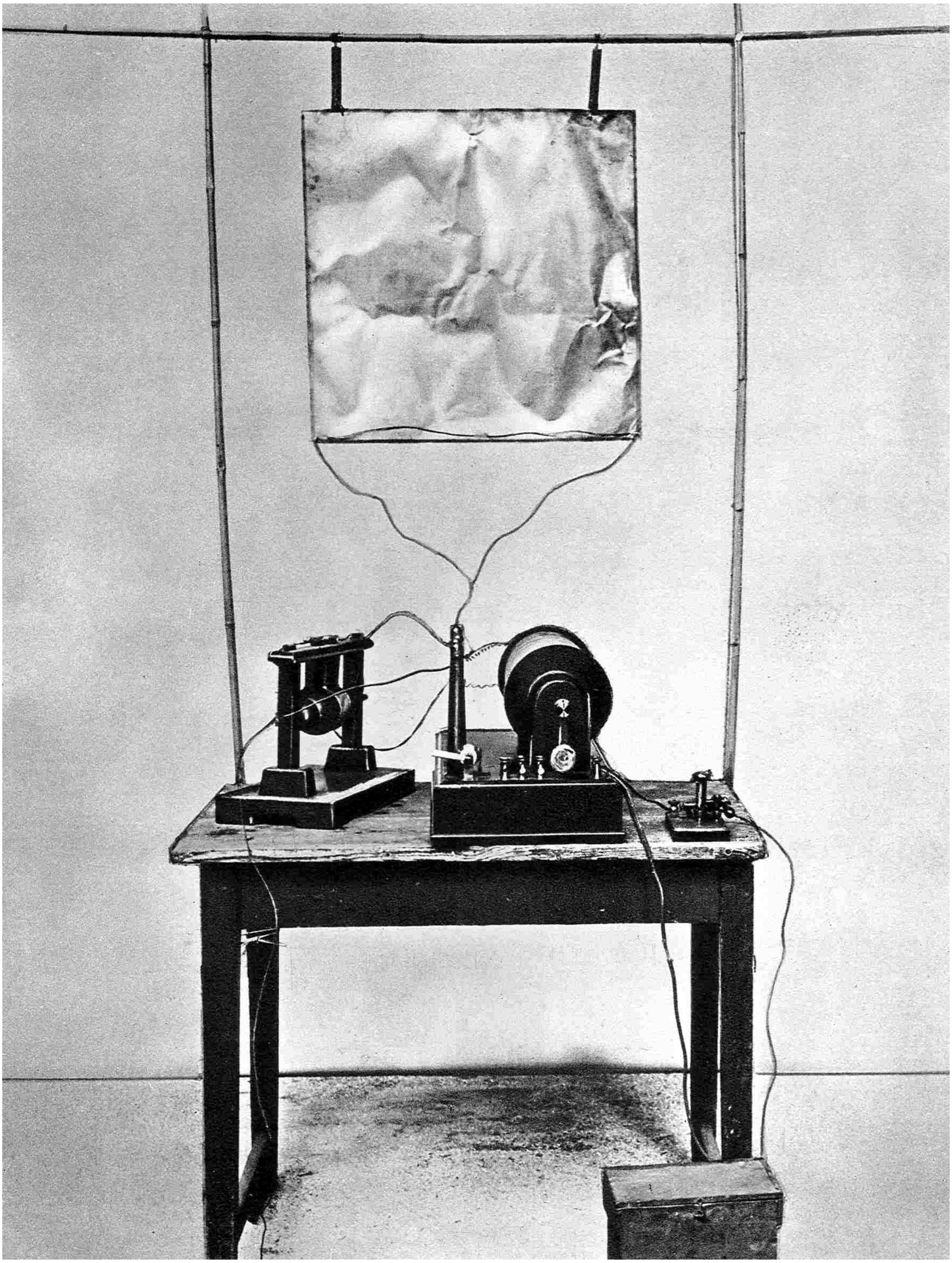

Figure 7.1:
Marconi apparatus

The Birth of Radio – Wireless Telegraphy

Chairman: Prof. Dr. Fabio Bevilacqua

Dipartimento di Fisica „A. Volta", Università degli Studi di Pavia,
Via A. Bassi, 6, I-27100 Pavia, Italy

bevilacqua@fisicavolta.unipv.it

Museum für Kommunikation
Gorch-Fock-Wall 1, D-20354 Hamburg

7.1 Die Karlsruher Experimente von Heinrich Hertz und die Rolle von Ferdinand Braun für die Entstehung der Radiotechnik in Theorie und Praxis in Deutschland und in Russland

Prof. Dr. Vitaly G. Gorokhov

Institut für Philosophie der Russischen Akademie der Wissenschaften
Volkhonka 14, 119842 Moscow
Tel. 007-495-2038607, Fax: 007-495-6099350

Vitaly.Gorokhov@itas.fzk.de

1. Heinrich Hertz – der experimentelle Beweis der Maxwellschen Theorie mit den technischen Folgen und die Verbesserung der Hertz'schen experimentellen Ausrüstung
2. Die Vervollkommnung der strukturellen Schemata für die Experimente und die Entstehung der drahtlose Telegraphie (Radiotechnik).
3. Ferdinand Braun war der erste, der wirklich verstanden hatte, was bei Radiosender und Radioempfänger elektrisch vor sich ging. Aus theoretischen Überlegungen kam Braun zu dem Schluss, die Funkenstrecke beim Sender und auch den Kohärer (an die Antenne) induktiv anzukoppeln. Das hat seinen Sender viel wirksamer gemacht und ermöglicht damit die Funkverbindung über den Atlantik. Brauns Erfindung des Kristalldetektors ersetzte bald den von Branly vorgeschlagenen Kohärer. *„Die ganze Technik des Sendens hat seit der Zeit, wo Braun den geschlossenen Kreis in die Praxis einführte, viele Wandlungen erfahren. Die Verwendung der Elektronenröhre hat eine vollständige Umwälzung gebracht und Möglichkeiten geschaffen, an die in den ersten Entwicklungsjahren kaum gedacht werden konnte.“*
4. Aufbau der radiotechnischen Theorie: Die Genesis der Theorie der Radiotechnik wird einerseits durch die naturwissenschaftliche Basisdisziplin bestimmt, andererseits durch die Vorstellungen und Aufgaben des Ingenieurs. Ihre Herausbildung geht deshalb in zwei entgegengesetzten Richtungen vor sich: erstens, durch zunehmende Konkretisierung des aus der entsprechenden Naturwissenschaft (Elektrodynamik) entnommenen theoretischen Schemas und, zweitens, vermittels der Verallgemeinerung theoretischer Teilmodelle, die in der gegebenen Technikwissenschaft im Prozess der Lösung von Ingenieuraufgaben entwickelt wurden.
5. Die drahtlose Telegraphie entwickelte sich von 1895 bis 1905 empirisch. Ferdinand Braun, der ein entschiedener Befürworter geforderten universitären Technikwissenschaft war, wollte eine technische Fakultät an der Universität Straßburg gründen. Er dachte, dass mit technischen Fakultäten innerhalb der Universitäten zusammen

mit mehreren erfolgreichen elektrotechnischen Unternehmen außerhalb „eine experimentelle und pädagogische Praxis mit klar definierten Zielen und Ausbildungsinhalten“ als eine neu zu schaffende universitäre Technikwissenschaft etabliert werden können. Er orientierte sich statt an der Theorie an den Notwendigkeiten der technischen Anwendung und entwickelte ein Programm zur Modernisierung der Physik als technische Physik. Dieses Projekt ist leider gescheitert. Die technische Physik führte an den Universitäten nur eine Art Schattendasein, obwohl die meisten Physiker im Bereich der Technik arbeiteten. Diese Ideen wirkten aber nicht nur in Deutschland sondern auch in Russland. Die engen Mitarbeiter Brauns aus Russland, L. Mandelstam und N. Papalexi, haben das Radiowesen in Russland im Sinne von Ferdinand Braun weiter entwickelt.

Dieses Abstract ist in Rahmen des RGNF-Projekts (05-03-03209a) “Methodological foundations of the technology assessment as a new complex problem-oriented and scientific-technological discipline” vorbereitet.

Information about the Author

Born in Moscow, Russia, in 1947. He studied electronic engineering and philosophy (Lomonosov University) in Moscow and received his doctoral degrees in 1975 („Methodology of Systems Engineering"') and in 1986 („Methodological Analysis of the Development of the Theoretical Knowledge in the Modern Engineering Sciences"') in the Institute for Philosophy of the Russian Academy of Sciences. He founded in 1988 Research Group for Philosophy of Technology in this Institute and is currently a leading scientist there. At the same time he is scientific coordinator of the German-Russian Postgraduate College and the International Academy for Sustainable Development and Technologies at the University of Karlsruhe, from 1.08.2006 also as visiting scientist in the Institute for Technology Assessment and Systems Analysis of the Research Center of Karlsruhe (FZK) in Germany. He was also in 1993–2000 managing coordinator of the international project for the environmental monitoring of the ecological dangerous objects and in 2001/2002 visiting professor at the economical faculty of the University of Bremen and in 2004/2005 in University Witten/Heideke. He is also from 2005 professor of the Moscow State Lomonosov University. He was published 180 articles and ten books in Russian, German and English.

7.2 Nikola Tesla's Contributions to Radio Developments

Prof. Dr. Aleksandar Marincic[1],
Zorica Civric[2] (curator)

1 Faculty of Electrical Engineering and
Serbian Academy of Sciences and Arts,
Knez Mihailova 35, RS-11000 Belgrade, Serbia

e-mail: emarinci@etf.bg.ac.yu

2 Museum of Science and Technology, Department of Electroenergetics,
Skendergebova 51, RS-11000 Belgrade, Serbia

e-mail: zorica.civric@muzejnt.org.yu

Following research and inventions into the field of polyphase low frequency alternating currents Nikola Tesla, around 1890, entered into a new field of high frequency currents. After developing novel generators capable of producing higher frequency alternating currents, he turned his attention to generating alternating currents by discharging condenser through a coil coupled to another coil – secondary of "Tesla transformer". In the three famous lectures between 1891 and 1893 he presented many new characteristics and possible uses of high frequency currents: for illumination, in medicine, industry and for wireless energy transmission. For wireless energy transmission, in 1891–1892 he developed connection of generator to antenna-ground through tuned Tesla transformer.

In 1893 he disclosed the principle of wireless energy transmission with already explained radio transmitter and receiver tuned to operating frequency of the transmitter. In 1897 Tesla submitted two USA patents on apparatus and system of electrical energy transmission, issued in 1900. These patents were used in the Supreme Court case brought by the Marconi Wireless Telegraph Company of America against the United States of America, alleging that they have used wireless devices that infringed on USA Marconi patent of June 28, 1904. After 25 years, the United States Supreme Court on June 21, 1943 invalidated the fundamental American radio patent of Marconi, as *"containing nothing which was not already contained in patents granted to Lodge, Tesla and Stone"*. However, in spite of this and many others who are recognizing Tesla as one of the radio pioneers, the inventor of the basic radio principle of four tuned circuits, Tesla's name is still waiting the full recognition of his role in the development of radio.

7.3 Highlights of amateur radio in the Netherlands to 1926

Prof. Dr. Richard Strom

ASTRON, Radiosterrenwacht Dwingeloo &
Sterrenkundig Instituut 'A. Pannekoek,' University of Amsterdam
Postbus 2, NL-7990 AA Dwingeloo, The Netherlands

strom@astron.nl

In the early twentieth century, the PTT (Post Office) had a monopoly on telegraphy in the Netherlands, the Marconi Company dominated overseas wireless communication, and private use of the airwaves was illegal. While this would seem to be an unpropitious climate for potential radio amateurs, the fatal attraction of something intriguing (and forbidden) proved irresistible to a significant minority. Early hobbyists listened in to Marconi messages before 1910, and followed the comings and goings of ships at sea. Anecdotes from these early days have been preserved in the writings of pioneers such as J. Corver and A. H. de Voogt. Because private use of the radio was banned, De Voogt built ingenious collapsible antennas which could be erected and dismantled in seconds. Corver, De Voogt and other enthusiasts formed a group nicknamed "the merry meteorologists", and later joined (perhaps "took over" would be a better description) the local Hague chapter of the Dutch amateur Society for Meteorology and Astronomy (*NVWS*). From 1912 to 1917, Corver chaired the chapter, De Voogt was its secretary, and both were active in the national organization. Grassroots pressure for the ban on private use of the airways to be lifted grew, and in 1913 the NVWS organized a meeting on the utility of radio for private users where both De Voogt and Corver spoke. It attracted widespread publicity, and several months later Corver was able to demonstrate to the Minister of Water Management, C. Lely, that by combining several freely available items, he would be breaking the law on radio. Intrigued, Lely let him demonstrate, and from a spool of wire, earphones and other paraphernalia in his pockets, Corver assembled a simple receiver which could pick up Radio Scheveningen. Lely agreed that the law forbidding private use of radio was an anachronism. In 1914 the ban was abrogated, only to be re-imposed at the end of the summer when the war broke out. Frustrated, the radio enthusiasts banded together and in 1916 formed the Dutch Society for Radio-Telegraphy (*NVVR*). Two years later the *NVVR* organized the 1st Dutch Radio Exhibition in The Hague, which attracted 1500 people a day including the queen and several ministers – an enormous success. The membership of the NVVR grew dramatically in this period, further stimulated by the early broadcasts of H. Steringa Idzerda. His regular *Radio Soirée-musicale* programs (station PCGG, 1919–1924) were arguably the first commercial broadcasts anywhere. By the mid-1920s, public broadcasting in the Netherlands began in earnest, private individuals were finally allowed to own radio equipment, and the *NVVR* celebrated its 10th anniversary: the pioneering days of amateur radio were over.

7.4 Wilhelm II. and Radio Technology

Prof. Dr. Wolfgang König

Technische Universität Berlin, Institut für Philosophie, Wissenschaftstheorie, Wissenschafts- und Technikgeschichte, Straße des 17. Juni 135, D-10623 Berlin

wolfgang.koenig@tu-berlin.de

Contemporaries and historians interprete Wilhelm II. as well as a reactionary and a modern. Among his modern activities, technology played a central role. Concerning radio, Wilhelm sent his technological consultant and intimate friend Adolf Slaby to England to observe Guglielmo Marconi's successful radio trials at Bristol Channel in 1897 and supported Slaby's own experiments when being back in Berlin. Wilhelm arranged very early for supplying his yacht "Hohenzollern" as well as the Imperial battle fleet with radio technology. And he supported industry's and government's initiatives for fighting Marconi company's supremacy in worldwide telegraphy. His interest in radio technology culminated between 1897 and 1903, afterward, it diminished. My contribution will argue that the Kaiser's interest and activity with radio originated in his egomania and neomania and his inability to establish and perform continuous politics towards technology and industry.

7.5 Telegraphy Without Wires – Technical Prerequisites and Economic Significance of the Early Radiotelegraphy

Prof. Dr. Horst A. Wessel

Heinrich Heine-Universität Düsseldorf, Philosophische Fakultät –
Abteilung Wirtschaftsgeschichte
Mannesmannröhren-Werke GmbH / Mannesmann-Archiv,
Wiesenstraße 36, D-45473 Mülheim a. d. Ruhr

horst.a.wessel@mrw.de

The open to the public telegraphy in Germany since the middle of the 19th century had become independent of weather conditions and made communication much faster than by optical telegraphy or letter mail, but it was wire-bound and required fixed stations. Despite the sea bridging cables, ships outside of the sight of the shore of continents or islands were not within reach of communication. An economically efficient operation as well as effective calls for aid in emergencies was thus not possible.

Not even ten years after Hertz had proven the existence of electromagnetic waves which Maxwell hat theoretically described, were these used by Popow and Marconi to transmit messages. The sea-going ships, but also other moving transport equipment such as the railroads, were thus integrated directly into the high-speed communication network. This contribution examines the technical prerequisites, the beginnings of the development and the economic effects.

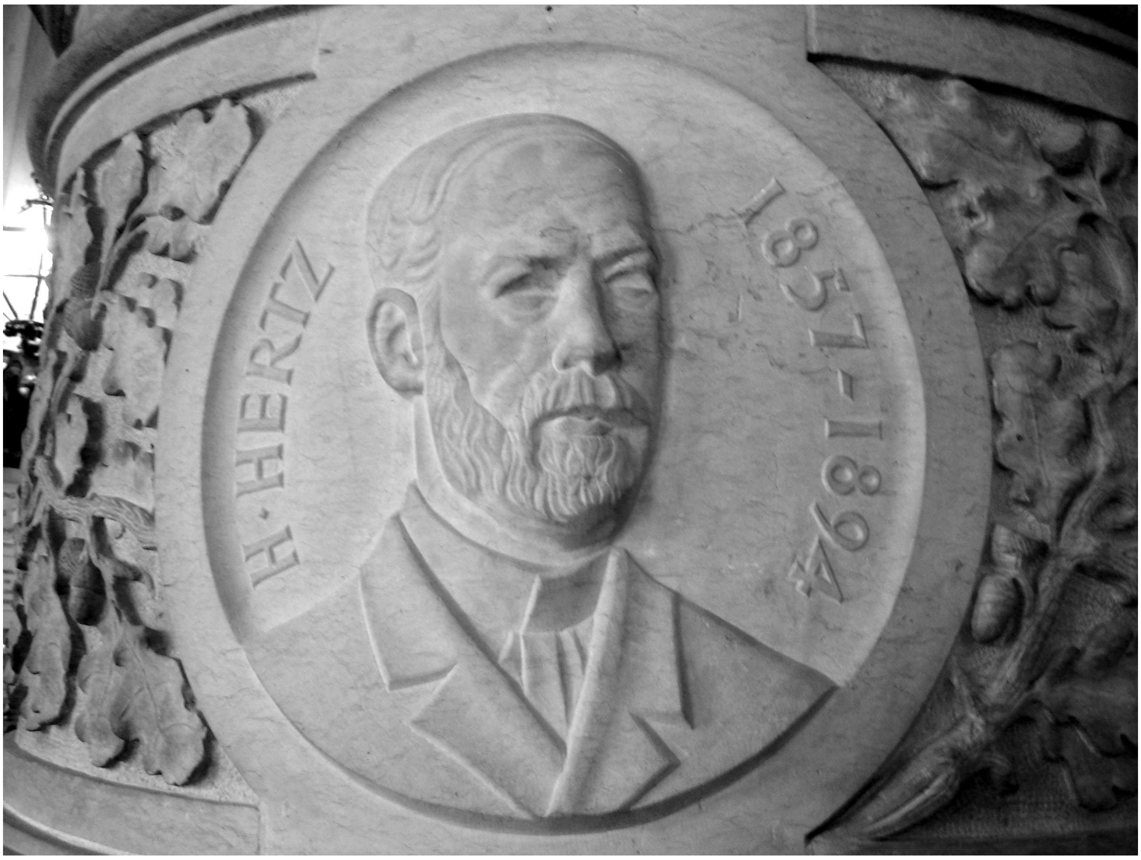

Figure 8.1:
Heinrich Hertz medaillon in Hamburg's city hall

Foto: Gudrun Wolfschmidt

Heinrich Hertz (1857–1894) – Life and Impact

Chairman: Prof. Dr. Claus Peter Ortlieb

Department Mathematik, Universität Hamburg
Bundesstrasse 55, D-20146 Hamburg, Germany
ortlieb@math.uni-hamburg.de

Museum für Kommunikation
Gorch-Fock-Wall 1, D-20354 Hamburg

8.1 The Hertz family – Protestants with a Jewish name

Dr. Stefan Wolff

Deutsches Museum,
D-80306 München, Germany

S.Wolff@deutsches-museum.de

The father of Heinrich Hertz was born as a child of a Jewish family in Hamburg in 1827. In the age of seven he became baptized Protestant together with his parents. This step was necessary to get the full civil rights at that time. Later he became a lawyer and married a woman who descended from a traditional Protestant family of Frankfurt. Therefore their son Heinrich Hertz was also a Protestant and had no connection to Judaism any more. At his time he did not have disadvantages because of his partly Jewish background.

In the NS-era, however, Hertz became a so-called Half-Jew posthumously. Monuments remembering him disappeared and at many places his name was not worth to designate institutions of science and education any longer. Even the use of his name for the unit of frequency was questioned. His assistant Lenard connected Hertz' theoretical research with his Jewish part of his race. According to the law of the so-called "Restitution of the Civil Service" his younger daughter Mathilde lost her Venia legendi at Berlin University as well as her position at the Kaiser Wilhelm institute as a "Non-Aryan" in 1933. Two years later she emigrated with her mother and her older sister to England. Heinrich Hertz' nephew, the Nobel Prize winner Gustav Hertz, remained in Nazi-Germany. He came to a kind of arrangement and continued his research at Siemens Company.

The history of the Hertz family illustrates that the racial laws of Nazi Germany did not concern the Jewish population only but also those Non-Jews who had Jewish ancestors. A lot of them belonged to the educated middle class. They were children or grandchildren of university-trained men who had married daughters of such and where one of them had a Jewish background.

Die Familie Hertz – ein jüdischer Name

Der Vater von Heinrich Hertz stammte aus einer jüdischen Familie und durch den Namen blieb diese Herkunft ganz unabhängig von der Zugehörigkeit zur evangelischen Religion weiterhin erkennbar. In der Laufbahn von Heinrich Hertz spielte dieser Umstand kaum eine Rolle, aber in der Zeit des Nationalsozialismus stand die Art der Erinnerung an ihn, den großen deutschen Naturforscher zur Disposition. Sogar die nach ihm benannte Frequenzeinheit wurde dabei in Frage gestellt. Die Haltung seines Schülers Lenard mag symptomatisch für die rassistischen Anschauungen des Nationalsozialismus sein, wenn dieser das jüdische Erbe von Hertz mit dessen theoretischen Untersuchungen in Verbindung brachte. Die beiden Töchter von Hertz, die Ärztin Johanna und Mathilde Hertz emigrierten nach England. Der Neffe Gustav Hertz versuchte sich nicht ohne Schwierigkeiten zu arrangieren.

8.2 The Concept of 'Ether' in Hertz's Kiel Lectures and its Meaning for the Concept of Space

Priv.-Doz. Dr. Frank Linhard

Institute for the History of Science / Department of Physics,
Johann Wolfgang Goethe-University
Robert-Mayer-Str. 1, D-60054 Frankfurt am Main

F.Linhard@em.uni-frankfurt.de

When Heinrich Hertz was appointed as a Privatdozent in Kiel in 1884 he had to work as a theoretical physicist without a laboratory. Hertz started to do conceptual work on the foundations of physics, which led to his lectures on the "Constitution of Matter". In this lecture series Hertz develops major concepts for his later work on the transmission of electrical waves through space, but on the foundations of his final work on the mechanical foundations of physics as a whole, as well. For his theoretical work on electrodynamics the conception of the 'ether' seems of paramount interest. Especially the questions of "action at a distance" are closely connected to these issues. Hertz did not come to a final conclusion concerning the questions of the 'ether', and he described the attempt to deduce the equations for movement in it from the laws of mechanics as 'too early' (verfrüht). The talk will sketch Hertz's ether conception of the Kiel Lectures and show the connections to the Hertzian notion of space.

8.3 Hertz's dilemma of the different velocities of transmission of electromagnetic waves in air and along wires. Why did he get the results he got?

Dr. James G. O'Hara

Leibniz-Archiv, Gottfried Wilhelm Leibniz Bibliothek /
Niedersächsische Landesbibliothek,
Waterloostrasse 8, D-30169 Hannover,
Tel. +49 (0)511 1267 323, Fax +49 (0)511 1267 202

webmaster@oharas.com

In his celebrated 1888 experiment on standing waves Hertz found the velocity of transmission along a wire line to depend on wavelength and to differ from that for wireless transmission, a result that was in contradiction to theory. Hertz called on others to repeat the experiments and verify or refute this unexpected and disturbing result. In Dublin George Francis Fitzgerald and associates repeated and elaborated Hertz's experimental discoveries. For wire transmission their results were in good agreement with those of Hertz.

In Geneva Edouard Sarasin and Lucien de la Rive obtained the result required by theory. Hertz looked for an explanation of his own results in the ambient conditions of his apparatus. He corresponded with both Fitzgerald and with the Genevan scientists. These letters are an important historical source in reconstructing the circumstances of Hertz's experiment.

8.4 Hertz on Meteorology: A Lasting Contribution and a Remarkable Inaugural Lecture

Dr. Joachim Pelkowski

Am Schlossberg 1, 61239 Ober-Mörlen,
Tel.: 06002-7606, Fax: 06002-7606

jo-ellen.pelkowski@t-online.de

Aside from one theoretical monograph, no single textbook on atmospheric thermodynamics has appeared in which thermodynamic diagrams are not made the subject of specialized discussion. Heinrich Hertz introduced the first such diagram into meteorological thinking, a “graphic method” to translate the mathematical state of a moist particle of air, undergoing thermodynamic variation without exchanging heat with its surroundings, into a pictorial representation of its possible states within an atmosphere of given condition. After he had introduced this new method in 1884, his diagram was redone in 1900 with improvement of details, and from then on thermodynamic diagrams proliferated, becoming a standard tool for evaluating the results of atmospheric soundings. This is certainly Hertz's lasting contribution to meteorology. His interest in meteorology had led him to investigate, while he furthered his particular physical interests in his younger years, different meteorological problems. A striking testimony of that curiosity is his inaugural lecture “On the Energy Balance of the Earth”, delivered at Karlsruhe in 1885, only recently rescued from oblivion, and in which Hertz drafts a vivid diagram of the then known energies involved in meteorological processes, showing a clear understanding of what is “the final aim of meteorological radiation research”. The lecture is a fine example of Hertz's catholic mind, and I shall, together with his famous diagram, discuss it for being likely the first instance of what has become the basic scheme underlying any assessment of “global warming”.

8.5 The Communication Museum Hamburg says "Ahoy"!

Guided tour through the Museum für Kommunikation

Dr. Oliver Rump

Director of the Museum für Kommunikation Hamburg
Gorch-Fock-Wall 1, D-20354 Hamburg
Tel. +49 (0)40 357636-0, Telefax +49 (0)40 357636-20

http://www.museumsstiftung.de
o.rump@mspt.de

Using this old seamanlike interjection at the beginning is no hazard. Hamburg – that means life next to the water, means harbour and trade, there are ships and people coming from all over the world. In addition, Hamburg stands for communication, for exchanging messages, news, information. A trip through the museum takes you along the history of communication. There is no strict chronological way you have to follow because the exhibition is based on the elements of earth, water and air.

Join the tideland post-vehicular on its way to the island Neuwerk, go for a ride with fast post-steamers and look through the eyes of a carrier pigeon on the hectic world lying beneath it. Thereby, you will meet the different varieties of human communication, from papyrus to satellite telephone, from pneumatic post to Internet. Of course, you will find Hamburg's particularities like the "Barkassenpost" in the famous harbour, the coffeetest-letterbox or the tram-post.

Figure 8.2:
Communication Museum Hamburg

Figure 8.3:
Communication Museum Hamburg

Figure 9.1:
Electronic tube, Siemens

Development of Communication Technology: From Tube to Digital Technology

Chairman: Prof. Dr. Hans-Joachim Braun

Universität der Bundeswehr Hamburg,
Professur für Neuere Sozial-, Wirtschafts-und Technikgeschichte,
D-22039 Hamburg

hjbraun@unibw-hamburg.de

Museum für Kommunikation
Gorch-Fock-Wall 1, D-20354 Hamburg

9.1 Thereminvox: The Career of a Unique Electronic Musical Instrument (with Audio Examples))

Prof. Dr. Hans-Joachim Braun

Universität der Bundeswehr Hamburg,
Professur für Neuere Sozial-, Wirtschafts-und Technikgeschichte,
D-22039 Hamburg, Germany
Tel. +49-40-65412794, Fax +49-40-65412084

hjbraun@unibw-hamburg.de

The thereminvox or aetherophon, designed and built by the Russian physicist and cellist Lev Termen in 1920, created quite a sensation at the time. The audience found the fact that the instrument produced sound <from the air> fascinating. But because the instrument is very difficult to play well and the sound can be somewhat enervating the instrument's career was not as successful as his inventor had wished. However, in recent years the instrument has become more popular again and is even used in pop music and in jazz. The paper will investigate the technological and aesthetic aspects of the theremin's career and will illustrate this with audio examples.

9.2 Das Heinrich-Hertz-Institut und die Pionierzeit der "Elektrischen Musik" in Berlin

Peter Donhauser

Technisches Museum Wien,
Mariahilfer Straße 212, A-1140 Wien, Austria

peter.donhauser@tmw.at

Die Entwicklung elektrischer Musikinstrumente in Deutschland ist untrennbar mit zwei Berliner Institutionen verbunden: der Rundfunkversuchsstelle und dem 1928 nahe der heutigen Technischen Universität gegründeten "Heinrich-Hertz-Institut für Schwingungsforschung" ("HHI"). Ziel dieser weltweit einzigartigen Institution war die Erforschung von Schwingungsphänomenen jeglicher Art. Besondere Schwerpunkte waren die Akustik (vom Musikinstrument bis hin zum Großstadtlärm), die Telegraphie und vor allem die Hochfrequenztechnik.

Oskar Vierling, der seit 1928 am HHI tätig war, sollte sich in der Folge als treibende Kraft bei der Entwicklung "Elektrischer Instrumente" am HHI entwickeln. Er arbeitete u. a. auch am Physikalischen Institut der Berliner Universität unter Walther Nernst an der Entwicklung des "Neo-Bechstein Flügels". Seine ersten eigenen Ergebnisse stellte er 1931 auf der "Zweiten Tagung für Rundfunkmusik" in München vor. Das HHI organisierte auch 1931 und 1932 ausgedehnte Präsentationen der neuen "Elektrischen Instrumente" bei der Berliner Funkausstellung, bei der auch experimentelle Konstruktionen vorgestellt wurden wie ein Lichtbogeninstrument oder ein Theremin-Zusatz für Rundfunkempfänger.

Aufgrund der politischen Entwicklung ab 1933 blieb auch das HHI nicht von Säuberungen verschont. Immerhin gelang noch einmal 1933 eine große Präsentation der elektrischen Instrumente bei der Berliner Funkausstellung. Vierling arbeitete unterdessen unermüdlich am HHI weiter an neuen Instrumentenkonstruktionen. 1936 kam die (unter anderem mit Mitteln der NS Organisation "Kraft durch Freude" und des Amtes "Feierabend") errichtete elektronische "KdF Großtonorgel" prominent heraus. Im gleichen Jahr präsentierte Förster die endgültige Version von Vierlings elektrischem Flügel "Elektrochord". Er arbeitete auch an Großlautsprecherinstallationen für NS Massenveranstaltungen: so errichtete er 1938 anlässlich der Wintersonnenwende auf der Burg zu Nürnberg eine Großanlage. Auch Harald Bode, der nach dem Krieg vor allem in den Vereinigten Staaten reussierte, arbeitete am HHI zusammen mit Vierling, z. B. am "Melodium".

Vierling trennte sich 1938 vom HHI. Er nahm nach seiner Habilitation eine Stellung an der Technischen Hochschule in Hannover an. Das war zugleich aber auch das Ende der Entwicklungstätigkeit elektronischer Instrumente am HHI: mit Vierlings Ausscheiden wurde die bisher aktive Gruppe "Elektrische Musik" aufgelöst.

9.3 Development of electronic tubes (Die Geschichte der Elektronen-Röhre)

Prof. Dr. Joachim Goerth

Hochschule für Angewandte Wissenschaften Hamburg (HAW)
Berliner Tor 5, D-20099 Hamburg

Goerth@etech.haw-hamburg.de

The state of the art of gas discharge tubes of the late 19th century led to Röntgen and Braun tubes and, pushed by the demand for telephone repeaters and sensitive wireless detectors, to the amplifying and rectifying tubes in the beginning 1900's. These electron tubes developed from delicate instruments into rugged industrial products till the end of World War I to meet the urgent requirements for military communication. This was possible, because a lot of theoretical work had been done thanks to Richardson, Langmuir, Schottky, van der Bijl, Barckhausen and others and because many manufacturing processes could be adopted from the incandescent lamp industry.

In the 20es and 30es the proceeding was carried mostly by the upcoming radio broadcasting, and a huge amount of radio tubes emerged. In the same time began what is called electronics, the key components of which were various kinds of tubes. During World War II special tubes for very high frequency use were built for radar applications.

In the 50es and 60es tubes were optimized regarding electrical and manufacturing parameters; the largest quantities were used in radio and television sets. But the competition by the transistor became increasingly severe. Transistors and integrated circuits made tubes for entertainment sets vanish about 1970. Just now we observe the replacement of Braun's tube by liquid crystal displays.

9.4 Mathematics – for improving the construction of valves

Dr. habil. Renate Tobies

Historisches Seminar, Technische Universität Braunschweig,
Schleinitzstr. 13, D-38023 Braunschweig

r.tobies@tu-bs.de

The vacuum tube (valve) was invented without mathematics. The famous Barkhausen tube equation, which connects the important characteristics of a valve (mutual conductance, penetration factor, internal resistance), was also found empiric. But in the 1920s, when the mass production of tubes – as a result of the development of wireless broadcasting and communication – began, mathematics was used in order to get reproducible products for mass production and to design better valves. There is a good analysis of the mathematical foundations of Communications in the Bell Labs (Millman 1984). The lecture will show that mathematics became an integral part of process of cognition also in German industrial electronic tubes laboratories (Osram, Telefunken). The analysis of laboratory reports reveals the international nature of the mathematical approach for solving technical and economic problems, and shows that women could as individuals play a decisive role as mathematical consultants. Thornton C. Fry (1892–1991), who created a special Mathematical Research Department at Bell Telephone Laboratories in the late 1920's, talked about "the fewness of the mathematicians" and only about "men of this type" in 1941. Iris Runge (1888–1966), who worked in research laboratories of Osram and Telefunken from 1923 to 1945, wrote in 1937: *„Ich mag gern rechnen und mathematische Überlegungen anstellen und tue das für den besseren Bau von Rundfunkröhren"* (I like calculating and mathematical cogitation and do this for improving the construction of broadcast vacuum tubes.) The position and mathematical approach of Runge will be described and compared with that of mathematical researchers in other industrial labs.

In the United States, there is a theory in the history of technology which reduces mathematics to an ancillary science (Hilfswissenschaft). It began with Eugene Ferguson in 1992, who argued that despite modern technical advances, good engineering is still as much a matter of intuition and nonverbal thinking as of equations and computation. Maybe there are differences in different engineering disciplines. Fry (1941, 1964) placed emphasis on mathematics not only as a tool, but also as method and language.

The mathematical approach for solving technical problems was international; as John R. Carson (1886–1940), a member of the above-mentioned Mathematical Research Department at Bell Telephone Laboratories, described in 1936: *„The art consists in seeing how to go at the problem; in knowing what simplifications and approximations are permissible while leaving the essential problem intact, in precise formulation in mathematical terms, and finally, in reducing the solution to a form immediately in physical and engineering terms."* That is modern Technomathematics (industrial mathematics) at a time when the computer did not yet exist.

9.5 Society on the move: The success story of the mobile phone

Dr. Erika Linz

Collaborative Research Center (SFB/FK 427) "Media and Cultural Communication"',
University of Cologne, Bernhard-Feilchenfeldstr. 11, D-50969 Köln and
Bonn-Aachen International Center for Information Technology (B-IT)

http://www.fk-427.de
e.linz@uni-koeln.de

In only one decade the mobile telephone has become an integral part of our daily life. In many countries the number of mobile phones exceeds the number of inhabitants. Its success is not restricted to Western societies but extends to all continents. Particularly in developing countries the diffusion of mobile phones has often overtaken the diffusion of fixed-line phones and the internet.

First developed as a car-phone system, mobile communication technology has long been seen primarily as a technology for communication on the move. However, the mobile phone does not chiefly owe its unprecedented expansion to its potential for increased mobility but rather to its potential for constant accessibility. The advantages of perpetual connectedness have initiated a fundamental change that affects all areas of social organization and social practices: from family life to the workspace, from personal relationships to the sociopolitical realm. Mobile communication technology is not only starting to transform our communication practices but also our conception of the private and the public sphere as well as our attitude to place and time.

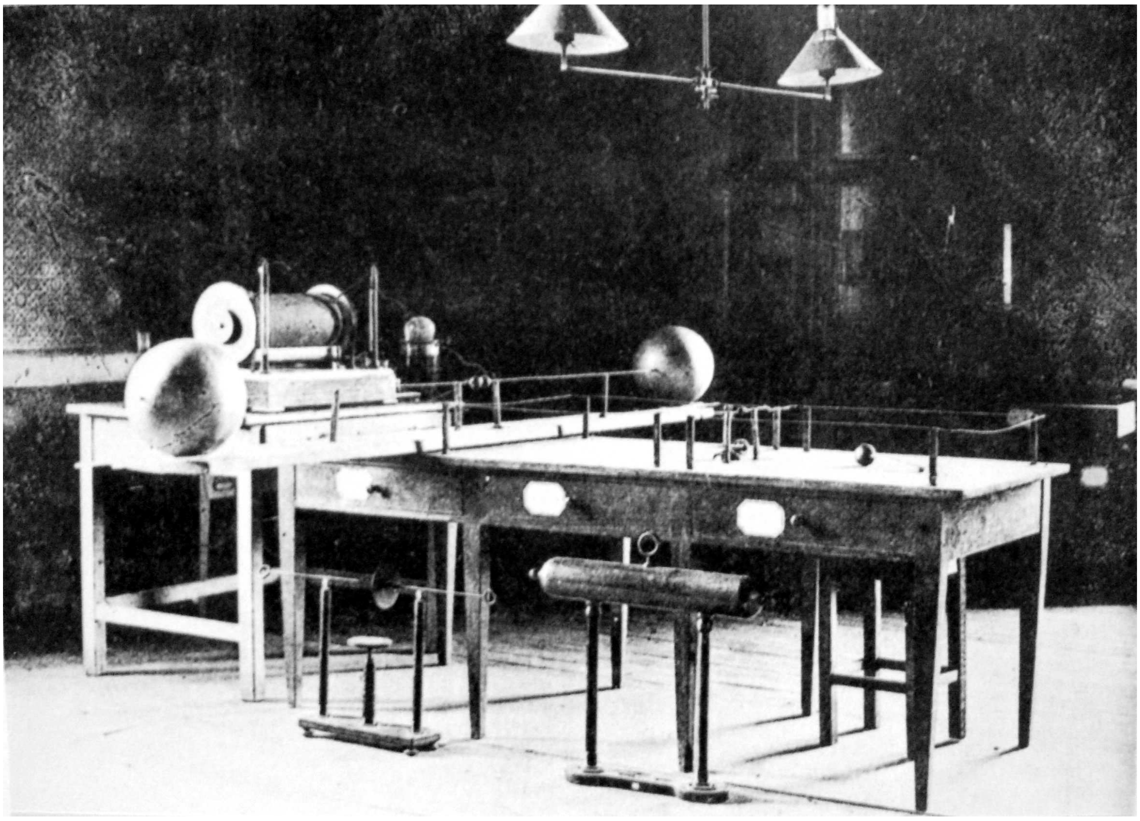

Figure 9.2:
The large oszillator of Heinrich Hertz

Closing remarks

Prof. Dr. Roger H. Stuewer

University of Minnesota, Program in History of Science and Technology,
Tate Laboratory of Physics, University of Minnesota,
116 Church Street SE, Minneapolis, MN 55455 USA,
Phone Number: 612-624-8073, Fax Number: 612-624-4578

rstuewer@physics.umn.edu

Museum für Kommunikation
Gorch-Fock-Wall 1, D-20354 Hamburg

Heinrich Hertz: Places of Life and Social Impact – Heinrich Hertz: Orte des Erinnerns in Hamburg

- Geburtshaus von Heinrich Hertz – Birthplace of Heinrich Hertz
  Poststraße 20, D-20354 Hamburg
  (Gedenktafel der Patriotischen Gesellschaft ab 8. Oktober 2007 –
  Memorial tablet of the "Patriotische Gesellschaft" since October 8, 2007
- Haus der Jugendzeit – House of his youth:
  Magdalenenstr. 3, Rotherbaum
  (privat, keine Besichtigungsmöglichkeit – private, no visits inside)
- Gelehrtenschule des Johanneums Hamburg (Gymnasium),
  Maria-Louisen-Straße 114, D-22301 Hamburg-Winterhude
- Familiengrab – Family Grave:
  Friedhof Ohlsdorf / Ohlsdorf Cemetery Q 25, 1-6
  (ca. 100m nw. Wasserturm – 100m nw. of Old Watertower)
- Portrait (Medaillon) – portrait medaillon):
  Rathaus, Eingangshalle – Town Hall, entrance hall
- Heinrich-Hertz-Turm – Heinrich-Hertz TV tower
  (Messehallen, nahe Bahnhof Dammtor – Hamburg fair, near Dammtor station
  5 min. walk from IGN, half way between Institute of Physics and IGN)
- Gebäude der ersten Heinrich-Hertz-Schule –
  Building of the first Heinrich-Hertz-School
  („Reform-Realgymnasium"): Architekt / archtect: Albert Erbe, 1908,
  Bundestraße 58, D-20146 Hamburg (gegenüber IGN / Geomatikum –
  opposite IGN / Geomatikum)
- Heinrich-Hertz-Schule
  Grasweg 72–76, D-22303 Hamburg
- Skulptur Ätherwelle im Eichenpark am Alsterufer –
  Sculpture „airwave" in Eichenpark near Alster shore
  Jüdischer Künstler / jewish artist: Friedrich Wield (1880–1940), 1931/33

Index