



Figure 0.1:
Portrait of Heinrich Hertz (1857–1894)
Painting in the Department of Physics, Hamburg University
Photography: Robert Klanner

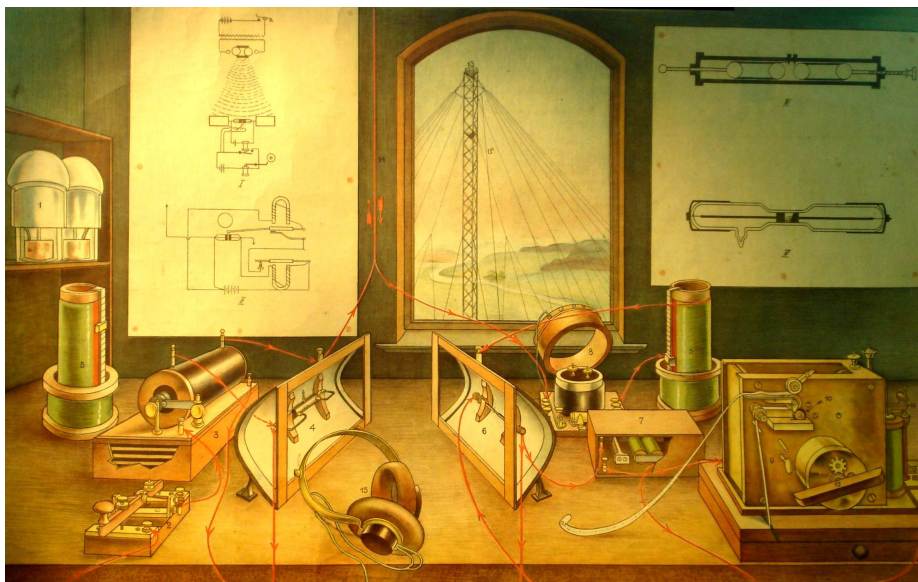
Nuncius Hamburgensis
Beiträge zur Geschichte der Naturwissenschaften
Band 10

Gudrun Wolfschmidt (ed.)

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

**Proceedings of the Symposium
for History of Science**

Hamburg, October 8–12, 2007



Norderstedt bei Hamburg 2008

Nuncius Hamburgensis

Beiträge zur Geschichte der Naturwissenschaften

Hrsg. von Gudrun Wolfschmidt,
Bereich Geschichte der Naturwissenschaften, Mathematik und Technik,
Department Mathematik, MIN-Fakultät, Universität Hamburg
ISSN 1610-6164

*Diese Reihe „Nuncius Hamburgensis“
wird gefördert von der Hans Schimank-Gedächtnisstiftung.
Dieser Titel wurde inspiriert von „Sidereus Nuncius“ und von „Wandsbeker Bote“.*

Wolfschmidt, Gudrun (ed.):
Heinrich Hertz (1857–1894) and the Development of Communication.
Proceedings of the Symposium for History of Science.
Hamburg, October 8–12, 2007.
Nuncius Hamburgensis – Beiträge zur Geschichte der Naturwissenschaften; Band 10
Herstellung und Verlag: Books on Demand GmbH, Norderstedt 2008
(ISBN 978-3-8370-3141-6).

Web page of the symposium:
<http://www.math.uni-hamburg.de/spag/ign/events/hertz07.htm>

*Figure on the cover in front and on the title page:
Hertz' discovery of electromagnetic waves
Museum für Kommunikation – Foto: Gudrun Wolfschmidt*

*Figure frontispiece:
Portrait of Heinrich Hertz (1857–1894),
Painting in the Department of Physics, Hamburg University*

*Figure on the back of the cover:
Cover back page: Advertisement of Telefunken (founded in 1903)*

*Zu besonderem Dank verpflichtet sind wir gegenüber der Behörde für Wissenschaft und
Forschung Hamburg (BWF), die das Symposium und den Druck der Proceedings unter-
stützt hat.*

Bereich Geschichte der Naturwissenschaften, Mathematik und Technik (SPGN),
Fachbereich Mathematik, Universität Hamburg
Bundesstraße 55 – Geomatikum, D-20146 Hamburg

Contents

Preface of the editor <i>Gudrun Wolfschmidt</i>	15
Welcome address <i>Staatsrat Dr. Roland Salchow</i>	17
Welcome address <i>Prof. Dr. Arno Frühwald</i>	21
Heinrich Hertz: Life, Work, and Influence <i>Roger H. Stuewer (Minneapolis, MN, USA)</i>	23
HEINRICH HERTZ (1857–1894) – PHILOSOPHY OF SCIENCE	29
Verlust der Welt im Bild: Ursprung und Entwicklung des Bildbegriffes bei Hermann von Helmholtz und Heinrich Hertz <i>Gregor Schiemann (Wuppertal)</i>	31
1.1 Bildhaftes im Zeichen. Elemente von Helmholtz’ Wissenschaftsauffassung bis etwa zum Beginn der 70er Jahre	32
1.2 Zeichenhaftigkeit im Bild. Elemente in Helmholtz’ Wissenschaftsauffassung seit etwa dem Beginn der 70er Jahre	36
1.3 Bildervielfalt der Zeichen.Hertz’ Wissenschaftstheorie in den „Prinzipien der Mechanik“ (1894)	40
1.4 Schluß	47
1.5 Literatur	49
Heinrich Hertz und das Konzept des mathematischen Modells <i>Claus Peter Ortlieb (Hamburg)</i>	53
2.1 Der Modellbegriff	53
2.2 Die Anfänge: Identität von Mathematik und Natur	56
2.3 Kants Neubestimmung des Verhältnisses von Mathematik und Naturwissenschaft	61
2.4 Verlust der Eindeutigkeit im 19. Jahrhundert	63
2.5 Anforderungen an Modelle	65
2.6 Grenzen mathematischer Naturerkenntnis	68
2.7 Literatur	70

The Implausible Story of	
How Heinrich Hertz Influenced Ludwig Wittgenstein	
<i>Allan Janik (Innsbruck)</i> 73	
3.1	Works Consulted 79
Hertz, Wittgenstein, and the Instrumentalist Turn	
in the Philosophy of Science	
<i>John Preston (Reading, England)</i> 81	
4.0.1	Hertz’s Kantian Presentation 82
4.0.2	The Status of the Rival Systems of Mechanics 84
4.1	The Status of Hertz’s own Fundamental Law 86
4.2	The Status of Hertz’s Concealed Masses 87
4.2.1	Philosophy of Science in the <i>Tractatus</i> 89
4.2.2	‘Principles of Nature’ 89
4.2.3	Systems of Mechanics 90
4.2.4	Conclusion: Hertz’s Anti-realism, and Wittgenstein’s 92
4.2.5	References 92
Hertz’s methodology and its influence on Einstein	
<i>Giora Hon (Haifa, Israel) and</i>	
<i>Bernard R. Goldstein (Pittsburgh, USA)</i> 95	
5.1	References 104
“Pictures”, “Bumps”, and Structures:	
Heinrich Hertz, Ludwig Wittgenstein and	
Concepts of Fuzziness in Epistemology	
<i>Rudolf Seising (Vienna)</i> 107	
6.1	Introduction 108
6.2	Heinrich Hertz’s epistemological system
	in the <i>Principles of Mechanics</i> 109
6.3	Wittgenstein I 111
6.4	Wittgenstein II 113
6.5	Heinrich Hertz’s epistemological system
	in <i>The Constitution of Matter</i> 116
6.6	The Theory of Fuzzy Sets and Systems 117
6.7	Computing with Words and the Computational Theory of Perceptions . . 121
6.8	The Structuralist View of Science 123
6.9	A Fuzzy Structuralist View of Science 125
6.9.1	Fuzzification: From Phenomena to Perceptions 126
6.9.2	Defuzzification: From Perceptions to Models 126
6.9.3	Theoretization: From Phenomena to Models 126
6.10	Outlook: Hertz’s pictures, Wittgenstein’s family resemblances, and Zadeh’s
	fuzzy sets 128
6.11	References 130

ELECTROMAGNETISM AND ELECTRODYNAMICS – THEORY AND EXPERIMENT	133
Some experimental uses of sparks – 18th century electricity research <i>Peter Heering (Oldenburg)</i>	135
7.1 Introduction	135
7.2 Some general aspects of 18th century electrical experiments	136
7.3 Generating electricity	137
7.4 The Leyden jar	139
7.5 Experimenting with electrical devices	139
7.6 Lightning as an electrical phenomenon	145
7.7 Conclusion	146
Heinrich Hertz between the older electrodynamics and Maxwell’s theory <i>Karl Heinrich Wiederkehr (Hamburg)</i>	151
8.1 Literatur	157
Berend Wilhelm Feddersen und die Hertz-Kontroverse” <i>Martin Henke (Hamburg)</i>	161
9.1 Einleitung	162
9.2 Die Hertz-Kontroverse	162
9.2.1 Die Kieler Zeitung	163
9.2.2 Die Ausländer	166
9.2.3 Branly	166
9.2.4 Zehnder	167
9.2.5 Bosscha	168
9.2.6 Bäcklund	169
9.2.7 Chwolson	170
9.2.8 Zenneck	173
9.3 Quellenverzeichnis – Originalbriefe	176
9.4 Publikationen	177
Wenn Funken Wellen schlagen – Die Hertz’schen Experimente <i>Martin Wegener (Karlsruhe)</i>	179
Heinrich Daniel Rühmkorff – Inventor of the induction coil <i>Frank Dittmann (Munich)</i>	181
11.1 Introduction	181
11.2 Function	182
11.3 On the biography of H. D. Rühmkorff	184
11.4 An attempt of a critical biography	187
11.5 The reception history	191
11.6 Literature	192

What Went on in the Laboratory? Replicating the Early Hertz Experiments <i>Roland Wittje (Trondheim/Regensburg), Wolfgang Engels (Oldenburg)</i>	197
HEINRICH HERTZ – PRINCIPLES OF MECHANICS	199
The Geometric Aspects of Hertz’s Prinzipien der Mechanik <i>Jesper Lützen (Copenhagen)</i>	201
13.1 Introduction	201
13.2 Hertz’s geometry of systems of points	202
13.3 The nature of geometry	204
13.4 Relations between the physical content and the geometric form	205
13.5 Hertz’s geometrization compared with that of earlier mathematicians	207
13.6 Conclusion	209
13.7 Literature	209
The Mechanics of Representation and the Problem of Life: The Philosophy of Heinrich Hertz <i>Alfred Nordmann (Darmstadt)</i>	211
14.1 A Philosophical Program	212
14.2 The Fundamental Law	213
14.3 Limitations of the Fundamental Law	216
14.4 The Virtue of Limitations	219
14.5 The Mechanics of Representation	224
14.6 Coda	227
14.7 References	229
Revision der Mechanik – Heinrich Hertz als Wegbereiter der Relativitätstheorien <i>Peter Klein (Hamburg)</i>	233
15.1 Zu 1.: Meßprozess	236
15.2 Zu 2.: Beseitigung des Äthers	237
15.3 Zu 3.: Lorentztransformationen: c als Maximalgeschwindigkeit	241
15.4 Zu 4.: Äquivalenz von Masse und Energie ($E = mc^2$)	241
15.5 Zu 5. und Zu 6.: Äquivalenz träger und schwerer Masse – Massenabhängigkeit der Metrik des Raumes	243
15.6 Schluß	247
15.7 Literatur	247
HEINRICH HERTZ (1857–1894) – LIFE AND IMPACT	251
Die Familie Hertz – eine nichtjüdische Wissenschaftlerfamilie mit jüdischem Namen <i>Stefan L. Wolff (Munich)</i>	253
16.1 Einleitung	253
16.2 Die Geschichte der Familie Hertz im 18. und 19. Jahrhundert – vor dem Hintergrund der allgemeinen Situation der Juden in Hamburg	255

16.3 Keine nachweisbaren Diskriminierungen von Heinrich Hertz	258
16.4 Die Erinnerung an Heinrich Hertz	258
16.5 Biographische Skizze von Mathilde Hertz	262
16.6 Biographische Skizze von Gustav Hertz	265
16.7 Schlußbetrachtungen	269
16.8 Bibliographie	271
150 Jahre Heinrich Hertz – Ansprache zur Enthüllung der Gedenktafel am Ort des Geburtshauses Poststr. 20 <i>Peter Klein (Hamburg)</i>	275
Hertz on Meteorology <i>Joachim Pelkowski (Ober-Mörlen)</i>	283
18.1 Introduction	285
18.2 Historical background to Hertz’s 1884 meteorological paper	289
18.3 Hertz’s thermodynamic diagram	291
18.4 The Karlsruhe inaugural lecture	300
18.5 Concluding remarks	306
18.6 References	307
The Concept of ‘Ether’ in Hertz’s Kiel Lectures and its Meaning for the Concept of Space <i>Frank Linhard (Frankfurt am Main)</i>	311
19.1 Introduction	311
19.2 Biographical Overview	312
19.3 Hertz in Kiel	312
19.4 The Kiel Lecture	313
19.4.1 Transversal and Longitudinal Waves	315
19.4.2 Action at a Distance and the Propagation of Forces	316
19.4.3 Potential Theory	318
19.4.4 Gedankenexperiment	320
19.4.5 The Electrodynamical Theory of Light	322
19.4.6 Dielectric Polarisation and Inertia	322
19.4.7 Hertz’s Dipole	323
19.5 Newton’s spirit	325
19.6 Conclusion	328
19.7 References	329
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? <i>James G. O’Hara (Hannover)</i>	331
20.1 Introduction	332
20.2 The Hertz-Fitzgerald Correspondence	333
20.3 Hertz’s Correspondence with Sarasin and De la Rive	336

20.4	Conclusions	341
20.5	References	344
20.5.1	a) Manuscript Sources	344
20.5.2	b) Printed Sources	344
THE BIRTH OF RADIO – WIRELESS TELEGRAPHY		347
Die Entstehung der Radiotechnik als eine technikwissenschaftliche Disziplin – die Rolle von Ferdinand Braun		
	<i>Vitaly G. Gorokhov (Moscow, Russia – Karlsruhe)</i>	349
21.1	Einleitung	350
21.2	Heinrich Hertz – der experimentelle Beweis der Maxwell’schen Theorie mit den technischen Folgen	351
21.3	Die Verbesserung der Hertz’schen experimentellen Ausrüstung	355
21.4	Die Entstehung der drahtlose Telegraphie (Radiotechnik)	363
21.5	Literatur	373
Nikola Tesla’s Contributions to Radio Developments		
	<i>Aleksandar Marinčić and Zorica Civrčić (Belgrade, Serbia)</i>	377
22.1	Introduction	378
22.2	Tesla Coil	378
22.3	Alternate Currents of High Potential and High Frequency	381
22.4	Basic Tesla’s radio scheme	382
22.5	Tesla’s four tuned circuits	383
22.6	Remote Control by Radio	384
22.7	Colorado Springs Laboratory	389
22.8	Between Colorado Springs and Long Island	389
22.9	Long Island Plant	390
22.10	Conclusions	392
22.11	References	393
Highlights of amateur radio in the Netherlands to 1926		
	<i>Richard Strom (Amsterdam, The Netherlands)</i>	397
23.1	Introduction	398
23.2	Roots of amateur radio in the Netherlands	399
23.3	Organization of Dutch radio amateurs after 1910	402
23.4	Beginnings of commercial radio	405
23.5	References	407
Wilhelm II. und die Funktechnologie		
	<i>Wolfgang König (Berlin)</i>	409
24.1	Literatur	418

Telegraphy Without Wires – Technical Prerequisites and Economic Significance of the Early Radiotelegraphy <i>Horst A. Wessel (Düsseldorf)</i>	421
25.1 Bibliographie	439
Das Museum für Kommunikation Hamburg sagt „Ahoi“! <i>Oliver Rump (Hamburg)</i>	443
FROM RADAR TECHNOLOGY TO RADIOASTRONOMY	447
Zur Einführung elektromagnetischer Kommunikations- und Navigations-Verfahren in der deutschen Schifffahrt <i>Albrecht Sauer (Bremerhaven)</i>	449
27.1 Einführung	449
27.2 Funk und Kommunikation	450
27.3 Funk und Ortung	455
27.3.1 Funkpeilung	455
27.3.2 Telemobiloskop	457
27.4 Funk und Praxis	458
27.4.1 Peilfunk	462
27.5 Literatur	464
Ir A. H. de Voogt’s Pioneering Role as Radio Amateur and Astronomer <i>Richard Strom (Amsterdam, The Netherlands)</i>	467
28.1 Introduction	468
28.2 Family background and childhood	468
28.3 Formative years: radio and education	470
28.3.1 The first radio station: VO	470
28.3.2 Higher education and a radio activist	473
28.4 Founding of the NVVR, working years to 1945	476
28.4.1 The Society for Radio Telegraphy	476
28.4.2 Professional career and private life, 1919–1930	479
28.4.3 Career, 1930–1945	481
28.5 Post-war: the radio astronomy years	482
28.5.1 The early initiatives	483
28.5.2 Purveyor of radio telescopes	486
28.5.3 Sun and ionosphere	488
28.5.4 The battle against radio interference	491
28.6 Later years, his achievements and legacy	493
28.7 Appendix I: the De Voogt family	494
28.8 Appendix II: the Doorman family	497
28.9 References	498

From Würzburg Giant to the Giant Telescope – Development of Radio Astronomy in Germany until 1970 <i> Gudrun Wolfschmidt (Hamburg)</i>	503
29.1 Radio waves from space	504
29.2 American, British and German Pioneers of radio astronomy	504
29.3 The rise of radio astronomy after the War	506
29.4 Starting points of radio astronomy in Germany	506
29.5 The Stockert Radiotelescope – the first successful German endeavour . .	509
29.6 Effelsberg – the development towards the giant telescope	513
29.7 Conclusion	514
29.8 References	515
Stellar music – detecting cosmic acoustic signals by electromagnetic waves <i> Zoltán Kolláth (Budapest, Hungary)</i>	517
30.1 Introduction	517
30.2 Parallels: Pulsating stars and musical instruments	519
30.3 Virtual stellar musical instruments	522
30.4 Conclusion	525
30.5 References	526
DEVELOPMENT OF COMMUNICATION TECHNOLOGY: TUBE – DIGITAL	529
Das Thereminvox. Zur wechsellvollen Karriere eines elektronischen Musikinstruments <i> Hans-Joachim Braun (Hamburg)</i>	531
31.1 Bibliography	537
Das Heinrich-Hertz-Institut und die Pionierzeit der „Elektrischen Musik“ in Berlin <i> Peter Donhauser (Vienna)</i>	539
32.1 Pionierzeit der „Elektrischen Musik“	539
32.2 Zwei neue Institute in Berlin	540
32.3 Die Arbeit an „Elektrischen Instrumenten“ am Heinrich-Hertz-Institut . .	542
32.4 Die Berliner Funkausstellung 1931	544
32.5 Vierlings „Elektrochord“	544
32.6 Die Entwicklung ab 1933	553
32.7 Die „KdF Großtonorgel“	554
32.8 Beschallung von Massenveranstaltungen	558
32.9 Arbeit abseits der Öffentlichkeit: Harald Bode	560
32.10 Das Ende der Entwicklung elektronischer Instrumente am HHI	560
Development of electronic tubes <i> Joachim Goerth (Hamburg)</i>	563
33.1 Technical Function	563
33.2 The Predecessors	564

33.3 The “Radio”- or Amplifying Tube	565
33.4 Other Tubes	572
33.5 References	574
Mathematics – for improving the construction of valves	
<i>Renate Tobies (Braunschweig)</i>	577
34.1 Valve Development	578
34.2 Mathematics and Valve Development	578
34.3 Osram and Telefunken, and the Use of Mathematical Methods	580
34.4 Iris Runge’s and Carl Runge’s Thought Collectives	583
34.5 Iris Runge’s Mathematical Treatment of Valve Problems	585
34.5.1 Use of Statistical Methods	585
34.5.2 Calculation of Valve Characteristics	586
34.6 Conclusions	592
34.7 Bibliography	594
Society on the move: The success story of the mobile phone	
<i>Erika Linz (Köln and Bonn-Aachen)</i>	601
35.1 The diffusion of the mobile phone	602
35.2 From mobility to constant connectivity	604
35.3 Social and communicative impacts of mobile communication technology .	607
35.3.1 The expansion of the private sphere: “ambulant privacy” and “nomadic intimacy”	607
35.3.2 The emergence of new communication rituals and routines	608
35.3.3 The softening of time scheduling	610
35.3.4 The creation of instant communities of interest	611
35.4 “Perhaps it is a body part” – The mobile phone as a cyborg technology .	612
35.5 References	613
Programme – Heinrich Hertz and the Development of Communication	
<i>Gudrun Wolfschmidt (Hamburg)</i>	617
List of Figures	626
Authors	635
Nuncius Hamburgensis	655
Index	659



Figure 0.2:
Experimental lecture by Peter Heering
during the opening of the Hertz Symposium, October 2007

Preface: Heinrich Hertz and the Development of Communication

First of all I would like to thank for the generous support of the Hertz-Symposium by the Deutsche Forschungsgemeinschaft (DFG) and by the Behörde für Wissenschaft und Forschung (BWF) Hamburg. Then I appreciate the help and advice of Roger Stuewer in organising and planning the symposium, which should bring together different scholars interested in Hertz, in his philosophy of science, his achievements in physics and the impact of his discovery of electromagnetic waves, the development of communication technology (beginnings of radio, radar, radio astronomy, electronic music and mobile phone). I am glad that nearly all, who participated during the symposium, have contributed to the book.¹

In Hamburg there are some places connected with the life and social impact of Heinrich Hertz: The birthplace (Poststraße 20, D-20354 Hamburg), where a memorial tablet of the „Patriotische Gesellschaft“ was fixed October 8, 2007, the house, where he lived during his youth (Magdalenenstraße 3, Hamburg-Rotherbaum), the family grave (Ohlsdorf Cemetery Q 25, 1–6), a portrait medaillon in the entrance hall of Hamburg’s Town Hall, a sculpture “airwave” in Eichenpark near Alster shore, made by the jewish artist Friedrich Wield (1880–1940) in 1931/33. Apart from a Heinrich Hertz street there are three buildings named after Hertz: the Heinrich-Hertz TV tower, the former Heinrich-Hertz-School (“Reform-Realgymnasium”): Architect Albert Erbe, 1908 (Bundesstr. 58, D-20146 Hamburg), and the Heinrich-Hertz-Schule (Grasweg 72–76, D-22303 Hamburg).

There were more activities in connection with Hertz’ 150th birthday, especially an exhibition with the title “Von Hertz zum Handy – Entwicklung der Kommunikationstechnik” was shown in five different places in Hamburg and Wittenberg;² in addition a catalogue was published in 2007.³ Another event, organised by Gudrun Wolfschmidt, was meeting of the Arbeitskreis Astronomiegeschichte (Working Group for History of Astronomy) in the Astronomische Gesellschaft, held in the Institute for Theoretical Physics and Astrophysics, Würzburg University, September 23 to 24, 2007, with the topic: “Astronomy in new wavelengths – historical studies”.⁴

¹ In addition a DVD about the symposium is published: HANDWERK, AGNES UND HARRIE WILLEMS: *Allein mit der Natur. Heinrich Hertz – Experiment und Theorie*. Hamburg 2008. A biography of Heinrich Hertz is prepared for the *IWF Wissen und Medien gGmbH* in Göttingen.

² <http://www.math.uni-hamburg.de/spag/ign/events/hertz-exh.htm>.

³ Wolfschmidt, Gudrun (ed.): *Von Hertz zum Handy – Entwicklung der Kommunikationstechnik*. Katalog zur Ausstellung zum 150. Geburtstag von Heinrich Hertz (1857–1894). Norderstedt: Books on Demand (Nuncius Hamburgensis, Beiträge zur Geschichte der Naturwissenschaften, Bd. 6) 2007 (360 pages).

⁴ Short Contributions are published in *Astronomische Nachrichten* **328** (2007), No. 7.

<http://www.math.uni-hamburg.de/spag/ign/events/wuerzburg07.htm>

A book about the meeting, edited by Gudrun Wolfschmidt is in preparation.

<http://www.math.uni-hamburg.de/spag/ign/research/nuncius.htm#12>.