# Preface

Nowadays, Experimental Gravitation is one of the exciting areas in modern physics. Many important experiments have entered their final state of realization: In 2001 the interferometric gravitational wave detectors will start to collect data, in May 2002 Gravity Probe B (Stanford orbiting gyroscope experiment) will be launched, and, in 2005, STEP (the Satellite Test of the Equivalence Principle) is planned to be put in orbit. All these experiments will give new momentum to the field of experimental gravitation and, of course, to the development of theoretical concepts in gravity.

Besides this, the development of many new devices for carrying through high-precision measurements will open up new areas for testing the gravitational interaction. New atomic *clocks*, such as the atomic fountain clock, for example, or clocks which will be based on Bose–Einstein condensates, will lead to an increased precision, giving better results of tests of, for example, the gravitational red shift, or will enable the measurement of gravitomagnetic effects for clocks. Also, new quantum devices like atom *interferometers* or interferometers with Bose–Einstein condensates will give much better results while probing the gravitational field. And, last but not least, clocks will have an application in establishing a global reference system which is used for the GPS (Global Positioning System) and for telecommunication.

From the theoretical point of view all these experiments are highly interesting and the new results will stimulate the effort of unifying the four interactions and/or finding a consistent combination of gravitation theory and quantum theory, i.e., a quantum gravity theory. It is a general feature of such generalized theories of gravity that extra scalar interactions emerge accompanying the gravitational interaction. As one consequence they lead to a violation of the Equivalence Principle. Moreover, anomalous spin interactions may arise in that context. Therefore, tests of gravity may be at the same time tests of our microscopic view of the world.

Experiments are designed for testing the predictions of a theory as well as for testing the foundations of theories. In these proceedings both aspects are represented. The Lense–Thirring effect and gravitational waves are two of the main predictions of General Relativity which have not yet been confirmed directly or with convincing precision. As far as the foundations of General Relativity are concerned, we deal with the test of the Equivalence Principle which is at the very heart of the geometric nature of General Relativity. This principle is characteristic for this kind of interaction. Other topics in this volume are experiments with clocks that measure the universality of the gravitational red shift. A violation of this universality implies the existence of more than one gravitational interaction. In addition, since the most precise clocks are atomic clocks, this class of experiments also yields information about the action of gravity in the quantum domain. Therefore, the application of new quantum-based devices, like atomic interferometers, has been examined for measurements of gravitational interaction. These and other devices seem to be very promising for increasing the experimental precision considerably. Thus, the effects of gravitation on quantum systems with spin are part of these proceedings. All these attempts will provide a better experimental foundation for the theory of gravity.

Accordingly, our meeting about *Gyros, Clocks, Interferometers, ... : Testing General Relativity in Space* held from 21 to 27 August 1999 in Bad Honnef and these proceedings are devoted to these topics:

- The Lense–Thirring effect
- The detection of gravitational waves
- Testing the Equivalence Principle
- Clocks and rods in gravitational fields
- Quantum tests of gravity
- Electromagnetic field and gravity

We want to present a review of the status of experimental gravity at the beginning of the 21st century. In doing so, we first tried to give a theoretical understanding of the various effects followed by reports about the status of the various experimental projects. We got the impression that this combination of theoretical and experimental talks gave a more complete picture of what is going on and contributed to the mutual understanding of theoreticians and experimentalists.

Finally, we would like to express our gratefulness to the *WE–Heraeus Foundation* for financing this meeting and the *Deutsche Forschungsgemeinschaft* (DFG) for giving support to many of our colleagues from Eastern Europe.

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*Claus Lämmerzahl*
*Francis Everitt*
*Friedrich W. Hehl*

# List of Contributors

**Luc Blanchet**
Department of Relativistic Astrophysics and Cosmology
Section de Meudon
Place Jules Janssen
92905 Meudon Cedex
France
blanchet@obspm.fr

**Christian Bordé**
Laboratoire de Physique des Lasers
Institut Galilée
UMR – CNRS 7538
Université Paris 13
Avenue Jean–Baptiste Clément
93430 Villetaneuse
France
chbo@ccr.jussieu.fr

**Saps Buchman**
W.W. Hansen Experim. Physics Labs
Stanford University
Stanford, CA 94305
USA
sasha@relgyro.stanford.edu

**Karsten Danzmann**
Institut für Atom- und Molekülphysik
Universität Hannover
and
MPI für Quantenoptik
Außenstelle Hannover
Callinstraße 38
30167 Hannover
Germany
kvd@mpq.mpg.de

**Daniel B. DeBra**
W.W. Hansen Experim. Physics Labs
Stanford University
Stanford, CA 94305
USA
ddebra@sun-valley.stanford.edu

**Hansjörg Dittus**
ZARM
Universität Bremen
Am Fallturm
28359 Bremen
Germany
dittus@zarm.uni-bremen.de

**C.W. Francis Everitt**
W.W. Hansen Experimental Physics Laboratory
Stanford University
Stanford, CA 94305-4085
USA
francis@relgyro.stanford.edu

**Ephraim Fischbach**
Purdue University
Department of Physics
West Lafayette, IN 47907-1396
USA
ephraim@physics.purdue.edu

**Leonid Grishchuk**
Department of Physics and Astronomy
University of Wales, Cardiff
P.O. Box 913
Cardiff, Wales CF2 3YB
UK
Leonid.Grishchuk@astro.cf.ac.uk

**Frank Gronwald**
Universität Magdeburg
Institut für Allgemeine Elektrotechnik und Leistungselektronik
Postfach 4120
39016 Magdeburg
Germany
frank.gronwald@e-technik.uni-magdeburg.de

**Mark Haugan**
Purdue University
Department of Physics
1396 Physics Building
West Lafayette, Indiana 47907-1396
USA
mph@physics.purdue.edu

**Friedrich W. Hehl**
Inst. Theor. Physics
University of Cologne
50923 Köln
Germany
hehl@thp.uni-koeln.de

**Eugen Holzschuh**
Physik–Institut
Universität Zürich
Winterthurer Str. 190
8057 Zürich
Switzerland
holzschu@physik.unizh.ch

**George M. Keiser**
W.W. Hansen Experim. Physics Labs
Stanford University
Stanford, CA 94305
USA
mac@relgyro.stanford.edu

**Iosip Khriplovich**
Butker Institute of Nuclear Physics
630090 Novosibirsk
Russia
I.B.Khriplovich@inp.nsk.su
kraused@wabash.edu

**Helmar Koch**
Institute of Solid State Physics
Universität Jena
Helmholtzweg 5
07743 Jena
Germany
Helmar.Koch@uni-jena.de

**Dennis Krause**
Department of Physics
Wabash College
Crawfordsville, IN 47933
USA
kraused@wabash.edu

**Walter Kündig**
Physik–Institut
Universität Zürich
Winterthurer Str. 190
8057 Zürich
Switzerland
kuendig@physik.unizh.ch

**Claus Lämmerzahl**
Faculty of Physics
University of Konstanz
Fach M 677
78457 Konstanz
Germany
claus.laemmerzahl@uni-konstanz.de
and
Institute for Experimental Physics
Heinrich–Heine–University Düsseldorf
40225 Düsseldorf
Germany
claus.laemmerzahl@uni-duesseldorf.de

**Herbert I.M. Lichtenegger**
Institut für Weltraumforschung
Österreichische Akademie der Wissenschaften
8010 Graz
Austria
him@iwf.tu-graz.ac.at

**Stefan Lochmann**
ZARM
Universität Bremen
Am Fallturm
28359 Bremen

Germany
lochmann@zarm.uni-bremen.de

**Nick Lockerbie**
University of Strathclyde
Department of Physics and Applied Physics
Glasgow G4 0NG
UK
nick@tesla.phys.strath.ac.uk

**Jim M. Lockhart**
W.W. Hansen Experim. Physics Labs
Stanford University
Stanford, CA 94305
USA
jim@relgyro.stanford.edu

**Dirk Lockowandt**
ZARM
Universität Bremen
Am Fallturm
28359 Bremen
Germany

**Lute Maleki**
Jet Propulsion Laboratory (JPL)
4800 Oak Grove Drive M/S 298-100
Pasadena, CA 91109-8099
USA
Lute.Maleki@jpl.nasa.gov

**Bahram Mashhoon**
Department of Physics and Astronomy
University of Missouri – Columbia
Columbia, Missouri 65211
USA
physgrav@everest.cclabs.missouri.edu

**Carsten Mehls**
ZARM
Universität Bremen
Am Fallturm
28359 Bremen
Germany
mehls@zarm.uni-bremen.de

**John Mester**
W.W. Hansen Experim. Physics Labs
Satellite Test of the Equivalence Principle (STEP)
Stanford University
Stanford, CA 94305-4085
USA
mester@relgyro.stanford.edu

**Barry F. Muhlfelder**
W.W. Hansen Experim. Physics Labs
Stanford University
Stanford, CA 94305
USA
barry@relgyro.stanford.edu

**Ralf Neubert**
Institute of Solid State Physics
Universität Jena
Helmholtzweg 5
07743 Jena
Germany
Ralf.Neubert@uni-jena.de

**Gernot Neugebauer**
Theoretisch–Physikalisches Institut
Universität Jena
Max–Wien–Platz 1
07743 Jena
Germany
G.Neugebauer@tpi.uni-jena.de

**Wei–Tou Ni**
National Tsing Hua University
Department of Physics No. 101, Sec. 2
Kung Fu Road
Hsinchu, Taiwan 300
Republic of China
wtni@phys.nthu.edu.tw

**Sandor Nietzsche**
Institute of Solid State Physics
Universität Jena
Helmholtzweg 5
07743 Jena
Germany
Sandor.Nietzsche@uni-jena.de

**Frithjof Nolting**
Lawrence Berkeley National Laboratory
1 Cyclotron Road, MS 7-222
Berkeley, CA. 94720
USA
FNolting@lbl.gov

**Kenneth Nordtvedt**
Northwest Analysis
118 Sourdough Ridge
Bozeman, MT 59715
USA
kennordtvedt@one800.net

**Bradford W. Parkinson**
W.W. Hansen Experim. Physics Labs
Stanford University
Stanford, CA 94305
USA
brad@relgyro.stanford.edu

**Achim Peters**
Fakultät für Physik
Universität Konstanz
78457 Konstanz
Germany
achim.peters@uni-konstanz.de

**Fritz Riehle**
Physikalisch–Technische Bundesanstalt (PTB)
Section 4.31: "Unit of Length"
Bundesallee 100
38116 Braunschweig
Germany
fritz.riehle@ptb.de

**Lewis Ryder**
School of Physical Sciences
University of Kent
Canterbury CT2 7NR
UK
l.h.ryder@ukc.ac.uk

**Gerhard Schäfer**
Theoretisch–Physikalisches Institut
Universität Jena
Max–Wien–Platz 1
07743 Jena
Germany
Schaefer@tpi.uni-jena.de

**Stephan Schlamminger**
Physik–Institut
Universität Zürich
Winterthurer Str. 190
8057 Zürich
Switzerland
schlammi@physik.unizh.ch

**Jürgen Schurr**
Physikalisch Technische Bundesanstalt (PTB)
Bundesallee 100
38116 Braunschweig
Germany
Juergen.Schurr@ptb.de

**Dietmar Theiss**
Institute for Theoretical Physics
University of Cologne
50923 Köln
Germany
Dietmar.Theiss@mediaways.net

**Rodney Torii**
W.W. Hansen Experim. Physics Labs
Satellite Test of the Equivalence Principle (STEP)
Stanford University
Stanford, CA 94305-4085
USA
torii@step.Stanford.edu

**Pierre Touboul**
Physics, Instrumentation and Sensing Department
ONERA
29 Avenue de la division Leclerc
BP 72
92322 Châtillon Cedex
France
touboul@onera.fr

**John P. Turneaure**
W.W. Hansen Experim. Physics Labs
Stanford University
Stanford, CA 94305
USA
john@relgyro.stanford.edu

**Stefano Vitale**
Department of Physics
University of Trento
38050 Povo, Trento
Italy
vitale@alpha.science.unitn.it

**Wolfgang Vodel**
Institute of Solid State Physics
Universität Jena
Helmholtzweg 5
07743 Jena
Germany
Wolfgang.Vodel@uni-jena.de

**Norbert Wex**
Max–Planck–Institut für Radioastronomie
Auf dem Hügel 69
53121 Bonn
Germany
wex@MPIfR-Bonn.MPG.de

**Paul W. Worden**
W.W. Hansen Experim. Physics Labs
Satellite Test of the Equivalence Principle (STEP)
Stanford University
Stanford, CA 94305-4085
USA
worden@step.Stanford.EDU

**J. von Zameck Glyscinski**
Institute of Solid State Physics
Universität Jena
Helmholtzweg 5
07743 Jena
Germany
zameck@dpserv1.ifk.uni-jena.de

## List of Abbreviations

| | |
|---|---|
| ALLEGRO | Gravitational bar detector, USA |
| ASTRE | Accelerometre Spatial TRiaxial Electrostatique |
| ASTROD | Astrodynamical Space Test of Relativity using Optical Devices |
| AURIGA | Gravitational bar detector, Italy |
| AXEL | AXial Experiment at Low temperature |
| CHAMP | CHAllenging Micro–satellite Payload for geophysical research and application |
| CODATA | Committee on Data for Science and Technology |
| CWDB | Close White Dwarf Binaries |
| EEP | Einstein Equivalence Principle |
| EP | Equivalence Principle |
| EXPLORER | A gravitational wave antenna located at CERN in Geneva |
| GAIA | Global Astrometric Interferometer for Astrophysics |
| GEO 600 | German–British gravitational wave interferometer in Hannover |
| GOCE | Gravity and Ocean Circulation Explorer |
| GP-B | Gravity Probe B |
| GRACE | Gravity Recovery And Climate Experiment |
| HIPPARCOS | HIgh Precision PARallax COllecting Satellite |
| HYPER | HYPER sensitive cold atom interferometry in space |
| IPLR | InterPlanetary Laser Ranging |
| LAGEOS | LAser GEOdynamics Sattelite |
| LIGO | Laser Interferometer Gravitational wave Observatory |
| LISA | Laser Interferometer Space Antenna |
| LLI | Local Lorentz Invariance |
| LLR | Lunar Laser Ranging |
| MOT | Magneto–Optical Trap |
| MICROSCOPE | MICRO–Satellite à trainée Compensée pour l'Observation du Principle d'Equivalence |
| NAUTILUS | Gravitational bar detector at Laboratori Nazionali di Frascati, Italy |
| PPN | Parametrized Post–Newtonian approximation |
| SORT | Solar Orbit Relativity Test |
| SQUID | Super conducting QUantum Interference Device |
| STAR | Space Three–axis Accelerometer for Research |
| STEP | Satellite Test of the Equivalence Principle |
| TAMA300 | Japanese gravitational wave interferometer |
| VIRGO | French–Italian gravitational wave interferometer in Pisa |
| VLBI | Very Long Baseline Interferometry |
| WEP | Weak Equivalence Principle |
| rf | radio frequency |
| rms | root mean square |