Introduction

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In the week of October 6–10, 2008, the International Space Science Institute (ISSI) welcomed a new community: About forty physicists and astronomers came to Bern to debate about “Probing the Nature of Gravity—Confronting Theory and Experiment in Space”. Following the tradition of ISSI Workshops, data obtained in space were the focus of the event. For the first time, physics experiments carried out in space provide data adding to the knowledge of fundamental physics that we have up till now got mainly through observations and from laboratory experiments. Presentation and discussion of all these data was embedded into the theoretical framework of gravity and its recent advances. As could have been expected, an important part of the discussions on this led to a look into the future of gravitational theory and experiment.

Two introductory talks on the status of experimental tests of General Relativity and on the transition to Quantum Gravity set the stage. Gravitomagnetism was then addressed, first by a theoretical exposé on this particular consequence of General Relativity and subsequently by measurement and observation—both as it arises from the rotation of the Earth and as it manifests itself in massive astrophysical objects. Experimentally, Gravity Probe B (GP-B), with its direct measurement of the Lense-Thirring effect, set a new standard of experimental elegance and refinement, but the gravitomagnetic results from analysis of observations of the LAGEOS system of satellites remind us that tiny effects crucial to fundamental physics may well be visible in high-precision observations of astronomical bodies.

Next, the Workshop turned to tests of basic laws and principles by exploring possible violations of Newton’s inverse-square laws and of the equivalence principle. Ground-based laboratory investigations were included here as well. Cosmological observations that could

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set constraints on gravitational theory rounded off the choice of subjects. All along, presentations of the theoretical foundations substantiated the analysis of results.

The last day of the Workshop was devoted to examining the crucial question that is persistently asked by space officials, who are sceptical about pursuing fundamental physics in space, namely: “To what extent are high accuracy measurements in space possible?” The measurement uncertainties of GP-B were scrutinised thoroughly and the specialists involved reported in detail on the way, in which the data sent back by GP-B were being analysed. The Workshop then continued with assessments of the accuracy of results that can be provided by future fundamental physics missions, and came to a close with a summary lecture.

According to the custom of ISSI workshops, the workshop participants were asked to supply a written version of their talks. These papers are reproduced here after having gone through peer review. For two additional talks, by Nicolas Gisin on ‘Entanglement and Decoherence’ and by Alan Watson, who spoke about ‘The Problem of Creating Particles with Energies above 10^{21} eV’, it was agreed to give references to papers that have been published elsewhere—D. Salart, A. Baas, C. Branciard, N. Gisin, H. Zbinden, Testing the speed of ‘spooky action at a distance’, *Nature* **454**, 861–864 (2008); A. A. Watson, Highlights from the Pierre Auger Observatory—the Birth of the Hybrid Era, *Proceed. 30th International Cosmic Ray Conference, Mérida, México, 2007, Vol. 6: Invited and Rapporteur Papers*, ed. by R. Caballero et al. (Universidad Nacional Autónoma de México, 2009) [arXiv:0801.2321v1](https://arxiv.org/abs/0801.2321v1) (astro-ph)—, because these topics are only indirectly related to gravity. On the other hand, we include the written version of the pre-dinner speech on ‘Wolfgang Pauli and Modern Physics’ by Norbert Straumann, where he shows how Pauli—referred to by colleagues as the conscience of the community of theoretical physicists—inspired and anticipated the development of physics not only through formal publications but in many cases through detailed letters to his colleagues.

In the preparatory stage of the Workshop, the Science Committee of ISSI has asked the Convenors to concentrate on gravity. Important discussions about the Workshop programme also took place with the ISSI Directorate: the one-day session of examining uncertainty estimates is one of the results. We are greatly indebted to Rüdiger Reinhard, who was instrumental as Convenor in the early stages of the Workshop, and helped shape the programme. We also wish to thank Brigitte Schutte-Fasler, Andrea Fischer, Saliba F. Saliba, Katja Schüpbach, Silvia Wenger and the other members of the ISSI staff for actively and cheerfully supporting us whenever we needed to use the infrastructure of ISSI.