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IARD 2012: 8th Biennial Conference on Classical and Quantum Relativistic Dynamics of Particles and Fields

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Preface

Although the subject of relativistic dynamics has been explored, from both classical and quantum mechanical points of view, since the work of Einstein and Dirac, its most striking development has been in the framework of quantum field theory. The very accurate calculations of spectral and scattering properties, for example, of the anomalous magnetic moment of the electron and the Lamb shift in quantum electrodynamics, and many qualitative features of the strong and electroweak interactions, demonstrate the very great power of description achieved in this framework. Yet, many fundamental questions remain to be clarified, such as the structure of classical relativistic dynamical theories on the level of Hamilton and Lagrange in Minkowski space as well as on the curved manifolds of general relativity. There moreover remains the important question of the covariant classical description of systems at high energy for which particle production effects are not large, such as discussed in Synge's book, *The Relativistic Gas*, and in Balescu's book on relativistic statistical mechanics. In recent years, the study of high energy plasmas and heavy ion collisions has emphasized the importance of developing the techniques of relativistic mechanics.

The results of Lindner et al [Physical Review Letters **95**, 0040401 (2005)] as well as the more recent proposal of Palacios et al [Physical Review Letters **103**, 253001 (2009)] and others, have shown that there must be a quantum theory with coherence in time. Such a theory, manifestly covariant under the transformations of special relativity with an invariant evolution parameter, such as that of Stueckelberg [Helv. Phys. Acta **14**, 322, 588 (1941); **15**, 23 (1942); see also R.P. Feynman, Physical Review **80**, 4401 and J.S. Schwinger, Phys. Rev. **82**, 664, (1951)] could provide a suitable basis for the study of such questions, as well as many others for which the application of the standard methods of quantum field theory are difficult to manage, involving, in particular, local properties of spacetime structure.

The scope of this series of conferences is, however, much wider. There have been recent developments in the understanding of general relativity concerning questions associated with dark energy and the dark matter problem, the distribution of stars in galaxies, and the distribution of galaxies in the visible universe, as well as the internal structure of stars. There are, moreover fundamental questions in the applications of relativistic dynamics to physical problems, and in its mathematical and logical structure.

It was for this purpose, to bring together researchers from a wide variety of fields, such as particle physics, astrophysics, cosmology, heavy ion collisions, plasma research, and mathematical physics, with a common interest in relativistic dynamics, that this Association was founded.

The International Association for Relativistic Dynamics was organized at its first meeting as an informal session of seminars among researchers with common interest in February 1998 in Houston, Texas, with John R. Fanchi as president.

The second meeting took place, in 2000, at Bar Ilan University in Ramat Gan, Israel, the third, in 2002, at Howard University in Washington, D.C., and the fourth, on June 12-19, 2004, in Saas Fee, Switzerland. In 2006, the meeting took place at the University of Connecticut campus in Storrs, Connecticut, and the sixth meeting, in Thessaloniki, Greece. The seventh meeting took place at the National Dong Hwa University in Hualien, Taiwan from May 30 to June 1, 2010, and the eighth meeting, reported here, at the Galileo Galilei Institute for Theoretical Physics (GGI) in Florence, Italy, 29 May to 1 June 2012.

This meeting forms the basis for the Proceedings of IARD 2012, recorded in this issue of *Journal of Physics: Conference Series*. Along with the work of some of the founding members of the



Association, we were fortunate to have lecturers from application areas that provided strong challenges for further developments in cosmology and astrophysics, the geometry of spacetime, including the possible presence of extra dimensions, and in the dynamics of systems described in the framework of general relativity.

There have been recent developments as well in the foundations of relativity, and in the understanding of electrodynamics in the framework of relativistic quantum theory. There is a study of relativistic quantum mechanics in the rest frame instant form of dynamics, and an analysis of the Laplace-Runge-Lenz symmetry in relativistic dynamics reported here, as well as a discussion of the quantization of massless fields of any spin. Results are reported on the existence and definition of a covariant Berry phase associated with a perturbed covariant harmonic oscillator.

A generalization of Stueckelberg's original classical and quantum model for pair production is found to provide a simple framework for the phenomenon of neutrino oscillation, which, along with recently published work on the spin of a system of relativistic particles, appears to provide a simple mechanism for CP violation in the presence of nonabelian gauge fields that seems applicable to the K, B and D meson systems as well, from the point of view of their inner quark structure.

New functional methods applicable to both classical and quantum relativistic systems are reported here, and a deep mathematical and philosophical discussion is given on a unified view of nonlinear systems in many areas, including that of perception.

We thank the Scientific Advisory Committee for their invaluable guidance and advice:

Stephen Adler (Institute for Advanced Study)
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The organizers express their gratitude to the Galileo Galilei Institute for Theoretical Physics for its support and the use of its excellent facilities, and to INFN for its generous support.

Finally, we thank the participants who contributed through their lectures, personal discussions, and these papers, to the advancement of the subject and our understanding.

For the Editors and Organizing Committee,

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