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Preface IARD 2008 Proceedings

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The International Association for Relativistic Dynamics was organized in February 1998 in Houston, Texas, with John R. Fanchi as president.

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.

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The results of Linder et al. [Physical Review Letters **95**, 0040401 (2005)] as well as the more recent work of Palacios et al. [Physical Review Letters **103**, 253001 (2009)] as well as others, have shown that there must be a quantum theory with coherence in time, suggesting that such a theory, manifestly covariant under the transformations of special relativity with and invariant evolution parameter, such as that of Steuckelberg [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 space time 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 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, some of which is recorded in the papers published here, in Thessaloniki, Greece, in 2008, with the significant guidance of Professor Ioannis Antoniou, the help of his institution, the Aristotle University of Thessaloniki, the Municipality of the Heroic City of Naousa and the Euxeinos Club of Naousa. The meeting took place at the Teleglion Foundation of Art at AUTH.

This meeting forms the basis for the Proceedings that are recorded in this issue of Foundations of Physics. 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 quantum field theory, cosmological problems, and in the dynamics of systems subject to accelerations and the effects of general relativity.

Topics treated in this issue include a review of manifestly covariant quantum theory and its applications in relativistic dynamics, and a study of the structure of an extended Hilbert space accommodating relativistic covariance, and showing how the nonrelativistic limit emerges in a systematic way. Tensor valued Lagrangians were studied for the construction of dynamics in the framework of relativistic theories and studies of the structure of the Maxwell equations, revealing new insights into relativity, are discussed here. It has, moreover, been shown that a covariant Hamiltonian theory with Einstein metric and gauge interactions, and an additive world scalar potential (representing a vacuum energy density distribution) can be mapped into a Hamiltonian with conformally modified metric resulting in geodesic motion governed by an effective Kaluza Klein metric. As shown here, this metric can take the form of the metric introduced by Bekenstein and Sanders (the *TeVeS* theory) to account for the MOND (modified Newtonian Dynamics) theory of Milgrom, which describes well the galaxy acceleration curves, as well as the observed bending of light passing the galaxy. This work shows how the Bekenstein-Sanders

vector field can be considered as a gauge field consistently with the normalization condition on the field. The resulting gauge theory is that of a Hilbert bundle.

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

L.P. Horwitz,
for the Organizing Committee, with
I. Antoniou, T. Gill,
J.R. Fanchi, past President,
M. Land, President,
R.M. Mallett, Vice-President,
and J.A. Lindesay