

PREFACE

One of the biggest and unsolved problems in fundamental Cosmology consists in explaining why the currently observed Universe is undergoing a phase of accelerating expansion. This problem is strictly related to another fundamental problem, that is widely known as the dark energy and dark matter problem. This is because the simplest and most direct explanation for the acceleration phenomenon is provided by assuming - under the hypothesis that Einstein field equations hold with matter - that spacetime satisfies a standard Einstein-Friedmann-Robertson-Walker cosmology with a mysterious and somewhat exotic fluid of unknown structure and origin. On the other hand, alternative theories of Gravity have been also proven to provide consistent models for explaining the acceleration of the Universe as a pure gravitational effect, depending on curvature nonlinearities in the gravitational part of the Lagrangian.

The 42nd Winter School of Theoretical Physics entitled Current Mathematical Topics in Gravitation and Cosmology was therefore devoted to discussing the status of the art about mathematical research on Gravitational and Cosmological Theories, based either on standard Einstein's General Relativity or alternative Lagrangian models of gravity, including first-order "Palatini" formalism, non-linear theories depending on curvature invariants as well as scalar-tensor theories of gravity. Emphasis was put on current cosmological issues, including early inflation, present day acceleration, dark matter and dark energy models; general techniques have been reviewed and comparisons with current observations - concerning, e.g., rotation of galaxies and other cosmological tests - have been discussed. On the other hand there have been also lectures on quantum cosmological properties of such theories, including (loop) quantization of standard gravity, Chern-Simons gravity and gravitational models ensuing from the low energy limit of strings and branes. The Schools was held in Łądek Zdrój (Poland), February 6-11, 2006.

During the School 8 specialized lecture courses were presented (M. Bojowald, S. Capozziello, M. Francaviglia, R. Kerner, L. Lusanna, S.D. Odintsov, H.J. Schmidt, L.M. Sokołowski), together with 7 one-hour invited lectures (L. Fatibene, J. Lukierski, E. Malec, Z. Oziewicz, V.N. Pervushin, M. Szydłowski, D. Vassiliev) and few contributed talks by School participants, enriching

the program. A divulgative video aimed at introducing Einstein's Relativity Theories (authored by M.G. Lorenzi in collaboration with L. Fatibene and M. Francaviglia) was also presented to the audience. The total number of participants was 56; most of them were PhD students and young researchers. The pleasant scientific and social atmosphere of the School, together with the appropriate location within the snow of Karpatian mountains near to the Czech border, helped participants to establish a very positive and fruitful collaboration and stimulated a number of animated discussions among them. We are very grateful to all participants for their creative contribution to this atmosphere.

The proceedings of the 42nd Winter School of Theoretical split into two volumes: the first contains the manuscripts of all lecture courses, except two. These two last one are placed into the second volume together with all one-hour lectures and contributions.

The 42nd Winter School of Theoretical Physics Current Mathematical Topics in Gravitation and Cosmology was organized by Institute of Theoretical Physics, Wrocław University, Polish Academy of Art and Sciences (Polska Akademia Umiejętności, Kraków) and Commettee on Physics, Polish Academy of Sciences (Polska Akademia Nauk, Warszawa). The members of the Organizing Committee were: A. Borowiec (chairman), M. Francaviglia (co-chairman), G. Allemandi (secretary), W. Cegła (treasurer) and A. Błaut.

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