Cosmoparticle Physics

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Cosmoparticle Physics

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*To Yakov Zeldovich, Andrei Sakharov,
Viktor Shwartsman, David Schramm and
all my teachers, friends and colleagues,
who are not with me now
but are forever in my heart and memory.
Their legacy is in the annals
of cosmoparticle physics.*

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PREFACE

Starting from 1980-s the cross-disciplinary, multi-dimensional field of links between cosmology and particle physics is widely recognised by theorists, studying cosmology, particle and nuclear physics, gravity, as well as by astrophysicists, astronomers, space physicists, experimental particle and nuclear physicists, mathematicians and engineers.

It is well understood that only joint efforts may lead to progress in this field.

The relationship between cosmology and particle physics is now one of the important topics of discussion at any scientific meeting both on astrophysics and high energy physics. National and international institutes, laboratories and centres all over the world study specific problems of such a relationship.

On some historical reasons many important results, trends and directions of scientific research, undertaken in 80-90s in this field, in USSR and then in Russia are not widely known. The present book is aimed to fill in this gap.

Covering this loophole in the English scientific literature the book, based dominantly on the most recent results, also includes discussion of some papers dated 80-s or early 90-s. One may surprise how up-to-date are the results of these papers. One may find how useful they are for solution of problems, clearly understood and formulated in the English literature only now.

However, the very general approach that appeared, evolved and highly developed in Russia in 80-90s is even more important. Originated from the works of

A.D.Sakharov, Ya.B.Zeldovich, M.A.Markov and their scientific schools this approach in its development naturally embeds all the existing trends in studies of fundamental links between cosmology and particle physics.

It offers the natural framework for self-consistent analysis of nontrivial relationships between the theory of Universe and particle theory. It provides the system of studies of cosmology and particle physics in the complex network of their indirect astrophysical and physical effects. It implies the specific name for the multidimensional field of science studying the fundamental relationship between micro- and macro- worlds.

This name "Cosmoparticle physics" is put into the title of the book.

The reason we use "cosmoparticle physics" to denote the problems generally referred to "astroparticle physics" or "particle astrophysics" is in no case the ambition of terminological originality. It has much deeper reasons than the simple following the Russian tradition to call "cosmonauts" those Americans call "astronauts".

There are many particular problems such as massive neutrino as hot dark matter, invisible axions or neutralino as cold dark matter in which astroparticle and cosmoparticle physics practically coincide. But the proper choice of dark matter candidate or of the mixture of different forms of dark matter appears in astroparticle physics as the matter of taste. Cosmoparticle physics can make this choice the matter of test.

Thus cosmoparticle physics naturally contains astroparticle physics as important element but represents much wider field of scientific research. The research in this field implies nontrivial system of cross-disciplinary studies, which are reflected in the specific form of scientific organization.

In USSR first under charge of Ya. Zeldovich and then of A. Sakharov the complex program of joint studies in cosmoparticle physics was elaborated.

Founded in 1992, Centre for Cosmoparticle physics "Cosmion" initiated practical realisation of some ideas of

this program in complicated conditions of rapidly changing Russia.

The first results of scientific activities of more than forty scientific groups from more than twenty Russian centres and institutions, joined in the Russian National project "Cosmoparticle physics", were reported at the 1 International conference on Cosmoparticle physics "Cosmion94", dedicated to 80 Anniversary of Ya.B.Zeldovich and 5 Memorial of A.D.Sakharov, December 4-14, 1994, Moscow.

The 2 International conference "Astronomy. Cosmoparticle Physics", dedicated to 75 Anniversary of A.D.Sakharov (COSMION-96), May-June 1996, Moscow, and the 3 International conference on Cosmoparticle physics "Cosmion 97", dedicated to 10 Memorial of Ya.B.Zeldovich, December 8-14, 1997, Moscow succeeded in the studies of various links between cosmology and particle physics and of various aspects of cosmoparticle research.

These various studies, being important by them, are within the project co-ordinated and started to be arranged into cross-disciplinary networks, putting together astronomers, space researchers and experimental physicists into the particular cells of proper cosmoparticle studies. In the context of cosmoparticle research theoretical studies play new important role gluing together experiments and observations in different fields of science.

These studies and their results presented at Cosmion conferences uncover the features of cosmoparticle physics as the new self-consistent field of scientific research.

The system of cosmoparticle research is open. It does not substitute for the well-established fields of studies in particle and nuclear physics, cosmology and astrophysics but it illuminates nontrivial links between them and offers new solutions for their old problems. It offers to each scientist the possibility to use all his scientific skill and experience in the joint study of the fundamental

laws of our reality. It is the aim of this book to facilitate participation in these studies.

The book uses personal author's experience in the presentation of the problems of cosmoparticle physics to both physical and astronomical audience. It accounts for the author's course of lectures "Introduction into cosmoparticle physics", given to students of Moscow Engineering Physics Institute. It also takes into account the similar course, given to post-graduate students of the University of Trieste.

Based on this experience the book concentrates the readers attention to the transparent outlining of the principal ideas of the modern particle theory and cosmology, their mutual relationship and nontrivial correspondence of their physical and astrophysical effects.

The puzzles of particles and Universe are bound in a complicated knot of problems. I am grateful to my teachers Ya.B.Zeldovich and A.D.Sakharov for my involvement into the beauty of these puzzles.

I express my gratitude to co-authors of all my papers, especially, to Z.G. Berezhiani, S.I. Blinnikov, V.M. Chechetkin, A.G. Doroshkevich, D. Fargion, S.S. Filippov, S.S. Gershtein, A.A. Klypin, R.V. Konoplich, A.D. Linde, G. Piragino, A.G. Polnarev, S.G. Rubin, A.S. Sakharov, M.G. Sapozhnikov, E.V. Sedelnikov, A.A. Starobinsky, to collaborators and participants of National Project "Cosmoparticle physics", to collaborators of International projects "Astrodamus", "Coseth", Eurocos-AMS for co-operation in unbinding some ties of this knot.

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