

*New Phenomena in
Subnuclear Physics*

Edited by Antonino Zichichi

Part A

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— *Part A* —

Edited by

Antonino Zichichi

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Preface

In July 1975 a group of 122 physicists from 68 laboratories of 27 countries met in Erice to attend the 13th Course of the International School of Subnuclear Physics.

The countries represented at the School were: Australia, Austria, Belgium, Brazil, Canada, Chile, Denmark, France, Germany, Greece, India, Iran, Israel, Italy, Japan, Mexico, The Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Turkey, The United Kingdom, The United States of America and Yugoslavia.

The School was sponsored by the Italian Ministry of Public Education (MPI), the Italian Ministry of Scientific and Technological Research (MRST), the North Atlantic Treaty Organization (NATO), the Regional Sicilian Government (ERS) and the Weizmann Institute of Science.

The School was one of the most exciting, due to the impressive number of discoveries made not only in the field of the new particles by the MIT-BNL (reported by S. C. C. Ting) and by the SLAC-SPEAR (reported by M. Breidenbach) Groups, but also in the field of high energy neutrino interactions where Carlo Rubbia observes μ -pairs, together with bumps in the total energy of the hadronic system at $W_h \sim 4$ GeV and a discontinuity in the $\langle y \rangle$ at $E_\nu \sim 50$ GeV plus a bump at $W_{\min} \sim 4$ GeV; all these phenomena being possibly connected.

To this remarkable amount of new and exciting results it has to be added the great discovery of DORIS (reported by B. Wiik) on the first example of a new particle P_C : the highlight of the Course. Needless to say that it was too easy this year to have discussions of great interest - the atmosphere of the School being such that, even in much more sober years of meagre discoveries, it was possible to have interesting discussions.

No doubt: a new era has been opened in particle physics; and this is the first volume of it.

At various stages of my work I have enjoyed the collaboration of many friends whose contributions have been extremely important for the School and are highly appreciated. I would like to thank most warmly: Dr. N. Craigie, Mrs. M. Denzler, Dr. A. Gabriele, Mrs. C. Giusti, Mrs. H. Kirk, Miss P. Savalli, Mrs. S. Vascotto, Mrs. K. Wakley, and Miss M. Zaini for the general scientific and administrative work, and Drs. R. K. Ellis and R. Petronzio for their work as Scientific Secretaries.

A final word of acknowledgment to all those who, in Erice, Bologna and Geneva, helped me on so many occasions and to whom I feel very much indebted.

A. Zichichi

Geneva, January 1976

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ONE DAY ALL MEN WILL BE SCIENTISTS

ANTONINO ZICHICHI

CERN, GENEVA, SWITZERLAND

Right Honourable Minister, Mr. Mayor, Your Excellencies, My Lords, Ladies and Gentlemen, I am happy and honoured to open this international course by welcoming the Rt. Hon. Mario Pedini, Minister of Scientific and Technological Research, who has been kind enough to honour us with his presence at the International School of Subnuclear Physics in which this year are participating 86 students from 18 countries and 36 lecturers coming from the main universities of the world. As is well known, our school permits amongst other things physicists from all over the world to meet and discuss the results of their most recent experiments. All countries involved in advanced scientific research are represented here through the expression of their higher and more recent scientific culture - that is the researchers actively engaged in investigating the fundamental properties of which everything, the world around us and ourselves are made.

An irreplaceable role of this school is the meeting between colleagues who know each other by name through the scientific works which they publish and which here make it possible to establish these human bonds of friendship and solidarity which are the basis of civilized living. That is why, during our courses, we can pretend for a few weeks that we are realising man's all-time dream - the world without frontiers: we talk, we discuss, we meet - without formality, without barriers, and without racial or religious distinction.

In a world in which the spread of information allows all inhabitants of the planet to feel the anxieties and emotions of peoples who live thousands of miles apart it is clear that the function of a scientific demonstration cannot only be one of

spreading information. Nor is there any substitute for that direct discussion which a work of research needs, be it experimental or theoretical, when it is of great current importance, as are the topics dealt with in this School.

But with what do these so-called high-energy physicists concern themselves? asks the man in the street, and what have their problems got to do with the progress of our knowledge?

I shall try and answer these questions by focusing on two points, the characteristics of our subject: a) intellectual humility; and b) the apparent detachment from everyday matters.

Intellectual Humility: A man has begun to understand nature when he has abandoned the intellectual arrogance which made him think that he could explain the origin of the Universe or the essence of life without even knowing how a stone falls or how a pendulum swings. Modern science, hence subnuclear physics, has humility as a point of reference. This implies that every theoretical speculation is subject to experimental verification since there is no intellectual speculation which can remain valid if not corroborated by proof of the facts. And the facts in Physics are the results of experiments. The Greeks began with brilliant axioms; if the facts did not then coincide with these axioms - too bad for the facts!

Just think that it took 2,000 years from Aristotle to Galileo to understand that force is not in proportion to speed (as Aristotle maintained), but to acceleration, and there are plenty of other examples.

For 2,000 years man went on maintaining as follows: if I can demonstrate with the strength of my intellect that my theory is right then it is clear that yours is wrong - since nothing can be superior to the intellectual test.

The truth of physical phenomena however is in the experimental test. Following this path, initiated less than 400 years ago by Galileo, man today has managed to synthesize in barely six forces, all the laws which govern the Universe, from the dimensions of the extremely small (subnuclear structures), to the dimensions of the extremely large (galactic structures). Today there is no known phenomenon which escapes one of these six forces. We have come so far thanks to the intellectual humility of modern science.

Now let us pass on to the second point. The phenomena which we study are apparently extraneous to everyday life. We study hyperons the collisions between protons, electrons and positrons, etc., etc. But what does this have to do with everyday life? With the quality of life? Other science subjects try to comprehend things which are within everybody's reach. For example, genetics studies, how

hereditary characteristics are transmitted, Biology studies and tries to understand living matter, Neurology studies and tries to understand how our brain functions. But the brain is there, likewise living matter and hereditary characteristics. No-one can ignore their existence.

This is the position in which Physics found itself in Galileo's time. Stones have always fallen from above to below, but nobody before him had understood on what basis of which laws. Motion, any motion, is a continuous struggle against friction as is testimony the long list of failed inventors of machines for perpetual motion. But for hundreds of years no-one had understood what passive resistance was and what its laws were. And yet it was everywhere.

It was enough to swing a pendulum as Foucault did, to establish that the earth rotates around itself: there was no need to observe the stars. Yet for thousands of years Man thought he was at the centre of the Universe.

The stars, the sun, the planets, the moon are there, we can observe them every evening by looking up at the sky, but the neutrons, the protons, the electrons; where are they? They are in everything, ourselves included.

These particles of which we are all made possess properties equally fascinating as those of a classical firmament. They are a firmament within us, and not as far distance as the stars.

The problems, the thematics of fundamental modern physics have abandoned the directly accessible phenomena for the observation of our macroscopic senses, thereby opening to Man the way which today allows him to say that never before has scientific know-how touched such elevated heights.

Let one sole example suffice for everyone as an object of the first lesson tomorrow.

One studies the properties of unstable matter, that is of matter which lives scarcely one hundred thousandth of a thousand millionth of a thousand millionth of a second. Working with these particles one is discovered which lives one hundred thousand times longer, which means one hundred thousandth of one hundred thousandth of a second. Thus is discovered a new spectroscopy which in the course of a few months gives clear signs of the existence of a new chapter in Physics which was beyond all possible human imagination. But why does one study these things? Why does one do scientific research?

For science Man is the son of the cosmos, and for two reasons. Firstly, because the laws which govern his physical structure are

identical to those in play in cosmic phenomena. Secondly, because any piece of matter, the same protons of which we are made, come from cosmic space. Just think that an ordinary little piece of iron has been forged at the core of a star during a process of nuclear combustion which required thousands of millions of years.

Vast spaces, enormous quantities of matter and hundreds of millions of years are necessary in order to realise this extraordinary thing which is life on our planet. But what is it that distinguishes Man from other forms of living matter? Clearly as long as Man works to feed himself and no more, he is no different from other animal species. And Ethology which teaches us that animals are much more similar to Man than one thinks: they love music, painting, and it cannot be excluded that they may also make reflections of a philosophical nature. However, no living species studies Nature with a view to discovering the fundamental laws which support the structure of the Universe and of all the things which surround us, ourselves included: this is what Modern Science does, invented by Man less than four centuries ago with Galileo.

To understand what four centuries represent in terms of a cosmic event, which Man is, we must relate this interval of time to the correct scale of cosmic time. We thus find that four hundred years correspond to barely twelve seconds of cosmic time. What will become of Man when not another ten seconds have passed, but a few years of cosmic time, in other words, in about a thousand million years?

Here is a possible forecast. If Man with his wisdom succeeds in avoiding self-destruction (just think that today the armed might of the U.S.A. and the U.S.S.R. is at least ten times larger than that which is needed to destroy all the centres of modern civilization and all the inhabitants of the planet put together) - if this is possible - one day "All men will be scientists". Because, as we were saying earlier, scientific research is the only act of our material existence which distinguishes us from all the other numerous forms of life which abound on our planet. Science is indeed always offering new frontiers to our intellect and giving each one of us - as an example of the human species - the sensation of extraordinary intellectual power, even if his role is not one of discovery, but only one of understanding what has been discovered. Think about what I was pointing out just now; today there is no known phenomenon from the submicroscopic world (tiny subnuclear structures) to the supermacroscopic (structures of enormous dimensions such as galactic groupings) which cannot be explained within the function of the laws of Physics, and all these are derived from barely six fundamental forces, without which we would not be able to exist.

Nature is an unrepeatable example and for Science is the only Mistress of truth. It is the certain source of every progressive step in science which has permitted Man in scarcely 400 years to

find out at least 1,000 times more than he did in the preceding 10,000 years.

It is with these reflections that I wish to repeat our heartfelt thanks to Minister Pedini for having shown us, with his lively sensitivity as a man of culture, the extreme importance for our institutions of having in positions of responsibility men who are not only professional politicians, but also and above all authentic representatives of the most genuine expression of our culture and civilization.

ADDRESS BY THE CHAIRMAN OF
THE CCSEM SCIENTIFIC ADVISORY COMMITTEE

I. I. Rabi

Mr. Minister, your Excellencies, Ladies and Gentlemen,

Here we are, talking about Subnuclear Physics, in this beautiful edifice dedicated to another purpose. Today Professor Wilson gave his opening lecture the title: "Quarks; reality or myth", and here we are in the midst of myth. And we have confession boxes where students can confess their errors both in experiments and theory and seek correction from their instructors, who are here.

But speaking more seriously, this Centre is a very great achievement. As you know there are every year some 30 or 40 different courses on different subjects; I have seen some of them, apart from this Subnuclear Physics School. They are at a high level of excellence; I do not know of any University which can do the sort of thing which has began here, in this Centre of Erice. As you see the subjects range from Mathematics to Biology, from Economics to Agriculture: There is nothing else like it in the world. And this School in the first place. In the second place, I am so much impressed by the truly international character of this Centre; in the Sessions I have attended I have seen many active young people from many different countries, learning about the latest developments in their fields, discussing with one another, knowing one another, and as such making an enormous cultural bond, which is necessary in this troubled world, in these troubled times. I think that seeds have been laid here for a future greater cooperation and understanding among peoples on the basis of the universal language of science and its aspirations for a better world.

I think that conditions will change and times will soon come, when a different class of people, with a different education, will assume the reins of power in the world; and they will rely on this sort of cultural Centres to direct their political action.

It is a great thing on the part of the Sicilian government, the cities of Trapani and Erice to support this venture. It is a unique thing