packed into galactic haloes because having been collisionless since they decoupled at $T \sim 10^{10}$K, their phase space density has had to be conserved. Despite this, it does seem possible that neutrinos could be populating the outer regions of galaxies and clusters.

The final point is concerned with the way in which matter took up the form of galaxies and clusters. It has become clear that it was not reasonable to assume that the Universe was strictly homogeneous and isotropic when its temperature was $10^{11}$K (say) and that all the observed large scale structure has arisen since then from chance fluctuations. Although gravitational instabilities exist, they do not grow at a sufficient rate to account for galaxy formation by the present time. There is need for some seed perturbations whose origin may possibly lie in what happened in the Universe at a very much earlier time. Whatever the origin of such initial perturbations may be, it seems certain that structure in the Universe must first have become apparent close to the time when the photons and matter decoupled which is also close to the time when the matter energy density first exceeded the radiation energy density. If the neutrinos have masses of the order of 10 eV/$c^2$, they are the main form of matter in the Universe and they have dominated the energy density since shortly before ordinary matter and photons decoupled. As a consequence, neutrinos could have played a crucial role in the establishment of structure because they could have responded to gravitational effects while the photons and baryons were still coupled. Indeed, the structures which subsequently turned into galaxies might consist primarily of neutrinos which formed a potential well into which matter later fell.

### Conclusion

The above gives only a broad outline of the principal aspects of the standard big bang theory as it involves neutrinos. Outside these are non standard versions containing degenerate neutrinos or a non-zero cosmological constant, the possible role of grand unified theories of elementary particles in providing the initial conditions, and the influence of what are at present hypothetical particles such as the gravitino and photino. Nevertheless, it should be clear why cosmologists are so interested in the number of neutrino species and their masses and lifetimes.

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# Galileo, Nobel and the $Z^o$

## W.S. Newman, Geneva

On 3 May 1983 in a small theatre on the Italian Riviera some of the world's leading physicists applauded spontaneously when the discovery of a first candidate of a $Z^o$ boson event at CERN's proton-antiproton collider was announced. The occasion was an international scientific symposium, one of six under the general heading of "Science for Peace" organized with remarkable flair by Antonino Zichichi and a committee of Nobel Laureates and prominent scientists to commemorate, first in San Remo, the 150th birthday of Alfred B. Nobel and then, in Rome, the 350th anniversary of the publication of Galileo Galilei's *Dialogues.*

In the audience of this nuclear physics symposium was S. Glashow, who with Salam and Weinberg had established the now vindicated theory unifying the electromagnetic and weak forces, where the intermediate bosons — the charged W previously found at CERN and neutral $Z^o$ — play an essential role. His words of praise for the achievements and excellence of CERN were echoed by I.I. Rabi who 30 years ago had inspired the creation of such a European laboratory to provide American physicists with some competition, even if he had not bargained for quite so much.

Even the larger accelerators which are now under construction are unlikely to solve all outstanding problems in this domain, and that encouraged distant visions of still bigger machines (or perhaps mirages in the case of one colossus called the "desertron"). Such a giant may well one day form the nucleus of a United Nations of the World of Science, just as CERN came to symbolize the scientific United States of Europe. Viktor Weisskopf was confident that such big developments will come about, because he felt that one of the great and positive features of our modern civilization is that we are willing to devote means and effort to fundamental research. Good science also needs good fortune and new sources of money will have to be found, so it was perhaps appropriate that this symposium was held in the splendid Casino of San Remo.

Meanwhile, at the Villa Nobel — where the Swedish inventor lived for six years until his death in 1896 — four other high-level symposia took place. The human brain, modern seismology, cancer research and the frontiers between the life and physical sciences were the themes on which the leaders in these fields presented and discussed their latest finding. For science to bring benefits to mankind — its true role — peace is a prerequisite. This was the idea which inspired Alfred B. Nobel, to conceive his remarkable last will establishing the Prizes. His initiative firmly recognized science as an integral part of human culture and did much to increase public awareness of the achievements of science. A prolific inventor — he held over 350 patents — and founder of the first multinational industrial complex based on R & D, he continued research into many industrial processes until his final days. The fact that his invention, dynamite, could be used for good or evil purposes, was probably one of the motives leading to the creation of a Peace Prize to reward those who contributed most to the "fraternity among nations and the abolition or reduction of standing armies...".

A special session on Science, Peace and Freedom was therefore a fitting complement to the scientific programme in the spirit of Alfred Nobel. Appeals for an abandonment of the collision course the great powers are now on, and for a return to a policy of détente culminated in a moving account by Sweden's Ambassador Per Anger of Raoul Wallenberg's single-handed fight for the freedom and the lives of up to 100000 doomed people in wartime Hungary. The San Remo days ended with a ceremony in the presence of the King of Sweden and members of the Italian government, in which Nobel's work and his important contribution to the progress of science were reviewed.

And so to Rome — to honour the memory of Galileo Galilei whose *Dialogues* laid the foundations of modern science but, unhappily, brought him into conflict with the Church. When the participants arrived, Italy's capital went wild with joy, normal traffic came to a standstill as flag-waving car processions wound their way through the city and the noise exceeded that bearable by non-Romans. Alas, it was not for the eminent visitors that the crowds rejoiced, but for the local football team who had regained the national trophy after 41 years. The proper welcome was all the more dignified when the 33 Nobel Laureates and about 200 scientists from all over the world assembled under Swiss guard in the Sala Regia of the Vatican to be greeted by Pope John Paul II. He reiterated his hope that dispelling of past misunderstandings and mistrust will lead to fruitful concord between Science and Faith. Scientists enjoyed great moral influence which should be used in the defence of man and his dignity. The task of scientists was gigantic and noble, and the world expected from them a service worthy of their intellectual capabilities and ethical responsibilities.

The sixth symposium, that on Galilean Science Today, rightly took place in the Barberini Palace in the very room where Galileo often visited his friend who later as Pope Urban VII and Head of the Church perhaps unavoidably came into conflict with him. The full programme of lectures provided a wide panorama of modern science which true to Galileo's principles carries on the search for truth in intellectual humility. The range of topics extended to the limits of perception and conception, from the utmost reaches of the Universe, its beginning and possible end, to the ultimate unification of Nature's forces revealed to us by successive revolutions in theory or perhaps in even larger accelerators. On a more human level, there was talk of the brain and the mind, of living cells and cancer, and of how to ensure the continuation of civilized life by the use of renewable fuels and nuclear fusion. That the threat to civilization and survival is even more imminent became clear in a Round Table discussion on Science, Religion and Peace. While nations in mutual fear are engaged in an irrational race to destruction, the action of scientists appears largely confined to speaking out against such insanity. By working with the leaders of nations who, in Rabi's words, were not wicked — "but why are they doing what they are doing?" — and, above all, by making the public aware of the true, beneficial role of science, some hope for the future could be maintained.

In concluding the symposium, Nino Zichichi justified such optimism because, after all, the amount of human intellectual power is enormous. Our striving towards a fuller understanding of Nature should lead to a better life in peace and human dignity. More means are needed for research, instead of for arms of destruction because, as must be made known as widely as possible, the work of scientists inspired by Galileo and Nobel can be of the greatest value to mankind.

These stimulating days of talks and meetings with eminent scientists in the public eye furthered such positive aims and were a worthy memorial to two great men of science.

# Histories of Science

A. Guinier and J. Laberrigue, Paris

All scientists, and in particular physicists, feel strongly that a knowledge of the evolution of the ideas of their predecessors may contribute to their own research. But while works on the history of science benefit everyone, serious research in this domain is restricted to a few specialist groups. We find, for example, that the American Institute of Physics has founded in New York a Center for the History of Physics; in Germany, there is a historical section of the Deutsches Museum in Munich. In France, the future Musée des Sciences et Techniques of La Villette (Paris) will host a group of historians of science.

One must distinguish two types of historical study: the ancient and the modern. The latter is especially interesting for the physicist, because his present work is mostly influenced by what has been done since, say, 1900. Documents from this period are very numerous, relatively easy to find and also to understand as they are written in a modern language.

Interest is undoubtedly growing among physicists in the history of their science over the last decades. Mixed groups of historians and physicists are now working in various places and we shall give examples here of two such activities that are typical. We are, nevertheless, still far from a systematic coverage of the field.

Even if a physicist is not personally engaged in any historical analysis, he should be conscious of the vital necessity of safeguarding what will be the source material for the work of future historians. Every scientist should feel a responsibility for preserving any document or piece of apparatus which "may" be important. Of course, many, too modest, think that their contribution does not deserve to be treated with a religious care, but it is impossible to know on the spot the real value of an apparently small detail. In any case, it is much easier to eliminate afterwards useless documents than to search desperately for some lost piece of work which has proved to be essential. A very small amount of classification, a few moments of caution, may avoid long hours of tedious research some years after.

A necessary condition for success in compiling a history of science is perfect impartiality. But everyone is inclined naturally to give the greatest importance to the part of the story he knows best: so possible distortions in favour of one author's country should be compensated by contributions from other sources; that implies that the working teams must be international.

**International Colloquium on the History of Particle Physics**

In July of last year an International Colloquium was held in Paris on the History of Particle Physics with more than 200 participants coming from 26 countries.

During the period chosen: 1930—1960, particle physics emerged as an autonomous field, separate from nuclear physics and cosmic ray physics. However, development over the period was so rapid and so impressive and the advance in our knowledge so important, that, at the Colloquium, it was necessary to limit the subjects covered and try to put emphasis on topics that had not been treated or much stressed before.

So the Colloquium was devoted to some of the main discoveries, the origin and evolution of the concepts (isospin, strangeness,...), fields (neutrino physics,...) theories (Q.E.D., weak interactions) and technical methods that appeared at that time, as well as the role played by institutions. Moreover, as the second world war was the most important historical feature of the relevant period, the position of elementary particle physicists in relation to the new weapons was also included.

One of the aims was to collect direct testimonies of eminent physicists, who made important contributions during the period. Another was to have the participation of young physicists and historians of science. A strong motivation was the feeling of many elementary particle physicists that the scale of experiments performed today is reaching a limit and they are looking at the near past in order to understand their roots.

Numerous eminent physicists participated with enthusiasm in the Colloquium. Reports were given on: Cosmic ray physics (B. Rossi, P. Peyrou); Early history of physics with accelerators (H. Anderson); Weak interactions (E. Amaldi); Neutrino physics (F. Reines); Isotopic spin (N. Kemmer); Strangeness (M. Gell-Mann), Q.E.D. (J. Schwinger). A report prepared by B. Pontecorvo on the Infancy and youth of neutrino physics was also distributed. Spencer R. Weart spoke on "The Road to Los Alamos". Round tables on elementary particles in cosmic ray physics, the role of institutions and evolution concepts were led by W. Fretter, V.F. Weisskoff and L. Michel with the participation of R. Armenteros, C. Butler, R. Dalitz, L. Leprince-Ringuet, C.O. Ceallaigh, O. Piccioni, G. Rochester, E. Amaldi, P. Auger,