PERSPECTIVES OF FUNDAMENTAL PHYSICS

Proceedings of the Conference held at
The University of Rome
7–9 September 1978

Dedicated to

EDOARDO AMALDI

on the occasion of his retirement
from his teaching duties at
The University of Rome

Edited by Carlo Schaerf
Istituto di Fisica "G. Marconi"
Università degli Studi di Roma

[Published in collaboration with the journal *Surveys in High Energy Physics*, edited by John M. Charap, *Department of Physics, Queen Mary College, University of London*]

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PREFACE

The idea of organizing a conference on the perspectives of fundamental physics was put forward in a special meeting of our faculty and in a general meeting of all the people working in the Institute. It was unanimously approved. We wanted to celebrate almost half a century of activity devoted to italian physics by one of its most distinguished teachers and scientists. And we wanted to do it in the style of Edoardo Amaldi, to show that we have learnt from him not only as scientists but also as people. For this reason we have decided to organize not a celebration or a hagiography but a scientific conference to review the status of our present knowledge in that field of physics, the study of the fundamental interactions, where the scientific work of Edoardo Amaldi, has been most significant.

In this way we wanted to achieve various results; we wanted to offer to everyone in general and to the younger scientists in particular, a forum for discussion here in Rome on the problems of nature's fundamental interaction. Having carefully listened for two full days to the reports and to the discussions that followed I feel I am able to say in all honesty that we have achieved our aim as the scientific level of the conference proved to be of the highest quality. It was our desire to assess the degree reached by italian physics at a time when its *pater familias* is about to leave its teaching duties. I believe that this conference has proved beyond doubt that italian physics in this field, and obviously not only in this field, has reached a high scientific level and is well established in the international arena. Our only concern is the ever increasing tendency to transfer abroad a good deal of our work and to have to depend more and more from decisions taken outside the country. We must consider this problem seriously for it creates negative consequences to the life of the universities.

We wanted to prove that notwithstanding the difficult times in the country and the university, it is still possible to pursue initiatives at high scientific level even in the centres that have most suffered in the past years, like this Institute and this University. We have succeeded in so doing by no little effort and the institute collaborators have put in a lot of hard work.

We hope that in having proved in our small way that there is the possibility to progress here and now, it will encourage everyone who has the responsability to solve the fundamental problems which make our activities as teachers and researchers so very difficult.

In conclusion it is a pleasure to thank all those who have contributed to make this possible:

-Antonio Ruberti, Rector of the University, and Giorgio Tecce, Dean of Science, have provided financial help and practical cooperation and assistance on many instances;

-Francesco Calogero, Marcello Conversi and Guido Pizzella have collaborated in preparing the program;

-the staff of the institute and of the roman branch of the National Institute of Nuclear Physics have provided the organizational work.

In particular I would like to thank Bruno Pellizzoni, Lidia Paoluzi, Gabriella Fascetti and Anna Centamore of the Dean's Office;

-the National Institute of Nuclear Physics has provided financial help;

-the Accademia Nazionale dei Lincei kindly agreed to host the final session.

The Conference consisted of three parts:

1. A series of review papers on the fundamental interactions and astrophysics.
2. Two historical papers reviewing the naissance of modern physics in Italy and its re-birth after the shambles of fascism _ the second world war.
3. The perspectives of high energy physics in Europe from the point of view of research trends and large accelerator projects presented by Leon Van Hove and John B. Adams, directors general of C.E.R.N.

Part of the material presented in the lecture by professor Bruno Pontecorvo has been included in the paper by professor Ettore Fiorini.

Carlo Schaerf

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NUCLEAR PHYSICS

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It is a great privilege to have this opportunity to participate in this Symposium in honor of Eduardo Amaldi. This is doubly so because I have been asked to speak on Nuclear Physics, a field in which Professor Amaldi was one of the great pioneers. He played a central role in the early investigations which uncovered the phenomena and the new concepts demonstrating the unique character of nuclear interactions. In the presentation which follows, I shall not discuss the accomplishments of nuclear physics research. Rather, I shall ask what are our goals now and shall make these concrete by discussing examples of unsolved problems or areas which are in the process of being explored.

The study of nucleus and nuclear dynamics has been and continues to be a rich source of fundamental physical concepts of wide importance. Of course, the questions which arise now and the experimental and theoretical techniques now employed have in large measure become much more subtle and sophisticated and require greater precision. In the period following the discovery of the neutron and preceding World War II the emphasis was on such questions as "Of what do nuclei consist? What is the nature of the forces acting among the neutrons and protons? What are the masses and the electromagnetic properties of their ground states? What are the properties of their low lying levels? Does quantum mechanics apply?" These questions were to be expected since they are based for the most part upon the very successful experience with the development of quantum mechanics and its application to atomic physics.

There were a number of surprises which required the formulation of additional questions. Perhaps the most striking at the time was the discovery of the nuclear resonances observed in the collision of nuclei with neutron and proton projectiles. This brought home in no uncertain terms the importance of the many body nature of the nuclear reactions. Another was the discovery of artificial radioactivity, which demonstrated that what we now refer to as the weak interactions were not confined to the very heavy nuclei. Indeed, it was not long before the selection rules for β decay and a quantitative theory was developed based upon the analysis of Fermi and the existence of a massless neutral particle, the neutrino, proposed by Pauli. Nuclear forces were considered as being of fundamental importance and the hope, based upon experience in atomic physics, was expressed that their understanding would lead to an understanding of all of nuclear physics. This hope, as we now realize, was naive. The nuclear many body problem differs qualitatively from that of atomic physics. Experiments on nucleon-nucleon scattering soon revealed that not only were nuclear forces short ranged and relatively strong but that in contrast to the Coulomb case, they were very strongly spin dependent. Indeed, they are, at a phenomenological level, as complicated as they could be subject to the constraints imposed by the conservation principles.

But there were some simplicities. One was charge symmetry, which asserts that in states of the same angular momentum and parity the potential acting between neutrons was the same as that acting between protons. And the other was charge independence, stating that again in such states this potential equaled that acting between neutron and proton. Of course, the electromagnetic forces as well as the neutron-proton mass difference perturb both the charge symmetry and charge independence so that these principles are approximate. The notion of charge independence could be reformulated in terms of isospin in which the neutron and proton are considered different states of the same particle, the nucleon. The concept of isospin must be considered as one of the more fruitful contributions made, as a consequence of the study of nuclei, to physical thinking. Up to that time a particle's degrees of freedom, position, momentum and spin had a spatial significance. Isospin was the first example in physics for which no such interpretation is immediately possible. Nucleons are said to possess an "internal degree of freedom". Since that time the study of other elementary particles has led to the discovery of strangeness, of charm, of color, and of other internal degrees of freedom. The value of the isospin concept for the description of β-decay was quickly recognized and incorporated into the statement of selection rules for such transitions.

Because nuclear forces are relatively strong, two kinds of models of nuclear structure were considered seriously. Since the binding energy for nucleon of nuclei is approximately constant, the analogy to the liquid drop was drawn and employed to obtain the semi-empirical mass formula. Another model was the molecular or alpha cluster model of nuclei in which the lighter nuclei were thought to consist principally of α particles. In this way the binding energy of the nuclei could be largely explained, the remainder coming from the interaction of the alpha particles.

What are the issues today, some forty years later? Again, some of the questions could have been easily envisaged by the experts in atomic physics of the late 1920's. The spatial distribution of the mass, charge and spin densities and their associated currents in nuclei in both ground and excited states are examples of quantities of obvious importance which can now be experimentally determined. These data form a severe test of the theories of nuclear structure and are forcing their revision. Expressed formally, these experiments provide values for the following quantities:

$$\rho_{aa}(\underset{\sim}{x};\hat{O}) = \langle a|\sum_i \delta(\underset{\sim}{x}-\underset{\sim}{r}_i)\,\hat{O}_i|a\rangle \tag{1}$$

where $\hat{O}_i$ (an operator) is chosen according to the type of density of interest. For the matter density $\hat{O}_i$ is just the unit operator. Inelastic processes probe the non-diagonal components of $\hat{\rho}$:

$$\rho_{ab}(\underset{\sim}{x};\hat{O}) = \langle a|\sum_i \delta(\underset{\sim}{x}-\underset{\sim}{r}_i)\,\hat{O}_i|b\rangle \tag{2}$$

At the next level of sophistication, the various components of the correlations inside nuclei are the targets of experimental and theoretical studies. These ask the question what is the probability of finding a nucleon of a given type and spin at $\underline{x}$ inside the nucleus when a nucleon of another type and another spin orientation is present at $\underset{\sim}{y}$. The two body density function which measures this probability is:

$$\rho^{(2)}_{aa}(\underset{\sim}{x},\underset{\sim}{y};\hat{O},\hat{P}) = \langle a|\sum_{i\neq j} \delta(\underset{\sim}{x}-\underset{\sim}{r}_i)\,\delta(\underset{\sim}{y}-\underset{\sim}{r}_j)\,\hat{O}_i\hat{P}_j|a\rangle \tag{3}$$

As in the case of the density, the non-diagnal component $\rho^{(2)}_{ab}(\underset{\sim}{x},\underset{\sim}{y};\hat{O},\hat{P})$ will be also important particularly for inelastic processes.

Another point of view regarding correlations which had its origins in early theoretical models of nuclei such as the cluster model can be taken. One can ask, for example, what is the probability of finding a deuteron; that is, a spin S = 1, and isospin T = 0 pair, inside a nucleus. This question can be related to the two body density. To this end we reorganize $\rho^{(2)}_{aa}(\underset{\sim}{x},\underset{\sim}{y};S=1,T=0)$ as follows:

$$\rho^{(2)}_{aa}(\underset{\sim}{x},\underset{\sim}{y};S=1,T=0) = \bar{\rho}^{(2)}_{aa}\left(\tfrac{1}{2}(\underset{\sim}{x}+\underset{\sim}{y}),\tfrac{1}{2}(\underset{\sim}{x}-\underset{\sim}{y});S=1,T=0\right) \tag{4}$$

If $\bar{\rho}^{(2)}_{aa}$ factors into a function of $\frac{1}{2}(\underset{\sim}{x}+\underset{\sim}{y})$ and a function of $(\underset{\sim}{x}-\underset{\sim}{y})$ then a two-body <u>cluster</u> exists inside the nucleus; if, moreover, the dependence on $\underset{\sim}{x}-\underset{\sim}{y}$ is similar to that of the deuteron density (some modification particularly for large $|\underset{\sim}{x}-\underset{\sim}{y}|$ would be expected because of interaction with the rest of the nucleus), then we have a deuteron "inside" the nucleus which has been modified by the nuclear environment. Other two-body clusters which have been found to be of interest are the $S=0, T=1$ pairs which are thought to be primarily responsible for the properties of "superconducting" nuclei. In any case, and this is the central point, two body clusters are a particular type of two-body correlations.

The history of the theory of four body clusters goes back to pre-World War II days when several investigators proposed an alpha particle model of the nucleus. As we see from the preceding discussion, such clusters are a limiting case of four body correlations with S=T=O. The question which is of interest is: What are the four body correlations? Do they factor so that there are alpha particles "inside the nucleus"?

Another class of quantities of importance, are the overlap integrals. For example the following is of importance for reactions involving one body transfer, such as (d,p) reactions or the knockout reaction

$$S_{ab}(\underset{\sim}{r}_1) = \int \psi_a^*(\underset{\sim}{r}_1, \underset{\sim}{r}_2 \dots)\,\phi_b(\underset{\sim}{r}_2, \dots)\, d\underset{\sim}{r}_2 \dots \qquad (5)$$

These overlap integrals provide a measure of the extent to which the A body system in state consists of the (A-1) body system in state ϕ_b .

Similar overlap integrals involving two coordinates can be defined for two body transfer and so on. Although it should have been possible to predict the importance of quantitites like the overlap integrals, S_{ab} from experience in atomic physics, this did not occur. It required the experiments demonstrating the existence of direct reactions before this fact was realized.

The preceeding discussion starting with the Eq.(1) is primarily concerned with the determination of the nuclear wave function. If this could be done precisely, it would permit a determination of the nuclear Hamiltonian. Of course this program cannot be carried all the way through to that result. But by comparing experimentally determined $\hat{\rho}(\underset{\sim}{x};\hat{O}), \hat{\rho}^{(2)}(\underset{\sim}{x},\underset{\sim}{y};\hat{O},\hat{P})$ etc. with theoretical predictions based on a restricted class of nuclear Hamiltonians it may become possible to make a choice amongst these.

The nuclear Hamiltonians are eventually to be based upon the description of nuclear forces. But many lacuna in our understanding of these forces remain today. On the one hand there is the question of the importance of multi-body forces and the closely related question of exchange charges and currents. Some of these issues would seem to be resolvable by study of the nuclear three body system where the theorists can rely upon the Fadeev equations together with the rapid modern computers. However, it is not simply a matter of solving these equations more exactly. There are important questions in the two body system which remain unresolved which are closely connected with the multi-body potential. These questions are most clear cut when applied to the region in which the interacting nucleons are very close together, $r \lesssim \frac{1}{2}\frac{\hbar}{m_\pi c}$ Several approaches for the description of nuclear forces in this region have been taken ranging from the "black box" description (the boundary condition model), a phenomenological description (which turns out not to differ greatly from the first), and the ansatz that nuclear forces even in this domain can be explained by the exchange of the low mass bosons, pions, rhos, omegas, sigmas, etc. These issues remain in the intermediate range $\frac{1}{2}\frac{\hbar}{m_\pi c} < r < \frac{\hbar}{m_\pi c}$ although they are not as acute. Recently two directions have been taken by the theorists. In one, the modern theory of the hadrons using quarks as constituent particles and, for example, the "bag" as a containment mechanism is used to obtain a description of the short range component of nuclear forces. In the second, the role of the excited states of the nucleon such as the Δ in nuclear forces is being recognized. Very briefly, excited states of the nucleon can serve as intermediate states as illustrated in Fig. 1. The latter development is forced by the discovery of resonances in the nucleon-nuclear system. These can affect even the long range component of the nuclear potential where for large angular moments the Bohr approximation was thought to be valid. In at least one case (${}^1D_2$) it has been clear for many years that there was an anomoly which now appears to be resolvable when the effects of the Δ isobar is taken into account.

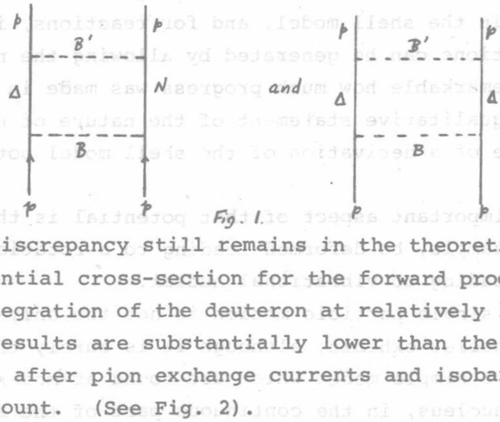

Fig. 1.

A surprising discrepancy still remains in the theoretical prediction of the differential cross-section for the forward production of protons by photodisintegration of the deuteron at relatively low energies. The experimental results are substantially lower than the theoretical predictions, even after pion exchange currents and isobar admixtures are taken into account. (See Fig. 2).

Finally, one should add as a problem in this area the proper relativistic treatment of the two body system, a treatment which is most important for the small interparticle separations where the interaction energies are thought to be large.

Another problem which was already posed in the pre-war era is that of nuclear matter. Nuclear matter is defined to be infinite in extent and of constant density, the constituent nucleons interacting through the nuclear forces discussed above. The theory is required to predict two quantities, the density and the binding energy per nucleon. A corollary quantity is the nuclear compressibility. The density and binding energy are taken from experimental data; the first has already been discussed, the second from the semi-empirical mass formula extrapolated to infinite A. Although the wave functions are very easily obtained, because of the infinite extent of nuclear matter, the calculation remains a formidible one. The calculation of the ground state of such an idealized collection of fermions is, of course, of general interest. The calculation is not yet complete, but it is beginning to converge. For example, it is already clear that the empirical Reid potential is inadequate.

We now turn to the new questions which could not be readily extrapolated from the pre-war nuclear physics. Perhaps the most significant discovery was that the complex nuclei composed for the most part of nucleons interacting through relatively strong forces could have unusually simple modes of motion. This result is fundamental for many body physics, especially for the strong interactions (which a-fortiori involves many body systems). It was found that a good first approximation could be obtained by assuming that an individual nucleon moves in the field generated by all of them. This "single particle" motion forms the basis of the discussion of the ground and low lying states incorporated in the shell model, and for reactions, in the optical model Other correlations can be generated by allowing the nucleons to interact. It is remarkable how much progress was made in this area with only a broad qualitative statement of the nature of nuclear forces and in the absense of a derivation of the shell model potential from first principles.

An important aspect of that potential is that is is dynamic. It can, for example, be deformed leading to a rotational spectrum; it can vibrate leading to vibrational nuclei.

The single particle motion is not the only simple mode of motion which nuclei exhibit, although it is surely the simplest. There are a number of simple modes which are found at moderately high excitations in the nucleus, in the continuous part of the spectra. These have been referred to as "doorway" states as these states are not exact eigenstates of the nuclear Hamiltonian, coupling as a consequence to other modes of motion to produce a fine structure in the cross-section. This is illustrated in Fig. 3. The doorway state resonance is a consequence of the coupling of the doorway states to the incident. The fine structure is a fragmentation of the resonance induced by the coupling of doorway states to more complex states. As an example the fine structure exhibited by the giant electric dipole resonance in ^{27}Al is shown in Fig. 4. There are several other examples of this kind of giant resonance. The most familiar are the isobar analog resonance and the shape isomer resonances in the heavy elements such as Pu (See Fig. 5); a quadrupole giant resonance and others of different multipole orders are indicated. These doorway states are states which are one order or more complex than the single particle states. The wave function for both the dipole and analog resonance is made up for the most part of particle-hole excitations. The shape isomer is a consequence of a second minimum in the dependence of the energy on deformation.

The search for these simple modes of motion is a continuing and most important experimental effort. Obviously the question of whether states of still higher order complexity can be observed, the secondary doorways, is on the experimentalists' agenda. As we have emphasized, these results bear most directly upon our understanding of strongly interacting many body systems. But these simple states in the continuum have so far been observable often because of the existence of a symmetry principle. In the case of the isobar analog resonance, it is the conservation of isospin. In the case of the giant dipole resonance, the symmetry involved manifests itself through the very simple connection between the target ground state and the excited nuclear state generated by the absorption of a dipole radiation. Finding then these doorway states, a giant resonance or intermediate structure being indications, is thus also important because it may imply the existence of a symmetry. These may very well fall outside of the relatively simple examples implied by the existence of spin, isospin and multiple order.

This central problem, the search for symmetries, is also a subject of importance for the bound states. The dynamical shell model included interactions is capable of describing any nuclear system. But this virtue rapidly becomes illusory as the mass number of the nucleus and its excitation energy increases. For example, Talmi has pointed out that in the case of the nucleus ^{156}Sm assuming that there are 12 valence protons and 12 valence neutrons and that these are restricted to the open major shells $(1g_{9/2}, 2d_{5/2}, 2d_{3/2}, 3s_{1/2}, 1h_{11/2})$ and $(1h_{9/2}, 2f_{7/2}, 2f_{5/2}, 3p_{3/2}, 3p_{1/2}, 1i_{13/2})$ for the protons and neutrons respectively, there are 6.1×10^7 levels with $J = 0^+$. For $J = 4^+$ the number rises to 10^{15}. Obviously there are too many states for each to be interesting even if it were possible to evaluate the matrix elements of the residual interaction and diagonalize the resulting secular determinant. So again we face an important issue, how do we select from this multitude of states those which have particularly simple properties and therefore of greatest physical interest? One procedure which has been adopted is to look for sets of states which bear a simple relation to each other; that is, satisfy a symmetry. This type of relationship is clearly manifested by the examples mentioned earlier and by the rotational and vibrational states. Iachello, Arima and Talmi assert that the important symmetry in the middle weight and heavier nuclei is SU(6). Another procedure whose development is largely due to J.B. French uses statistical measures to characterize a large ensemble of states, like the ones mentioned above. Statistical procedures are important, for they tell us what is a reasonable expected behavior. A large deviation from that behavior indicates a special situation which may have substantial physical significance. In any event this is another question whose resolution it seems to me will have an impact not only on nuclear physics, but also more generally on our understanding and treatment of the many body problem.

New areas of investigation have become available through the construction of new accelerators which produce beams of heavy ions, or beams of high energy protons which in turn are used to produce secondary beams of pions and muons whose decay neutrinos can possibly act as probes of nuclear structure though those experiments have yet to be performed. In addition the K beams and anti-proton beams at CERN and Brookhaven are being used for nuclear structure studies.

Beams of heavy ions whose mass range up to U, and with energies up to the order of a few hundred MeV/n for the light nuclei and of the order of several MeV/n for U are now or will shortly be available Light heavy ions such as ^{16}O with energies of up to 2.1 GeV/n have been employed in a number of experiments. This is an extraordinarily rich field. Since the projectiles are composite, they can transfer particles to the target and vice versa. Nuclei far off the stable valley can thus be produced. Since they are highly charged, they can subject the target to intense electric fields. Since they have large momenta, they have very short wavelengths. Moreover, they can transfer large amounts of angular momenta to the target in peripheral collisions. Since they have large momenta, there is the possibility that in central collisions they can penetrate into the target nucleus and produce local regions of high density and excitation. Finally since they are energetic, large energy transfers become a possibility. In a phrase it becomes possible to study nuclei under extreme conditions far from those which have been available so far. One can ask what happens to nuclei when they are spinning very rapidly? What happens to nuclear matter when the density is high? One speculation suggests that a transition occurs to a new type of nuclear matter referred to as abnormal nuclear matter with a a quite different equation of state. A similar speculation proposes the possibility of a pion condensation. The proposal that has also been made that a new form of matter consisting of quarks of various kinds might be formed.

The collision of heavy ions also requires a substantial generalization of the theory of nuclear reactions so that phenomena involving substantial transfers of angular momentum, energy, charge, as well as the more catastrophic fragmentation or its inverse fusion, can be described. As Weidenmüller has pointed out, this area of research could be considered as a branch of non-equilibrium statistical mechanics. Indeed, several investigators have adopted and adapted techniques employed in the macroscopic physics of continua such as hydrodynamics with viscosity, the diffusion equation in differential as well as in integral forms; and as these theories attempt to become more ambitious, one can anticipate a gradual evolution to a more microscopic picture via the Lorentz-Boltzmann equation. Another statistical approach has considered the effect of these new degrees of freedom from the point of view of the current theory of nuclear reactions; that is, has started with the microscopic point of view and then applied statistical methods, employing principally the random phase hypothesis as well as the "chaining" assumption. We shall come back to these later. But they lead at least in one version to a more general statement to which a macroscopic approximation can be applied where that is appropriate. One corrollary development has been a new understanding of the formation of the compound nucleus. Be that as it may, it is clear that we are dealing here with a subject of fundamental importance in which relatively small energetic units of matter consisting of strongly interacting particles are colliding and sharing their energy, mass, charge, angular momenta, etc. The understanding of these phenomena will provide new insights into the many body reactions, particularly to the statistical approximation, and will undoubtedly be important for other fields of physics as well as chemistry.

The existence of beams of pions and kaons provides new tools for the study of nuclear structure. In part this is because these particles have different combinations of spin and isospin, for the pion S=0, T=1, for the kaon S=0, T=1/2 than the traditional projectile the nucleon S=1/2 T=1/2, or the deuteron S=1, T=0, or the alpha particle S=0, T=0. The kaon has an additional degree of freedom, strangeness or hypercharge, which can also play a role. But in addition the interaction of the kaon and pion with nucleons has a substantial new feature, namely the formation of baryonic resonances.

Of particular interest are the excited states of the nucleon such as the $\Delta(S=3/2, T=3/2)$, the $\Lambda(S=\frac{1}{2}, T=0)$, $\Sigma(S=\frac{1}{2}, T=1)$ and their excited states. As probes of nuclear structures, these particles have an attribute which has not been available up to this time. Their interaction with nucleons is strong and short ranged, they have baryonic mass and, this is the important point, they differ from the nucleus and thus need not satisfy the Pauli principle with respect to these particles. For example, a Λ can be added to the nucleus in any single particle level while a neutron or proton would be required to be in an empty one. It thus becomes possible for the baryonic resonances to be present in the interior of the nucleus providing new tests of nuclear structure. On the other hand the study of the behavior of these particles in the nuclear medium by, for example, observing the modifications inside nuclear matter of their lifetime, decay modes and electromagnetic properties such as magnetic moments probes the properties of these particles and may provide new information not available by other means. Again, an interesting and important many body problem presents itself; namely how to determine the behavior of a baryonic resonance inside a medium, a nuclear one in this case, and the consequent impact on the interaction of pions and kaons with nuclei.

Finally, let us turn to the weak interactions where nuclei have served as a source of insight into the weak interactions via β decay, and which as we mentioned earlier enables us to determine the quantum numbers of nuclear energy levels via β decay selection rules and also to obtain information on their wave functions from the lifetimes. The study of β transitions more recently have made it possible to demonstrate almost conclusively the absence of second class currents. The close analogy between the charge current and the pseudovector current suggests the possibility and importance of studying the latter and mapping out its spatial dependence inside nuclei. For this purpose the study of photoproduction of pions (or its inverse, radiative capture) and the (ν, e) reaction, the process analogous to electron scattering offer two possibilities. The first type of experiment has been performed, but the interpretation in terms of pseudovector current distributions is not yet available. An interesting recent development in this area is that of measuring the parity non-conserving amplitude in proton scattering by nuclei [4]. This capability will in the long run keep determining the hadron-hadron weak interaction. Moreover, because it is weak, the distorted wave Born approximation is accurate so that the nucleus wave functions can be studied. However, this will require a knowledge not yet available of the dependence of the weak interaction potential upon space, spin and isospin. The recent observation of the violation of