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CONCLUDING REMARKS
XXV Mazurian Lakes School *

H. Rebel

Forschungszentrum Karlsruhe, Institut für Kernphysik
P.O.B. 3640, D 76021 Karlsruhe, Germany

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"Ich bin kein ausgeklügelt Buch,
ich bin ein Mensch in seinem Widerspruch."

Johann Wolfgang von Goethe

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1. Introduction

Considerations of symmetries of physical systems play a fundamental role in understanding the forces and constituents of our Universe. They start with an orientation on the strong belief in the PCT invariance, telling us that our world is symmetric under simultaneous space inversion, charge conjugation and reversal in time. However, breaking of these particular symmetries occurs already in the early history of the Universe, developing towards matter rather than to antimatter, to the left-handed weak interaction, but with strict invariance for the strong, electromagnetic and gravitational forces, at least at the present level of our knowledge. It has been the general topic of this XXV Mazurian Lakes School to review our actual conception and current understanding of symmetries of the fundamental interactions, interrelating micro- and macro physics phenomena.

At the end of these beautiful days, a period of very inspiring scientific and personal interactions, with updating our views on a variety of facets of a frontier subject, it is my great privilege and a real pleasure for me to conclude the XXV edition of this traditional Mazurian Summer School with some mostly general remarks. They are compiled from my personal point of view and do neither demand to be complete nor they do reflect a balanced

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evaluation of the new, less new and the brandnew messages. In order to characterize my actual outlook tower I have to indicate my involvement in experimental studies [1] of a particular phenomenon of the non-thermal Universe, of high-energy Cosmic Rays, whose energy spectrum extends many orders of magnitude beyond energies of man-made accelerators and whose sources, accelerator mechanisms and propagation through the interstellar space provide challenging astrophysical problems.

2. General frame

The close connection between the laws of microphysics, *i.e.* nuclear and particle physics with the macrophysics, *i.e.* astrophysics and cosmology is one of the most important insights and discoveries of our century. Showing their interwoven operation an impressive view with a wide horizon about the role of "Broken Symmetries at the Origin of Matter, at the Origin of Life and the Origin of Culture" has been the overture of our school. *Johan van Klinken* conducted a concert starting from the development of the first microseconds of our Universe, passing to the mystery of the pre-biotic evolution with the preference of nature for left-handed amino acids, finally exhibiting the homo sapiens with predominant right handedness, as broken symmetry with ramifications in religions and cultures — "broken, sometimes a choice by necessity, sometimes by random with bifurcation". His view may be challenged, but the melodies led to exceptional intellectual joy, and joy should be gratefully accepted, and less rationally analysed in detail. This may be my formulation of expressing that without symmetry breaking and exceptions of a severe construction, our world would lose its inspiring variety and would condense in a degenerated, completely unpleasant boring state.

When considering our school programm, the laboratory from which we did dominantly report has been the Atomic Nucleus, a collaboration of A nucleons, *i.e.* confined clusters of quarks and gluons, whose interactions carry the Universe.

The nucleus as a distinct physical entity has been studied for most of this century. A casual reviewer of our extended studies may come to the conclusion that the subject is in a mature status and provides now a complete picture of nuclear matter, and that further research is for filling up details and of less priority. This is also often expressed by colleagues from other specialties, corroborated — we must admit — by occasional immobilities of established sub-branches of our field. Consequently, such opinions are nowadays very often uncritically adopted in administration and government's offices, surely biased by public opinions in our societies and an irrational understanding of the role of nuclear energy for mankind.

However, the field — and I think various contributions to this Mazurian Lakes School give witness — is currently going through an exciting renaissance with the potential of a radical change of our perception of nuclear matter, due to new experimental techniques and new insights and with a rather conclusive demonstration of the relevance and links of nuclear physics with other physical sciences: Astrophysics, Elementary Particle Physics and Cosmology. What concerns Nuclear Physics itself the renaissance is prompted by *the development of new techniques for probing subnuclear degrees of freedom, of production of intensive radioactive beams to investigate nuclear matter at extreme charge-to-mass ratios and new instrumentation to probe nuclei spinning at their limits.*

Even seen from a distant point of view, this renaissance appears to be so remarkable, that nuclear physicists should have no need to justify their topics merely by spinoffs useful for the society and following each public wind, as "victims of an inferiority complex" (Allan Bromley [2]). Applications are certainly important and Applied Physics is certainly challenging and of own fascinating interest — what we probably sometimes tend to ignore. However, science of understanding our World, their invariant quantities and broken symmetries, is for itself a service for mankind, for human culture and a basis of common understanding.

3. Orientation of the programme

In order to highlight the aspects of a nuclear physics meeting, it appears sometimes to be useful to adopt a scheme of the Nuclear Physics European Collaboration Committee (NUPECC), shown *e.g.* by Achim Richter at the INPC in Wiesbaden (1992). It orders the richness and progress in the garden of nuclear physicists [3]. That scheme displays the dimensions of nuclear physics expansions: along excitation energy or temperature or density, respectively, along spin and isospin excitations, showing the perspectives of the observed nuclear phenomena.

However, as guideline of the walk through the landscape of the XXV Mazurian Lakes School, such a display may set wrong flags. It is a characteristic feature appearing in this particular edition of the Mazurian Lakes School, that the contributions are aligned along an outlook to a lighthouse located beyond the fence of the nuclear physics garden: The nucleus as laboratory for research of fundamental questions. From these reasons I introduce a more specific coordinate system as orientation for the physics of our present meeting. Certainly this system is not orthogonal, and the projection onto the axes may truncate some presented aspects. Some of the speakers may even feel to be forced in a wrong bed, some appear with considerable spreading width in several beds!

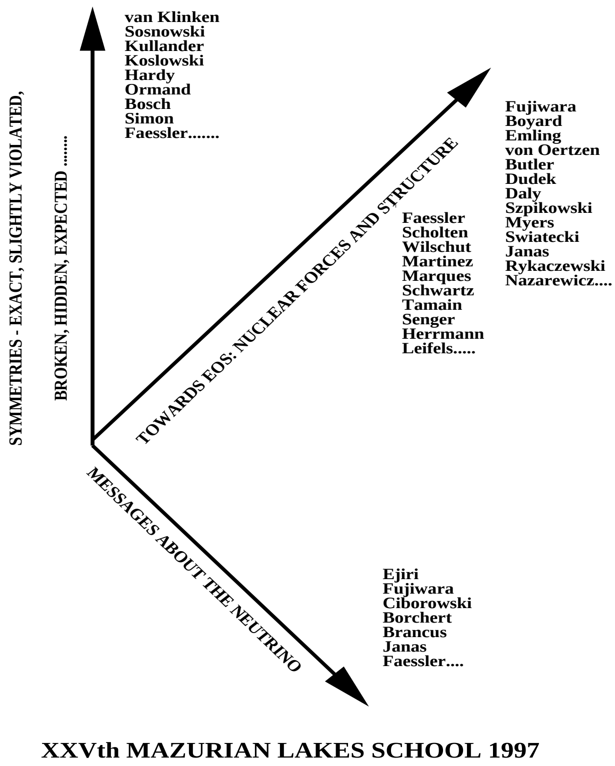


Fig. 1. Coordinate system of the topics of the XXV Mazurian Lakes School.

4. The programme

Quite timely, the workshop started with an astrophysical theme of high interest. In a very interesting and educational lecture *Marek Kutschera* showed us the end of a specific stellar evolution: Formation and structure of neutron stars, where and in which variety they do occur as pulsars of electromagnetic waves. We notice "quite timely" since we approach in November the 30th anniversary of the discovery of the first radio pulsar due to a spinning neutron star (Bell and Hewesh 1967).

Many of us know the impressive appearance of the famous Crab nebula [4], the remnants of a Supernova (SN 1054), which appeared visibly on the sky in July 1054, as Chinese astronomers did report. In the interior, there is a neutron star, a pulsar emitting electromagnetic radiation in all wave bands. In fact, the Crab is also a standard candle of High Energy Gamma Ray Astronomy. However, not each SN remnant does carry a neutron star. For example, there is no evidence for the SN 1987A. Particularly interesting is the suggestion that collisions of two neutron stars may be sources of the observed and rather mysterious gamma ray bursts, and that nonrotating, nonradiating neutron stars could potentially contribute to the dark matter searched for. Marek Kutschera introduced us furtheron in the current understanding of the structure of a neutron star, with some speculations based on calculations using realistic nuclear forces, discussed under the actual questions. Do there exist limits and constraints for mass and magnetic field? What are the empirical constraints for the equation of state? We learned, there are 5% protons, which induce the spin polarisation, in addition to the corresponding number of electrons also one percent muons of that.

Messages About Fundamental Symmetries

Continuing with the discussion of the role of symmetries for understanding our world, we all have certainly enjoyed the elegant lecture of *Ryszard Sosnowski*, reviewing: "How quarks have been discovered" and leading our interest to the current questions, related to symmetries in elementary particle physics "exact ones, slightly violated, broken, hidden or expected". The presentation was finally focused to the structure of the Cabbibo–Kobayashi–Maskawa matrix. The matrix arises as the weak interaction states and the mass eigenstates are not exactly the same.

The beta decay is universal. A charge $-2/3$ quark can turn in a charge $-1/3$ quark, by emitting a W^+, which appears as a lepton-antilepton pair ($c \to s + (\mu, \nu)$ *e.g.*). The matrix quantifies the predilection of quarks to decay in other quarks and represents the effect of rotating from the weak-interaction basis to the mass eigenstate basis. The element V_{ub} is the amplitude of the decay of a b in an u. The question is, if there exist complex matrix elements which would induce CP violation, and if, in an sufficient amount, when compared with the experimental observations. We touched the audacious issue of Supersymmetry, insisting that for every fundamental particle there exists another related particle whose spin differs from it by half a unit, for the electron a spin-zero *selectron*, for a quark a spin-zero *squark*, for the bosons W, Z, and photon a spin-one-half fermion *wino*, *zino* and *photino*. None of these bizarre supersymmetric entities has as yet exhibited itself, but it could not be excluded that this hidden world has been already evidenced by exotic events of cosmic ray observations [5].

Sven Kullander familiarized us with present days knowledge about CP violation, exercising first the case of CP violation in K_0 decay, and illustrating the test possibilities of CP breaking in rare Eta decays. The challenging topic has been discussed with the appearance of new experimental facilities, like WASA in Sweden. In order to remind you of the aspect, I just show one of the proposed tests of CPT invariance in a hadronic decay mode, looking for differences in the angular distribution. We have to realize the aspect

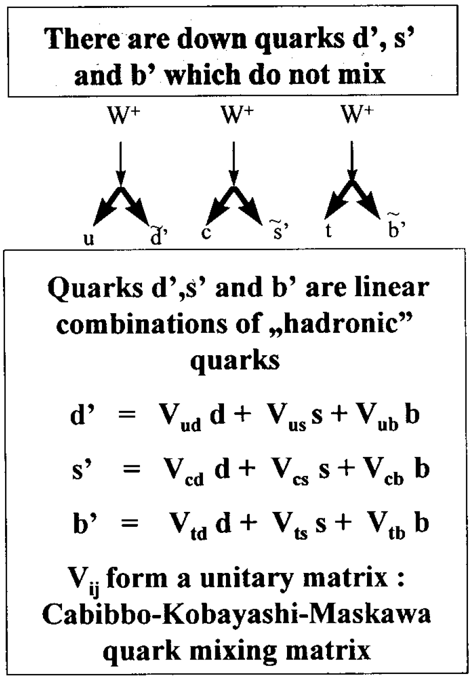


Fig. 2. CKM matrix.

that CP violation in nonhadronic decay modes should quantitavely relate to observations of the size of the electric dipole moment of the neutron.

Another study of rare decays searching for symmetry violations and effects beyond the Standard Model, has been presented by *Tadeusz Kozłowski*, who did introduce the SINDRUM project. This endeavour is focused to look for unexpected decay modes of the muon like the decay of the muon in electron and gamma, forbidden by our Standard Model.

$$\mu^- + (A,Z) \to e^- + (A,Z)\,, \qquad \mu^- + (A,Z) \to e^+ + (A,Z-2)\,.$$

The clue is that an atomic nucleus acts as catalyst for coherence, where the flavour oscillation *e.g.* of muonic neutrino to a subsequently reabsorbed electronic neutrino or other nonstandard mechanisms are mediated by the protons of the nucleus. Under the view: *The nucleus, as a breaking symmetry system and a micro-laboratory for symmetry studies* we had really excellent presentations by *John Hardy* and *Johan van Klinken*, using beta decay experiments with difficult and excellent experimental work to test fundamental symmetries. John Hardy discussed the superallowed beta decay as a probe, with tests of the CVC theorem and of the unitarity of the

Cabibbo–Kobayashi–Maskawa quark mixing matrix. Let me remind of the results based on the world data presented in the lecture!

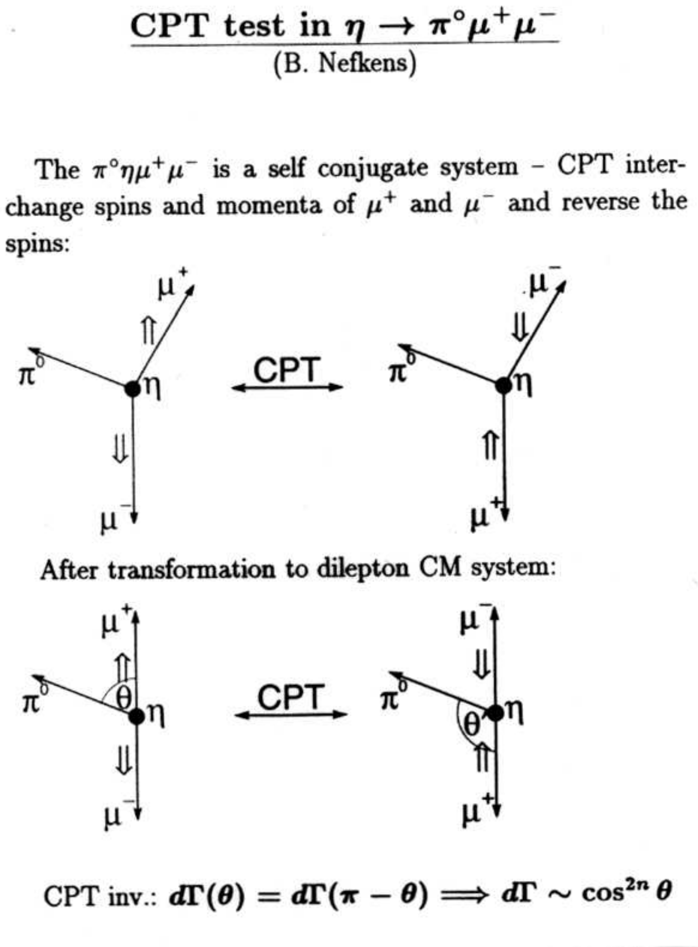


Fig. 3. CPT test in Eta decay.

CVC and UNITARY Test — World Data 1996

- Nuclear $0^+ \to 0^+$ Decays: $\overline{ft} = (3072.3 \pm 1.0 \pm 1.0)\,\mathrm{s}$
- Muon Life Time: $G_\mu/(\hbar c)^3 = (1.166639 \pm 0.00002)10^{-5}\,\mathrm{GeV}^{-2}$
- Radiative Correction: $\Delta_R = (2.40 \pm 0.0008)\,\%$

$$V_{ud} = (\kappa/(2(1+\Delta_R)\overline{ft})^{1/2} G_\mu^{-1}$$
$$= 0.9740 \pm 0.0005 \pm 0002$$

- Hyperon Decays: $V_{us} = 0.2205 \pm 0.0018$
- B-Meson Decay: $V_{ub} = 0.0032 \pm 0.0009$

$$V_{ud}^2 + V_{us}^2 + V_{ub}^2 = 0.9972 \pm 0.0013$$

The present result on unitarity, potentially indicating (within 3 σ) a small violation, provokes the question for the reason: Right handed currents? The topic has been substantially corroborated by the lively contribution of *Eric Ormand* detailing the influence of Coulomb interaction and isospin mixing, which distort the observations about symmetry violations, introducing also the aspect of parity violating electron scattering. The aspect of polarized particle scattering, we did slightly ignore in our discussion.
I enjoyed, in particular the exposé of John Hardy on the enormous experimental efforts for achieving the necessary precision, for example for the Q values, in the order of 100 eV.

Starting with an reminder of the CP theorem and finally focussed to the actual experimental status of tests of time reversal symmetry in beta decay, *Johan van Klinken* gave us an excellent review, with a detailed understanding of the problems and delicate difficulties of the experiments devised with fascinating experimental ideas.

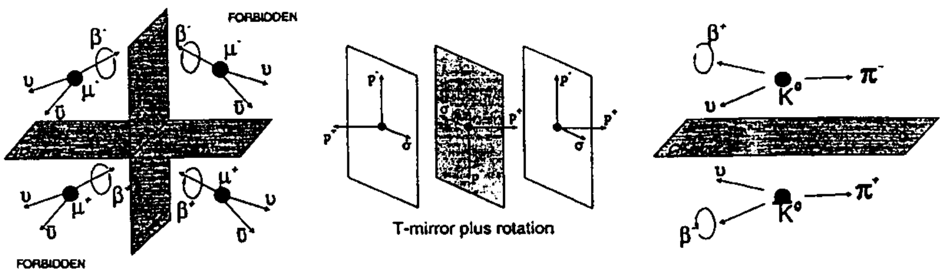


Fig. 4. Discrete transformations — the differential decay probability [6].

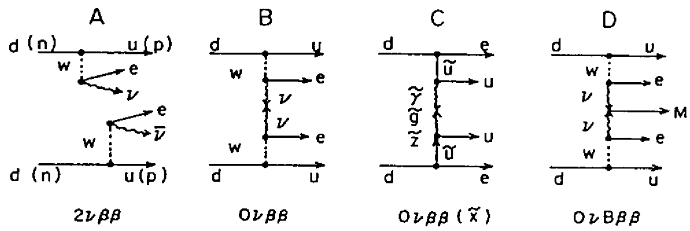
Time reversal with T symmetry implies that the reversal of all movements of the elementary particles does not change the outcome of the experiments. T violation has been never observed directly, but is inferred from PC violation (kaon decay). In the expression of the differential decay probability (see Fig.4), there are two terms for time reversal tests by observing triple correlations: *(i)* Looking for a nonzero the D term implying neutrino recoil experiments and *(ii)* R type tests with transverse electron polarimetry. The parameters D and R are combinations of the coupling constants. Johan's message after discussing various current experiments: *The effects remain stubbornly within the Standard Model.*

Messages About the Neutrino

One of the best examples of a situation of interwoven micro and macro physics is offered by the neutrino. The neutrino plays by its nature (Majorana or Dirac particle?) and its quested mass a key role in modern physics. It is a candidate for nonbaryonic dark matter in the Universe, plays a decisive role for the energy transport in supernovae. Anomalies in the solar neutrino flux and for atmospheric neutrinos suggest explanations in terms of flavor oscillations. The presently sharpest limits on the electron neutrino mass are coming from nuclear physics experiments.

Our specific discussion has been opened by a message of *Eric Sheldon* reading us a translation of the famous letter of Wolfgang Pauli to the Tübingen people, in particular to Lise Meitner and Hans Geiger: "Sehr geehrte radioaktive Damen und Herren!......".

Certainly, the neutrino plays today a role being at least as important as at that time. The apparent difference, however is: At that time eminent physicists like Pauli missed a physics meeting in favour of a Christmas ball in Zurich — how Pauli apologized, — nowadays they leave earlier or arrive delayed at our school due to their importance with a committee commitment.



Schematic diagrams of ββ decay processes: A, two-neutrino process, B, neutrino-less process with the Mjorana neutrino exchange; C, neutrino-less process in the SUSY model; and D, neutrino-less process followed by the Goldstone boson (Majoron).

Fig. 5. Double beta decay [7].

The Standard Model implies the conservation of lepton number, which has been tested and confirmed to high accuracy. However, this conservation law is expected to be violated for Grand Unified Theories and Supersymmetry. With this aspect the search for the neutrinoless double β-decay $(2n \to 2p + 2\beta^-)$. *Ejiri-san* followed the view: The nucleus, as a breaking symmetry system and a micro-laboratory for symmetry studies. The examples, he did stress, were double beta decay processes, studied with the ELEGANTS setup, measuring the spectra of the energy sum of the emitted electrons. Double beta decay processes can appear in different modes, and the measurements put, for example, limits for the existence of the neutrinoless decay via a Majorana neutrino exchange. In case of ^{100}Mo for the two-neutrino double beta decay ($0^+ - 0^+$) $T_{1/2} = 1.15 \cdot 10^{19}$ y has been found, *e.g.*, while for the neutrinoless decay limits of $T_{1/2} = 5.2 \cdot 10^{22}$ y are quoted. This implies for the mass of the Majorana neutrino $m_\nu < 2.2$ eV, a value which is actually dependent from the nuclear matrix elements.

Forwarded by *Jan Żylicz* in the discussion, some questions did come up about the nuclear matrix elements, finally accounted in detail by the calculations of *Amand Faessler*. Amand Faessler stressed the importance of the Pauli principle to be included in the RPA calculations in order to reproduce the observation of double neutrino beta decay and to provide reliable values for the neutrinoless case.

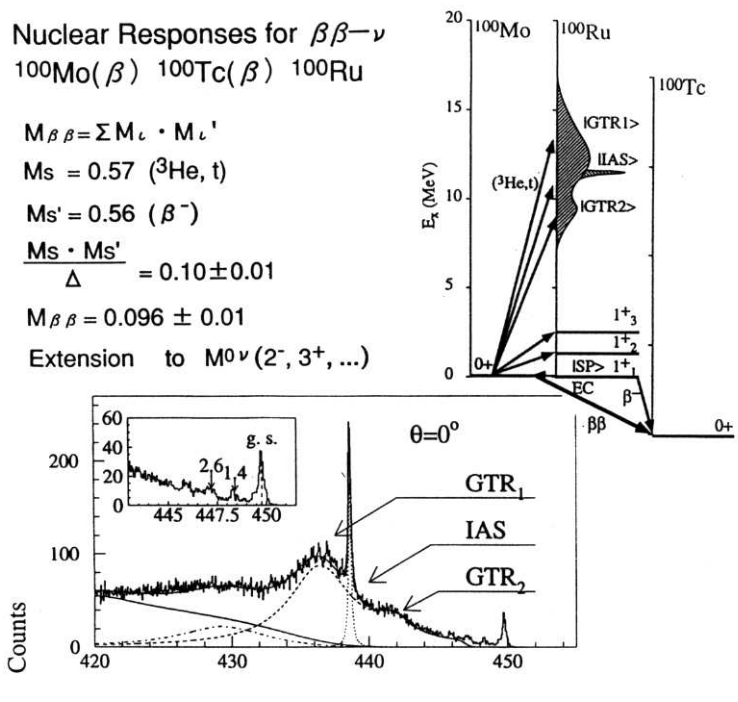


Fig. 6. Nuclear response.

The case has been considered from a complementary side, by studies of the spin-isospin responses by charge exchange nuclear reactions (^{3}He,t), done at the GRAND RAIDEN spectrometer RCNP OSAKA, with ^{100}Mo and ^{71}Ga.

This aspect — Gamow–Teller resonance studies as source of information about the nuclear matrix elements, involved in weak interaction processes, —

has been discussed by *Fujiwara-san* in his experimentally motivated lecture about charge exchange reactions, presenting wonderful data. I found interesting the suggestion, how to explain the large differences between GT_- and GT_+ excitations. The longstanding question with the Gamow–Teller resonance is the quenching of the strength and a possible explanation by coupling to the Δ resonance. *Jean Louis Boyard*, talking about Diogene, explicitely studied this coupling in the charge exchange reactions by (^{3}He,t,π) studies specifying *quasifree, absorption and coherent* processes mediated by the Δ resonance.

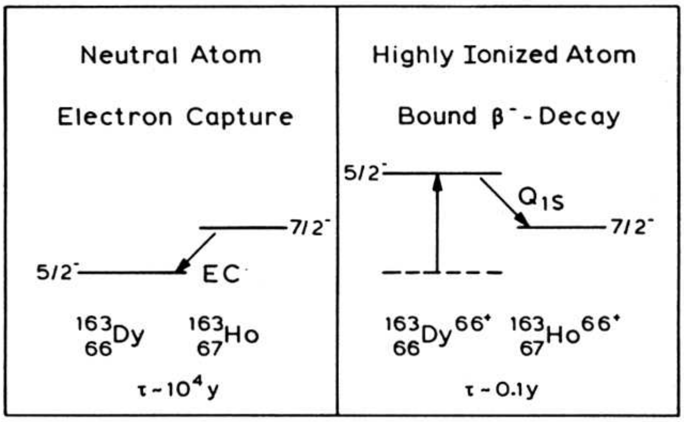


Fig. 7. Inverse electron capture: Scheme of β-decay of a bare Dy nucleus into bound electron states in single ionized Ho [3].

In quite another way the nucleus has been exposed as laboratory of fundamental research in the fascinating lecture of *Fritz Bosch* about a beautiful example for the linkage between nuclear physics and astrophysics. He introduced us in the features of beta decay in bound state (Fig.7) as a mode of general importance, especially however, for the element production in hot stars. We learned the relevance to our topic and were impressed about experimental techniques at the ESR cooler ring, used as mass spectrometer of ultimate precision. With the ^{187}Re–^{187}Os decay (an example where the bound-state beta decay plays a decisive role), the actual confusion about the age of the Universe has been addressed. This is a topic which has induced embarrassment under astrophysicists, formulated with the question: Why we find stars in globular clusters being considerably older than the whole Universe, at all, as far as we infer the age from one of the particular favored values of the Hubble constant?

The final result of direct age measurements by the Re-Os method, after explicitely taking into account the beta decay mode in bound states, exhibits our Universe as a capricious lady of the fair age larger than 12 Gyrs, in accordance with other direct results. Combining now that result with the recently adopted value of the Hubble constant (now settled after the discovery of clock nuclei, Cepheides in the Virgo cluster) — and as far we trust Hubble's law and the Big Bang story, at all, Lady Universe has a matter density smaller than the critical density, being still open for new experiences and she disappoints all speculations of other kinds. The spectacular feature of the story to be noted is: Nuclear Physics provides finally key information for that far-reaching question!

Returning to the neutrino I have to mention the remarkable and at a first glance certainly peculiar view of *Jacek Ciborowski*, bringing tachyonic neutrinos into the discussion. Tachyonic neutrinos would provide a "natural explanation of parity violation" and explain the observed step-like termination at the endpoint of the β-spectrum of tritium decay (a feature, for which also less spectacular explanations can be given). I have to admit, I feel unable to follow the arguments, removing some familiar causal paradoxa, but leading on the other side to new paradoxa. Nevertheless his view appears to be consistent, and a fair discussion does certainly need some penetration through psychological barriers. Let us tentatively note his *"educated guess"* about the *imaginary* neutrino mass of ca. 5 eV/c^2 when inspecting the actual list of upper limits for the neutrion mass!

Before turning away from our favourite, the elusive neutrino, let me add some comments about neutrino signals from astrophysical sources! Several times signals of neutrino oscillations have been claimed in the past. In Internet (http://neutrino.pc.helsinki.fi/neutrino/nd-osc.html) you find a long list of negative results. The evidence from reactor and accelerator experiments did evaporate, and the only actual positive signal, reported from the Los Alamos — LAMPF group is under debate and need surely a thorough confirmation. Thus, it seems that the solar neutrino deficit might be the only positive indication.

TABLE I

Compilation of results about electronic neutrino mass
(http://neutrino.pc.helsinki.fi/neutrino/nd-mass.html)

Experiment	Measured mass squared	Format limit	C.L.	Year
Mainz	$-22 \pm 17 \pm 14$	5.6	95%	1995
Troitsk	$1.5 \pm 5.9 \pm 3.6$	3.9(2.2)	95%	1997
Zürich	$-24 \pm 48 \pm 61$	11.7	95%	1992
Tokyo INS	$-65 \pm 85 \pm 65$	13.1	95%	1991
Los Alamos	$-147 \pm 68 \pm 41$	9.3	95%	1991
Livermore	$-130 \pm 20 \pm 15$	7.0	95%	1995
China	$-31 \pm 75 \pm 48$	12.4	95%	1995
Average of PDG (96)	-27 ± 20	15	95%	1996

We are aware of that so-called solar neutrino problem, which is often too uncritically interpreted as obvious signal for flavour oscillations. In context of nuclear physics studies, necessary for understanding the detector response of the ICARUS experiment *Zenon Janas* has sketched the problem in a simplified way. Looking more carefully in the matter there are a number of serious internal inconsistencies, and we have at least three different problems in the observations of the solar neutrino deficit, as registrated by various different detector setups and unclarified influences of effects tending to traditional explanations. Thus, presently any conclusion is premature, and we should not put our hand in that covered cage and tell a bird is therein, when eventually only a nail has scratched us. With the GALLEX result in mind we may conclude, that we are missing the neutrinos from ^{7}Be decay, but the reason remains still unclarified.

There is another hint under discussion, the so-called the atmospheric neutrino problem. This has been indicated by *Iliana Brâncuş* in context of charge ratio measurements of atmospheric muons. The Kamiokande II and IBM detectors, *e.g.*, observe an anomaly in the contained neutrino events, but some other underground detectors do not so. The measured ratio of muonic to electronic neutrinos seems to be considerably lower than predicted according to all rules of the art. As possible interpretation flavour oscillations of the muon neutrino are invoked. The Superkamiokande group seems to be quite certain. But also in that case, a number of uncertainties enter in the delicate evaluation of the data [8]. At the recent International Cosmic Ray Conference in Durban, most delegates agreed with the view, that we have in the moment no good reasons to follow some wishful thinking and to propagate unclear signals from astrophysical neutrinos.

Hadronic Matter in Various Phases

Passing now to questions of hadronic matter in various phases, to nuclear forces and nuclear structure, we realize that we did meet this topic already with the consideration of neutron stars. The present research in the laboratories is strongly coupled to the field of heavy ion research, exploring *heated nuclear matter, hot, compressed and excited nuclear matter* on the road to highest densities, to an eventual reproducible short moment of the Early Universe: the *quark-gluon plasma*.

Quasi as an introduction in the basics *Amand Faessler* formulated the nucleon-nucleon interaction on the basis of quark and gluon exchange, in the limit of chiral symmetry *i.e.* of massless quarks, where left and right handed quarks are decoupled ("do not talk to each other", how Norbert Herrmann nicely formulated). The reality of different masses does imply an explicit symmetry breaking.

Adjusting a few parameters, this QCD inspired approach is able to reproduce the results, formerly described by meson exchange approaches with some ad-hoc assumptions. As an example, we may have a look, how well the phase shifts for spin orbit coupling *e.g.* are produced (see the contribution of A. Faessler). A remarkable feature is the natural way to explain the hard core of the NN interaction, as consequence of a correct handling of the symmetries (the Young tableaux) of the six-quark system. I ask me, of course, how such a formulation will hold, when extrapolated to higher energies. Could the description of proton proton bremsstrahlung be based on that approach? There have been coherent contributions of increasing complexity about bremsstrahlung emission in proton-proton, proton-nucleus and nucleus-nucleus scattering by *Olaf Scholten*, *Hans Wilschut* and *Gines Martinez*.

Olaf Scholten defined the basics of appearance of bremsstrahlung in deceleration of nuclear particles. We learnt that the pp bremsstrahlung, which implies the off-shell behaviour, does not help at all to discriminate various scattering potentials. This disappoints former hopes. There is a difference between pn and pp bremsstrahlung. The leading electric dipole term in pn collisions is suppressed in pp collisions. Presenting the actually most refined theoretical calculations and observing conspicuous discrepancies with the data, Scholten's message is, that the process is still not fully understood and is able for surprisals.

Hans Wilschut stressed the aspects of medium effects in a complex nucleus and explained coherence and quenching of the amplitudes, finally with an interesting discussion of the α+p case. There nuclear bremsstrahlung turns out to originate from radiative capture in unbound states of ^{5}Li. I should add, that impressive experimental efforts have been reported for studying the problem.

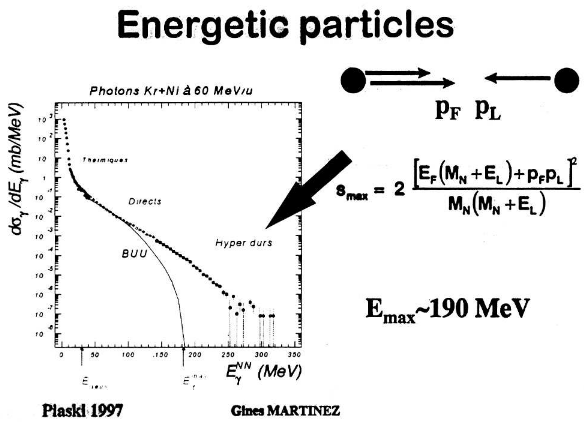


Fig. 8. Richness of bremsstrahlungs photons in *AA* collisions.

The richness of bremsstrahlungs photons produced in HI collisions, and photons as a probe for studies of hot and dense nuclear matter has been finally called to our attention by Gines Martinez with information about the evolution of the primordial source. The photon spectrum extends the usual kinematical limit, due to adding up with pion-nucleon processes. The sensitivity to the nuclear compressibility has been displayed by BUU calculations.

There have been some critical remarks with doubts on the theoretical treatment by using the Bolzmann–Uehling–Uhlenbeck transport model and ignoring the momentum dependence of the Skyrme force.

Actually, examining nuclear matter under extreme conditions, one of the major challenges is the establishment of the equation of state (EOS). For that we have to prepare the dense and hot system of an adequate size to reach local thermal equilibrium. Quite evidently, that implies a much more complicated and intransparent situation than in the few nucleon case. Yokingly the conditions have been called "dirty" in the discussion. I contrast with a quotation of a word of Werner Heisenberg, freely translated : "Physics, that is to wash clean with dirty water".

The topics, excellently presented by *Norbert Herrmann* and *Peter Senger*, extended by an informative seminar of *Yvonne Leifels*, familiarized us with quite another probe, exploring dense matter, for which I see large perspectives: kaons, especially when produced with subthreshold energies. A decade ago, when we were active in experimental determinations of nuclear matter and neutron distributions in nuclei, it had been our dream to get a fine K^+ beam as equivalent to electromagnetic probes: "The positive kaon, the electron of the strong interaction", due to ist long range, *i.e.* the reduced interaction with baryons as consequence of the antistrange quark content of K^+.

Embedded in dense nuclear matter K^+ and K^- behave differently. The mass modification in dense media has been convincingly shown. In contrast to naive expectations, there appear nearly no differences in the production probabilities at equivalent beam energies. For that there are different explanations of the rapidity distribution of the K^-/K^+ ratio. The medium effects with mass shifts are one possibility, but also Coulomb effects may be of importance.

The K^-/K^+ spectra show for larger collision systems clear signals of the equation of state and do favour the soft solution. *Peter Senger* communicated us that Gerry Brown *et al.*, using the KaoS data for adjusting the medium effects, could theoretically reproduce the mass of neutron stars with the most frequent value of ≈1.5 solar masses, as tentatively required as some upper limit of the astronomical observation.

Evidently closely related to the EOS is the question: *Is multifragmentation, which starts from clean conditions and allows the study of the dynamical evolution of the system, — is multifragmentation a probe for the long searched for liquid-gas phase transition?* The topic of boiling nuclei has been discussed by *Carsten Schwarz* and *Bernard Tamain*.

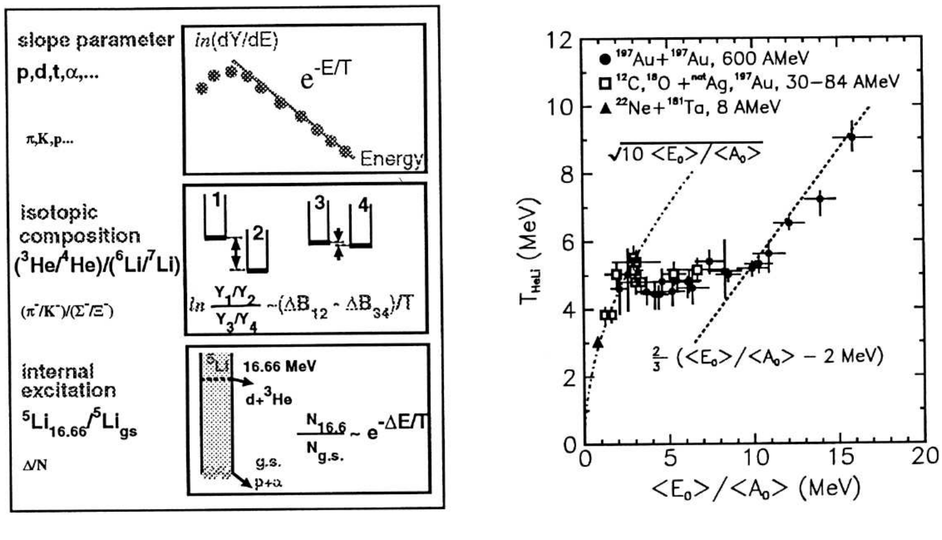


Fig. 9. Illustration of different hadronic thermometers and the caloric curve of nuclei: Liquid-gas phase transition? [9].

The ALADIN collaboration *e.g.* has mapped out the evolution of multifragment emission (Fig. 9), and the question concentrates to: Do the plateau and the subsequent rise resist to improved evaluations? The calorimetry, using different types of nuclear thermometers (slope of the evaporation spectra, relative population of excited states and double ratios), implies a lot of delicate questions, and the presentations of Carsten Schwarz and Bernhard Tamain, completed by a comment of *Jean Péter*, did clarify for us the present horizon of the state of the art. There are new considerations of the problem in the discussion, which include secondary evaporation and seem to reconcile different nuclear thermometers [10].

Jerzy Dudek, *Peter Butler*, *Wolfram vom Oertzen* and *others* discussed symmetries internally present in the structure of the A-nucleon system, in the atomic nucleus at lower temperatures, exhibiting a variety of nuclear shapes. The horizon has been widened by the model of nuclear rotation, introduced by *Bill Meyers* and by the question for Jacobi-like superdeformed nuclei, put by *Wladek Swiatecki*.

The aspects have been focused to intrinsic reflection symmetries and octupole, pear-shaped nuclei. *Jerzy Dudek* introduced two new λ =3 modes, the mode *d'amour* (with a nuclear shape like a heart) and the *cubic* mode, may be both reflecting the different historical French and German influence of Strasbourg life. I shall not discuss specific messages of these topics, which did in fact impress me and widened my look to the relevance of nuclear spectroscopy.

Experimental Devices and Projects

TABLE II

Compilation of new experimental projects

WASA (Wide Angle Shower Apparatus)	
in Uppsala (Sweden)	S.Kullander
ELEGANTs (Electron Gamma Neutrino Telescopes)	
in KAMIOKANDE (III, IV,V) and	
in Ohto Cosmo Observatory (VI) (Japan)	H.Ejiri
SPring -8 (Super Photon ring -8 GeV)	
in Harima (Japan)	M. Fujiwara
ELBE (Electron Linac with Brilliance and Low Emittance)	
in Dresden (Germany)	E.Grosse
REX–ISOLDE	
at CERN, Geneva (Switzerland)	I.Martel-Bravo

Before approaching my very final remarks, we should not forget that there has been a lot of interesting physics communicated in context of some presentations of new experimental devices. I remind briefly by a compilation (Table II), together with the advertisement of the Super Photon ring of 8 GeV, just going in operation in Japan with extremely interesting experimental perspectives. I have nothing to add to the fresh impression about "Unconventional physics with big Ge arrays", guided by *Wolfram von Oertzen* and *Witek Nazarewicz*.

5. Finale

Let us come to the finals! What is the global situation? Our knowledge of fundamental particles and interactions is such that we can explain everything about everdays world, and we explain nothing at all. The current theory of particle interactions, formulated with the standard model, gives a set of explicit rules for computing the forces between the various quarks and leptons, mediated by bosons. Given the masses of quarks and leptons and nine other closely related quantities, that theory can account in principle for all phenomena. On the other hand, we have no explanation, why there are three families, or why they have the masses they do, why the symmetries are broken.

We may imagine for a short moment a world where electrons are as massive as muons, indeed replaced by muons. In this peculiar world the distance scale would be 200 times smaller, the energy scale would be 200 times greater, but atoms could not be stable due to muon capture, this world would be finally made up of just neutrons and neutrinos. Or imagine, *e.g.* that the proton would be heavier than the neutron, or in our language the u quark would be heavier than the d quark. Hydrogen would decay, the nucleosynthesis would have happened in quite another way. Actually we do not know: *Why not so*? We realize, our present theory is fundamentally incomplete. May be it will remain always an illusion to get rid off arbitrary free parameters. But on the other side the questions may only reflect our current ignorance, and we have to look for the interpendence of seemingly free parameters. That is just the physics beyond the Standard model, where various speakers did point to.

Such general considerations on the level of an experimentalist did accompany me when *Amand Faessler* sketched with a scholar lecture the consequences of grand unified theories with respect to the nature of the neutrino. It is an attractive possibility that weak, strong and electromagnetic interactions are really unified, *i.e.* different manifestations of one single force. But at our current knowledge there is no experimental evidence, which would provide a constraint or hint, ruling out different speculative formulations of an unification.

In the beginning, we started the journey with Johan van Klinken's view on broken symmetries in our world — *le meilleur monde possible* — and did end with the perspectives presented by Amand Faessler. We should realize the direction, and I am sure that the discussions of this meeting will influence future research plans in our laboratory: The Atomic Nucleus.

It is a reserved privilege of the chairman of the final session to express our common thanks to the organizers, and I do not intend to take this pleasure away from him. But I take the chance to thank personally, first the scientific directors *Ziemek Sujkowski* and *Danka Chmielewska* for an extremely interesting outline of the programm and for all guidance, and then all the staff, especially *Kasia Delegacz* for a perfect organisation of this school and kind help in personal matters. In particular, I thank various colleagues for some indirect help in preparing my summary, in particular *Jan Kownacki* and *Wiktor Kurcewicz* in organising efficiently and also successfully* my leisure time, and finally *Eric Sheldon* for his wise and enlightning comments to the social and cultural aspects around. Our Polish colleagues — some of them I have the privilege to call my friends — have again understood to prepare a creative atmosphere mediating the interaction of promising young scientists with established oldtimers. That feature is of greatest importance for the future of a lively field. Actually an important role of a summer school community is to be a "training camp" for establishing a healthy style of intellectual exchange and communication, competing in finding out the truth, but not in suppressing the colleague's achievements. A relaxed and pleasant atmosphere like we experienced here had often prompted important great insights. Isaac Newton found the gravitation when dreaming under an apple tree. One of my teachers in theoretical physics, Hans Jensen, told that he got the idea of strong spin-orbit coupling during a dancing party, observing the alignments of the rotating pairs . *"Se non ĉ vero, ĉ ben trovato"*! May be someone of us has progressed in understanding solitons, when sailing on the Lake.

Through my actual job here I have learnt a lot, thanks to excellent and fascinating presentations of all speakers. It is my great pity that due to my limitations in understanding and with obvious restriction in time, I have been unable to comment all communications in an extent as they had deserved. I am sorry, in particular, for the excellent seminars and poster presentations. I apologise to those which I could not mention in my biased selection of examples. They may comfort themselves by the thoughts of Saint Exupery's Le Petit Prince : *"Les gens ont des étoiles qui ne sont pas les mêmes. Pour les uns, qui voyagent les étoiles sont des guides. pour autres ..... pour autres qui sont savants elles sont des problémes.... Toi, tu auras* *des étoiles comme personne n'en a.....".*" I myself enjoyed this intellectual pleasure and thank again for the privilege to attend this XXV Mazurian Summerschool: *Sto lat, Sto lat! Niech żyje, żyje nam!*

**The Mazurian Lakes regatta 1997 has been won by the sailing team Witek Kurcewicz (skipper), Tadek Kozlowski, Heinigerd Rebel (vorschooters), and Iliana Brâncuş (flaggist).*

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