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REACTOR BASED FUNDAMENTAL PHYSICS

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Résumé - Un Sommaire De La Conférence "Reactor Based Fundamental Physics"

Abstract - Summary of the Conference on Reactor Based Fundamental Physics.

INTRODUCTION

The ultimate standard for a summary speaker was established by one of my friends many years ago. A new sub-field of physics seemed to be emerging so an international conference was called and my friend was asked to give the summary talk. All seemed to be going well at the conference until he gave his summary talk. In the summary talk he pointed out - quite validly - that approximately one-third of the conference papers were merely reformulations of previously well known results, another third were trivial and the remaining papers were totally wrong. Not only did the summary talk so destroy the conference that no proceedings were published but it even annihilated the new sub-field, which has never emerged again.

By that high standard my present summary will be a failure. I am happy to report that the field of Reactor Based Fundamental Physics is thriving and it will continue to thrive following my summary.

After I realized, I could not destroy the subject itself, I thought of a way in which I might at least prove that the conference itself was useless and merely contributed much talk followed by no action. Since there was a conference six years ago on the same subject, this hypothesis is subject to experimental test. Geoffrey Green Greene, Blayne Heckel and I therefore analyzed the papers presented at the earlier conference to determine the number of topics for which there has been substantial progress since the last meeting, the number with questionable progress and the number with no significant progress. I am pleased to report that of 20 topics, there has been substantial progress in 16, questionable progress in 2 and no progress in 2. With such a good record it is clear that not only is the field thriving but also the meetings are serving a valuable function. I am sure that all who have been here during the past three days have independently reached the same conclusion without the necessity of a quantitative test.

In advance of this meeting, I planned in my summary talk to concentrate our attention by focussing on the four or five most significant reports and to omit entirely the topics which were unimportant or uninteresting. However, now that the reports have been presented I find that the Conference Committee has already done this elimination for me and that almost all of the topics on the program were both interesting and fundamental. I therefore decided last night to follow exactly the opposite procedure and to discuss all of the reports briefly but to do so in an outline form which emphasizes the coherent unity of the whole field. In the outline I will give some of the principal results, but to preserve the outline form
I shall not report the explanations given in the talks and to avoid losing the physics in a list of names I shall give in parentheses only the last name of the person who presented the report. An equation giving a current result but followed by an arrow pointing to a different number indicates the progress that is expected in future experiments.

I. NEUTRON PROPERTIES AND SYMMETRIES

(a) Electric Charge

\[ q_n = (-1.5 \pm 1.4) \times 10^{-20} \text{ e} \quad (\text{Gähler}) \]

\[ \rightarrow 10^{-22} \text{ e} \]

(b) Electric Dipole Moment

\[ d_n = (-2.0 \pm 1.0) \times 10^{-25} \text{ e cm} \quad (\text{Serebrov}) \]

\[ = (+0.3 \pm 4.8) \times 10^{-25} \text{ e cm} \quad (\text{Morse}) \]

\[ \rightarrow 10^{-26} \text{ e cm} \]

Proposed experiment in liquid \(^4\text{He}\) (Golub)

Proposed Los Alamos experiment with pulsed neutrons (Ringo)

Importance to cosmological theories that attribute proton-antiproton asymmetry to CP violation shortly after the big bang.

(c) Decay

1. Mean life \(\tau_n = 918 \pm 14, 877 \pm 8\) or \(937 \pm 18\) (Byrne)

New experiment (Liaud)

Importance of \(\tau_n\) in the \(^4\text{He}\) production in the universe and in the cosmological limit to the number of quark-neutrino generations.

2. Angular distribution

\[ \beta\text{-decay asymmetry} \]

\[ \lambda = -g_A/g_V = 1.270 \pm 0.009 \quad (\text{Last}) \]

Experiment to test time reversal symmetry in left-right symmetric models (Bowles)

(d) Electric Polarizability

Reliable measurements needed (Leeb)

(e) Parity-Non-Conserving (PNC) Neutron-Nuclei Interactions

1. Theory

   General theory (Desplanques)

   n-d theory (Avishai)

2. Fission

   PNC in fission. Experimentally confirmed and theoretically reasonable (Petrov)
3. Spin rotation

$^{117}\text{Sn, Sn, Pb, La}$. Hope eventually to do lighter elements (Heckel)

4. Resonance cross sections

Br, Sn, La, Cd, Nb, Nd (Sharapov)

5. PNC in n,γ reactions

Effects persist in heavy nuclei even with many γ's (Nazarenko)

np → dγ

New experiment (Avenier)

$P_\gamma = (1.8 \pm 1.8) \times 10^{-7}$ (Nazarenko)

(f) Nucleon Decay

Review of proton decay. A few candidate events, no evidence (Fiorini)

No magnetic monopoles yet seen

No bound n-¯¯n oscillations seen

(g) Free n-¯¯n oscillations

$\tau > 10^6$ sec (90% c1) (Baldo-Çeolin and Prosper)

$\tau < 10^8$ sec

II. γ-RAYS

(a) Prompt γ-Ray Spectroscopy

Calibration of wave lengths, deuteron binding energy, neutron mass and fundamental constant $N_Ah/c$. (Greene)

III. NEUTRINOS

(a) Neutrino Oscillations

1. Review

No evidence for oscillations. Extensive exclusion plots of experimentally unacceptable values of mass and mixing angle. (Mossbauer)

2. The data taking phase of the Bugey experiment has been completed, the data are being analyzed and final results should soon be presented. (Koang)

3. Reactor $\bar{\nu}$ spectrum (Schreckenbach)

4. Search for massive neutrinos in $\beta$-decay (Schreckenbach)

(b) Theory

1. Majorana neutrinos (Bernabeu)

2. Neutrino oscillation and stellar collapse (Bernabeu)

3. Unified theories and internal structure of leptons and quarks (Fritzsch)
IV. WAVE PROPERTIES OF NEUTRINOS

(a) Neutron Interferometry and Its Relation to Fundamental Physics

Longitudinal and transverse coherence studies. Dynamic effects. Phase echo. Time dependent wave packets and interactions. All experiments agree with quantum mechanics. (Rauch)

(b) Symmetry Violations in Neutron Interferometry

Effect of neutron spin and Schwinger scattering in neutron interferometry. Possible interferometer tests of time reversal symmetry and parity. Enhancements by Larmor length equal Pendellosung length. (Zeilinger)

(c) Generalized Aharanov-Bohm and Wheeler Delayed Choice Experiments (Zeilinger)

(d) Determination of $h/m_n$

$h/m_n = 3.956093(65) \times 10^{-7}$ m$^2$s$^{-1}$. Expected improvements. (Weirauch)

(e) Wave Functions in Polarized Neutron Beams

Some polarization effects are related to an interplay between the spatial and spin wave functions. (Mezei)

(f) Quantum Mechanical Effects on Beam Chopping

Effect on neutron wave function of passage of beam through a slit with time dependent width. FOTOF. Mechanical time of flight spectrometer. (Gähler)

(g) Neutron Wave Pockets and Longitudinal Coherence

Coherence length not necessarily equal to packet length. Diffraction in time experiment. (Klein)

(h) Wave Optics with Cold Neutrons

Fresnel diffraction zone plate. Verification of quantum mechanics and elimination of non-linear term in Schrodinger equation to $10^{-15}$. (Klein)

(i) Neutron Fibres: A Possible Application of Neutron Optics. (Alvarez-Estrada)

(j) Dynamical Effects in Neutron Optics and Spin Interactions.

Dynamical diffraction to use nuclear fields in a crystal as a source of P and T violating polarization effects. (Forte)

(k) Neutron Wave Optics with Ultra-Cold Neutrons

Gravitational effects, gravity focussing, gravity spectrometers, neutron microscope. (Steyerl)

(ll) New Applications of Ultra Cold Neutron Physics in Magnetic and Gravity Fields.

Magnetic neutron deceleration with adiabatic spin flip. (Utsuro)
(m) Summary of Wave Properties of Neutrons
All experiments fit quantum mechanics remarkably well.

V. FACILITIES

(a) ILL Facilities for Fundamental Physics Experiments
Description of present and future ILL facilities. (Ageron and Mampe)

CONCLUSION

It is appropriate that we should end the conference with a description of facilities. All of us who do experiments in fundamental reactor based physics are greatly dependent on the facilities and those who provide and maintain them at the ILL and elsewhere.

In conclusion, therefore, I should like on behalf of all of us to express our deep appreciation to all those who help provide these valuable facilities. In addition, we particularly thank the ILL management and staff for serving as such excellent hosts for this stimulating conference on Reactor Based Fundamental Physics.