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UNDER A CONTRIBUTION FROM THE
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The contributions on individual experiments in this report are outlines intended to demonstrate the extent of scientific activity at TRIUMF during the past year. The outlines are not publications and often contain preliminary results not intended, or not yet ready, for publication. Material from these reports should not be reproduced or quoted without permission from the authors.

THEORETICAL PROGRAM

Introduction

The Theory group provides a focus for the theoretical research at TRIUMF and support for the TRIUMF experimental program in all its many facets. Complementing the experimental program, the theoretical research program also covers a wide range of topics in nuclear and particle physics. Part of this research involves working directly with the experimentalists on particlular experiments; part with a more general background to the experimental program; and part with fundamental areas not currently related to the experimental program.

The Theory group has four permanent staff members: H.W. Fearing (group leader), B.K. Jennings, J.N Ng, and R.M. Woloshyn, plus E.W. Vogt (professor emeritus, UBC). This year our research associates are: H.-W. Hammer (since November), T. Hemmert, W.D. Jones (since September), S. Karataglidis (since October), R. Lewis, I. Maksymyk, K. Mitchell, H. Müller, T. Shoppa, V. Stoks (to August) and G.-H. Wu (to August). In addition S.-W. Hong has been visiting since April.

The visitors to the Theory group this year include:

C. Cardall	D. Michaud
G. Carter	A. Misra
L.-N. Chang	N. Mobed
B. Desplanques	C. Morningstar
J. de Swart	E. Ormand
A. Gal	P. Page
W. Haxton	A. Rinat
B. Holstein	M. Scadron
N. Itoh	F. Scheck
C. Johnson	S. Scherer
F. Khanna	I. Towner
G. Knöchlein	D. Wilkinson
K.-H. Langanke	M. Wingate
P. Lee	R. Wiringa
H. Lipkin	L. Zamick

In addition to their research activities the theorists have taken an active part in laboratory activities including: the Long Range Planning Committee, the Experiments Evaluation Committee, the Computer Facilities at TRIUMF (CFAT) Committee, the Library Committee, the TRIUMF Summer Institute, and TRIUMF public relations.

As usual the Theory group has been very active and below we briefly describe some of the specific research projects undertaken by the group during the year.

Miscellaneous

Light-front approach to the bound state problem
(B.D. Jones)

The non-perturbative bound-state problem in QED and QCD in four dimensions in a light-front Hamiltonian approach is studied. Examples in QED in four dimensions are given in order to analytically study the problem. Even though rotations about the transverse axes are dynamical for field theories initialized on a light-front, we show that the correct angular momentum multiplets arise for the leading ground state hyperfine splitting in positronium. The fact that rotational invariance is dynamical complicated the calculation: second-order bound-state perturbation theory including a sum over all bound and scattering Coulomb states was required to obtain the correct result. A trick which leads to a much simpler calculation is also given. In order to further test the method, a derivation of the dominant part of the Lamb shift in hydrogen is completed. The previous work is improved and extended in a thesis.

Hadron physics

Non-relativistic aspects of lattice NRQCD
(R.M. Woloshyn)

A number of general features of non-relativistic quantum mechanics which follow from the structure of the two-body Schrödinger equation with a local potential are shown to be satisfied for mesonic states in lattice NRQCD. The quark mass dependence of the wave function at the origin, which is sensitive to the shape of the potential in quark models, is investigated. Using the leading non-relativistic terms of the NRQCD action the behaviour of the wave function at the origin was found to be consistent with a linear potential in contrast to QCD-motivated quark models where effects of short-distance Coulomb-like terms are significant for heavy quarks.

Relativistic corrections to light-heavy meson masses in lattice NRQCD
(R. Lewis, R.M. Woloshyn; H.D. Trottier, SFU)

NRQCD provides a systematic approximation of the QCD action for heavy quarks. This can be combined with a relativistic description of light quarks to calculate the properties of D- and B-mesons. For such systems the expansion of the NRQCD action is ordered in inverse powers of the heavy quark mass. We carried out a systematic study including all terms up to $O(1/M^3)$. The focus of this work is the effect of higher order terms on the hyperfine splitting. The leading spin-dependent interaction for the heavy quark is

$O(1/M)$. The $O(1/M^2)$ corrections tend to increase the hyperfine splitting while $O(1/M^3)$ terms decrease it. For D-mesons it was found that the effects of $O(1/M^3)$ terms are even larger than those of $O(1/M^2)$ and relativistic corrections lead to a significant net decrease of the hyperfine splitting. For B-mesons $O(1/M^2)$ effects dominate giving as small net increase to the hyperfine splitting relative to the leading $O(1/M)$ term. This calculation reinforces the conclusion reached in the study of charmonium that relativistic corrections are too large for NRQCD to be an adequate approach to QCD in the charm mass region.

Strange vector form factors of the nucleon
(H.-W. Hammer; M.J. Ramsey-Musolf, Seattle; D. Drechsel, Mainz)

The low energy structure of the nucleon's $s\bar{s}$ sea has become a topic of intense studies in the hadron physics community. In particular, the contribution of strange quarks to the spatial distribution of the nucleon's charge and magnetic moment is interesting, since it can be measured directly in parity violating electron scattering. On the theoretical side a plethora of calculations is available, each having its particular merits and limitations. Our alternative approach is to start from a spectral decomposition of the strange vector form factors and to evaluate the obtained imaginary parts using dispersion relations and experimental data. Some previous model calculations are recovered as certain approximations in this framework.

Most model calculations base on the so called "kaon cloud dominance" assumption, i.e. the strange sea in the nucleon is generated by virtual transitions of the nucleon to a kaon and a hyperon (e.g. $p \to K^+\Lambda \to p$). Using dispersion relations, we have studied the lightest such contribution, the $K\bar{K}$ intermediate state. In the physical region of the dispersion integral, the contributing $K\bar{K} \to N\bar{N}$ P-wave amplitudes have been replaced by their unitarity bounds. In the unphysical region, we used an analytical continuation of experimental KN scattering amplitudes. The continued amplitudes show a resonance structure close to the $K\bar{K}$ threshold, presumably from the $\phi(1020)$. Since the strange form factor of the kaon is also dominated by the ϕ, the $K\bar{K}$ contribution to the strange radius of the nucleon is increased by a factor of three compared to the usual one-loop model calculations. As a consequence, the discrepancy between the predictions for the strange radius by one-loop model calculations and vector meson pole models is reduced, thus indicating a possible solution for this long standing problem.

Nevertheless, the lightest intermediate state in the spectral decomposition consists of three pions. Because of the low threshold energy it is strongly weighted in the dispersion relation, however, its contribution is proportional to a nominally OZI-violating matrix element. Such a violation has mostly been neglected so far. We find that the resonant processes $3\pi \to \omega$ and $3\pi \to \rho\pi$ can enhance the contribution of this intermediate state to the level of typical OZI-allowed contributions. Therefore, the kaon cloud dominance assumption might be questioned.

Meson-baryon coupling constants from a chiral-invariant SU(3) Lagrangian and application to *NN* scattering
(V.G.J. Stoks; Th.A. Rijken, Nijmegen)

We present a chiral-invariant meson-baryon Lagrangian which describes the interactions of the baryon octet with the lowest-mass meson nonets. The nonlinear realization of the chiral symmetry generates pair-meson interaction vertices. The corresponding pair-meson coupling constants can all be expressed in terms of the meson-nucleon-nucleon pseudovector, scalar, and vector coupling constants, and their corresponding $F/(F+D)$ ratios, and for which empirical estimates are given. We show that it is possible to construct an NN potential of reasonable quality satisfying these theoretical and empirical constraints.

Meson-baryon coupling constants and baryon-baryon interactions
(V.G.J. Stoks)

We present a chiral-invariant SU(3) Lagrangian describing the interactions of the baryon octet with the lowest-mass meson nonets. Empirical estimates for the strengths of these vertices are given. The non-linear realization of the chiral symmetry generates pair-meson interaction vertices, the coupling constants for which contain no new free parameters. A baryon-baryon potential is evaluated and its quality is examined for the NN sector.

Off-shell effects in nucleon-nucleon bremsstrahlung
(H.W. Fearing)

Nucleon-nucleon bremsstrahlung ($NN\gamma$) is one of the simplest reactions involving the off-shell nucleon-nucleon (NN) amplitude. For nearly fifty years, since the original suggestion of Ashkin and Marshak, theoretical and experimental efforts in $NN\gamma$ have been devoted to measuring this off-shell amplitude and distinguishing among various NN potentials on the basis of their off-shell behaviour. Currently a number of new experiments are under way, designed specifically to attain kinematics further off shell than in the past, and thus to be more sensitive to the off-shell behaviour. It has been shown, however, that, contrary to these expectations, and as a consequence of the invariance of the S-matrix under transformations of the fields, the off-shell NN amplitude is actually *as a matter of principle* an unmeasurable quantity in $NN\gamma$.

A simple model to illustrate ambiguities in off-shell information in electromagnetic processes
(H.W. Fearing; S. Scherer, Mainz)

It was shown for nucleon-nucleon bremsstrahlung, both via general arguments based on field transformations and via a simple chiral perturbation theory model for spin zero particles that the off-shell amplitude is not a measurable quantity. Basically one can always make a field transformation which changes the off-shell amplitude but leaves the experimentally measurable quantities unchanged. Here we have developed another simple model which is much closer, in fact identical in many aspects, to the models used for bremsstrahlung and Compton scattering. Using that model we can show exactly the same result. Thus contrary to historical expectations and some current claims, it is just not possible to get unequivocal information about off-shell amplitudes by measuring processes like bremsstrahlung or Compton scattering.

Compton scattering and the spin structure of the nucleon at low energies
(T.R. Hemmert; B.R. Holstein, Massachusetts; J. Kambor, Zürich; G. Knöchlein, Mainz)

We analyze polarized Compton scattering which provides information on the spin-structure of the nucleon. For scattering processes with photon energies up to 100 MeV the spin-structure dependence can be encoded into four independent parameters – the so called spin-polarizabilities $\gamma_i,\ i = 1...4$ of the nucleon, which we calculate within the framework of the "small scale expansion" in SU(2) baryon chiral perturbation theory. Specific application is made to "forward" and "backward" spin-polarizabilities.

Heavy baryon ChPT with light deltas
(T.R. Hemmert; B.R. Holstein, Massachusetts: J. Kambor, Zürich)

We have developed a SU(2) HBChPT formalism that allows a systematic treatment of spin 1/2 nucleon and explicit $\Delta(1232)$ degrees of freedom. We start from the most general relativistic spin 3/2 Lagrangian, explicitly keeping "point-transformation" invariance and all possible "off-shell" coupling structures. After having separated the spin 3/2 and the spurious spin 1/2 components of the Rarita-Schwinger spinor via a projector formalism, we make the transition to the heavy mass formalism. To leading order, we reproduce the known results of the NN- and $\Delta\Delta$,ΔN-sectors. In next-to-leading order we explicitly construct all 1/m corrected vertices for the NN, $N\Delta$ and $\Delta\Delta$ Lagrangians. Furthermore, we discuss the $O(p^2)$ vertices of the $\Delta\Delta$ and $N\Delta$ Lagrangians accompanied by counterterms and show how our methods can be generalized to obtain the corresponding Lagrangians at arbitrary high orders.

Generalized polarizabilities and the chiral structure of the nucleon
(T.R. Hemmert; B.R. Holstein, Massachusetts; G. Knöchlein, S. Scherer, Mainz)

We have performed the first ChPT calculation for the 10 generalized polarizabilities of the nucleon as defined in the framework of Guichon *et al.* We also discuss the pertinent response functions to be measured in the upcoming experiments in virtual Compton scattering at Mainz, MIT-Bates and TJNAF which should lead to a first experimental determination of the momentum dependence for the generalized polarizability $\bar{\alpha}_E$. Furthermore, we point out the surprising rise of the generalized polarizability $\bar{\beta}_M$ at low momentum transfer.

The form factors of the nucleon at small momentum transfer
(V. Bernard, Strasbourg; H.W. Fearing, T.R. Hemmert; U.-G. Meissner, FZ Jülich)

We study the low energy expansion of the nucleon's electroweak form factors in the framework of an effective chiral Lagrangian including pions, nucleons and deltas. We work to third order in the so-called "small scale expansion" and compare the results with the ones previously obtained in the chiral expansion and recent analyses of the experimental data utilizing dispersion relations. In addition, these calculations of simple vector and axial-vector three-point functions serve as a first exploratory study of renormalization and decoupling with the "small scale expansion".

Nuclear physics and reactions on nuclei

Electric quadrupole strengths of highly excited shell model states
(S. Karataglidis; V. Zelevinsky, NSCL; T. Døssing, Niels Bohr)

An analysis of excited nuclear states obtained in shell model calculations has revealed interplay between single-particle, collective and chaotic features of dynamics. In this work, $E2$ transition probabilities are being calculated in the *sd* shell model for all excited states in ^{24}Mg. Strong transitions are manifest for the rotational bands based on the ground state and low-lying states. In the high-level denisty region, the transitions show a progressive increase in strength and a regular decrease with excitation energy (for the transitions between states of even angular momentum), the trend opposite to that of the Gamow-Teller strength. By investigation of specific $E2$ transitions in this region, one may find possible rotational band structures, analogous to those in the low-excitation region, at the onset of chaos.

Many-body approaches to ^{3}He and ^{4}He
(S. Karataglidis; P.J. Dortmans, K. Amos Melbourne; P. Navrátil, B.R. Barrett, Arizona)

The mass-3 and mass-4 systems have been successfully described using exact 3- and 4-body wave functions obtained as solutions of the Faddeev and Faddeev-Yakubovsky equations. It is now possible for those systems to compare the many-body approach to the few-body one. This is possible with the use of multi-$\hbar\omega$ shell model spaces where the inclusion of high $\hbar\omega$ excitations in the model space introduces the correlations which are a property of the Faddeev solutions. We have calculated shell model wave functions obtained from a complete $(0+2+4)\hbar\omega$ model space, using a shell model interaction derived microscopically from the nucleon-nucleon interaction. Together with wave functions obtained in an $(0+2+4+6+8)\hbar\omega$ model space, we have analyzed electron and proton scattering data, providing important information on the many-body approach to these systems, and its convergence to the few-body solutions.

Direct capture astrophysical S factors at low energy
(B.K. Jennings, S. Karataglidis, T.D. Shoppa)

The S factors for the $^7\text{Be}(p,\gamma)^8\text{B}$ and $^{16}\text{O}(p,\gamma)^{17}\text{F}^*$ ($\frac{1}{2}^+$; $\frac{1}{2}$, 0.498 MeV) reactions both rise at low energies. We have investigated the energy dependence of the S factors for both reactions. The source of the rise at low energies is a pole in the S factor at $E_{c.m.} = -Q$, the point at which the energy of the emitted photon vanishes. The pole arises from a divergence of the radial integrals and is related to the usual soft photon divergences.

Can the magnetic moment contribution explain the A_y puzzle?
(V.G.J. Stoks, TRIUMF–ANL)

We evaluate the full one-photon-exchange Born amplitude for *Nd* scattering. We include the contributions due to the magnetic moment of the proton or neutron, and the magnetic moment and quadrupole moment of the deuteron. It is found that the inclusion of the magnetic-moment interaction in the theoretical description of the *Nd* scattering observables cannot resolve the long-standing A_y puzzle.

Simplifications of the $O(p^6)$ chiral perturbation theory Lagrangian
(H.W. Fearing; S. Scherer, Mainz)

Some time ago we derived the most general chiral perturbation theory Lagrangian to order p^6 for the meson sector. The emphasis was on a systematic procedure that started with all possible terms and used various tricks to eliminate some classes of terms in favour of others. This approach gives all terms, but does not show that the resulting set is independent. We have been looking at some additional relations deriving from Bianchi identities involving multiple covariant derivatives and have found a few additional relations among the original set of terms.

Radiative and non-radiative muon capture on the proton in heavy baryon chiral perturbation theory
(H.W. Fearing, R. Lewis; N. Mobed, Regina; S. Scherer, Mainz)

We have evaluated the amplitude for muon capture by a proton, $\mu+p \to n+\nu$, to $\mathcal{O}(p^3)$ within the context of heavy baryon chiral perturbation theory (HBChPT) using the new $\mathcal{O}(p^3)$ Lagrangian of Ecker and Mojžiš (E&M). We obtain expressions for the standard muon capture form factors and determine three of the coefficients of the E&M Lagrangian, namely, b_7, b_{19}, and b_{23}. As a next step we are applying the same formalism to a calculation of the radiative muon capture process, $\mu+p \to n+\nu+\gamma$.

Pion elastic scattering from ^{12}C
(S.-W. Hong, TRIUMF–Sung Kyun Kwan Univ.,Suwon)

Pion-nucleus elastic scattering cross sections are calculated by solving a Schrödinger equation instead of the Klein-Gordon equation. In doing so, kinematical variables are redefined, local potentials are assumed, and potential parameters are searched. The potentials for $\pi^- + ^{12}$C system are obtained energy dependently so as to reproduce not only elastic differential cross sections but also total elastic, reaction and total cross sections in the pion energy range of 120–766 MeV. The real and imaginary parts of the dispersion relation are obtained in the radial region between $r \approx 1.3\,A^{1/3}$ fm and $r \approx 2.0\,A^{1/3}$ fm, which is an outer nuclear surface region. The imaginary part of the potentials as a function of the pion energy is peaked near the $\Delta(1232)$-resonance energy, which is due to the production and decay of the Δ's in nuclei. The strong absorption radius of the pion projectile with incident energies near the Δ-resonance region is found to be about $1.6\,A^{1/3}$ fm, which is consistent with previous studies of the region where the Δ's decay in nuclei.

Quasi-elastic peak in pion inelastic scattering
(S.-W. Hong, TRIUMF–Sung Kyun Kwan Univ.,Suwon)

The quasi-elastic peak observed in pion inelastic scattering with a 500 MeV bombarding energy is studied by using a response function method, where the continuum states (nucleon knock-out modes) are properly taken into account. For the pion distortion, we solved a Schrödinger equation and obtained the pion distorted wave function that can fit the elastic scattering data. The $\pi - N$ scattering amplitude is simply parameterized as a spin-flip and a spin-non-flip term, and we extracted the magnitude of the amplitude so as to fit the magnitude of the experimental cross section. The obtained magnitude of the $\pi - N$ scattering amplitude turned out to be more or less similar to the Jülich potential in magnitude. The peak position of the quasi-elastic peak was fitted at all angles where data were available (30, 40, 50 and 70 degrees) with a Woods-Saxon potential, where the depth of the real potential was energy-independently chosen to be 75 MeV. The shape of the quasi-elastic peak was also well reproduced and was not affected by different choices of the imaginary potential.

Λ-hypernucleus in (π, K) reaction
(S.-W. Hong, TRIUMF–Sung Kyun Kwan Univ.,Suwon)

The response function for the Λ-hypernucleus created by (π^+, K^+) reaction is calculated. The reaction part is treated by distorted wave impulse approximation, where the pion and kaon distorted wave functions reproducing the differential elastic scattering data are used. For the transition amplitude of the elementary reaction, $N(\pi, K)\Lambda$, a parameterized form obtained by Sonota and Zofka which fit the $\pi^- p \to K^0\Lambda$ cross section and polarization data is used. We properly took into account the continuum state as well as the bound state of the Λ and reproduced major bound states and the quasi-free peak with a simple mean field potential for the Λ. However, small bound state peaks observed in $^{12}C_\Lambda$ are not reproduced at the right energy by a simple mean field potential.

Nuclear matter properties of the modified quark meson coupling model
(H. Müller, B.K. Jennings)

We explore in more detail the modified quark meson coupling (MQMC) model in nuclear matter. Based on previous studies two different functional forms for the density dependence of the bag constant are discussed. For uniform matter distributions the MQMC model can be cast in a form identical to QHD by a redefinition of the sigma meson field. It is then clear that modifications similar to those introduced in QHD will permit the reproduction of all nuclear matter properties including the compressibility. After calibrating the model parameters at equilibrium nuclear matter density, we examine the model and parameter dependence of the resulting equation of state. We discuss nucleon properties and scaling relations between the bag constant and the effective nucleon mass.

Properties of finite nuclei in the modified quark-meson coupling model
(H. Müller)

I apply the modified quark-meson coupling (MQMC) model to describe the properties of finite nuclei. The concept of a density dependent bag constant is used to calibrate the model at equilibrium nuclear matter density. By a redefinition of the scalar meson field, the MQMC model can be cast in a form similar to a QHD-type mean field model. I analyze binding energies, charge radii and single-particle spectra of spherical nuclei and compare with QHD calculations and with results based on the original quark-meson coupling model. I find that the accurate reproduction of the effective nucleon mass in the MQMC model leads to a realistic description of single-particle spectra and spin-orbit splittings. I also investigate changes of the internal quark structure of the nucleon in the nuclear environment.

Analysis of effective mean fields models for nuclei: Nuclear shapes and implications for parity-violating electron scattering
(H. Müller; C.J. Horowitz, IUCF)

We study an effective hadronic mean field model which includes all the interaction terms that are consistent with the underlying symmetries of QCD. We analyze the impact of non-linear isovector interactions on properties of finite nuclei. These terms are important for the shape of neutron densities which are poorly known at present. On the other hand, the next generation of high precision measurements of parity-violating electron scattering will be sensitive to uncertainties in the nuclear structure. Of great importance here is the difference between the proton and neutron rms radius. We find that by introducing all the allowed interaction terms this difference can be varied by more than 30%. Variations of the neutron and proton density distribution lead to sizeable effects in the parity-violating electron scattering asymmetry. We explore whether a measurement of the asymmetry can be exploited to determine neutron densities more accurately.

Particle physics and supersymmetry

Supersymmetric time reversal violation in semileptonic decays of charged mesons
(G.-H. Wu, J.N. Ng)

We provide a general analysis of time reversal violation arising from misalignment between quark and squark mass eigenstates. In particular, we focus on the possibility of large enhancement effects due to the top quark mass. For semileptonic decays of the charged mesons, $K^+ \to \pi^0\mu^+\nu_\mu$, $D^+ \to \overline{K}^0\mu^+\nu_\mu$, and $B^+ \to \overline{D}^0\tau^+\nu_\tau$, the transverse polarization of the lepton $P_l^\perp$ is a T-odd observable that is of great experimental interest. It is noted that under favourable choice of parameters, $P_\mu^\perp$ in $K_{\mu3}^+$ decay can be detectable at the ongoing KEK experiment and it holds a promising prospect for discovery at the proposed BNL experiment. Furthermore, $P_\tau^\perp$ in $B^\pm$ decay could well be within the reach of B factories, but $P_\mu^\perp$ in $D^\pm$ decay is not large enough for detection at the proposed τ-charm factory.

T violation in $K^+ \to \mu^+\nu\gamma$ decay and supersymmetry
(G.-H. Wu, J.N. Ng)

Measurement of the transverse muon polarization $P_\mu^\perp$ in the $K^+ \to \mu^+\nu\gamma$ decay will be attempted for the first time at the ongoing KEK E246 experiment and also at a proposed BNL experiment. We provide a general analysis of how $P_\mu^\perp$ is sensitive to the physical CP violating phases in new physics induced four-Fermi interactions, and then we calculate the dominant contributions to $P_\mu^\perp$ from squark family mixings in generic supersymmetric models. Estimates of the upper bounds on $P_\mu^\perp$ are also given. It is found that a supersymmetry-induced right-handed quark current from W boson exchange gives an upper limit on $P_\mu^\perp$ as large as a few per cent, whereas with charged-Higgs-exchange induced pseudoscalar interaction, $P_\mu^\perp$ is no larger than a few tenths of a per cent. Possible correlations between the muon polarization measurements in $K^+ \to \mu^+\nu\gamma$ and $K^+ \to \pi^0\mu^+\nu$ decays are discussed, and distinctive patterns of this correlation from squark family mixings and from the three-Higgs-doublet model are noted.

Testing time reversal invariance in exclusive semileptonic B-meson decays
(G.-H. Wu, K. Kiers, J.N. Ng)

We demonstrate that polarization measurements in exclusive semileptonic B decays are powerful tools for unraveling non-standard model sources of T violation. Measurements of the transverse polarization of the τ lepton in the $B \to D\tau\overline{\nu}$ and $B \to D^*\tau\overline{\nu}$ decays probe separately effective scalar and pseudoscalar CP violating four-Fermi interactions, whereas the D^* polarization in the $B \to D^*l\overline{\nu}$ ($l = e$, μ) decay is sensitive to an effective right-handed quark current interaction. Two T-odd polarization structures exist involving the D^* polarization and they can be isolated and studied separately. An estimate of these T-odd effects is also given in the context of supersymmetric theories.

Polarization measurements and T violation in exclusive semileptonic B
(G.-H. Wu, K. Kiers, J.N. Ng)

We provide a general analysis of time reversal invariance violation in the exclusive semileptonic B decays $B \to D\ell\overline{\nu}$ and $B \to D^*\ell\overline{\nu}$. Measurements of the lepton and D^* polarizations can be used to search for and identify non-standard model sources of T violation. Upper limits are placed on the T-odd polarization observables in both the supersymmetric R-parity conserving and R-parity breaking theories, as well as in some non-supersymmetric extensions of the standard model, including multi-Higgs-doublet models, leptoquark models, and left-right symmetric models. It is noted that many of these models allow for large T violating polarization effects which could be within the reach of the planned B factories.

On the interactions of light gravitinos
(T.E. Clark, T. Lee, S.T. Love, Purdue; G.-H. Wu)

In models of spontaneously broken supersymmetry, certain light gravitino processes are governed by the coupling of its Goldstino components. The rules for constructing SUSY and gauge invariant actions involving the Goldstino couplings to matter and gauge fields are presented. The explicit operator construction is found to be at variance with some previously reported claims. A phenomenological consequence arising from light gravitino interactions in supernova is reexamined and scrutinized.

Disentangling non-standard model T violating sources in exclusive semileptonic B decays
(G.-H. Wu)

Measurements of the polarization of the lepton and D^* in the exclusive semileptonic B decays, $B \to D\ell\overline{\nu}$ and $B \to D^*\ell\overline{\nu}$, can be used to separate and identify the non-standard model sources of T violation. These T-odd effects, estimated in both supersymmetric and non-supersymmetric models, could be within the reach of the planned B factories.

Superstring theory
(I. Maksymyk)

Superstring theory is a candidate for a unified theory of all the forces of nature. All superstring theories predict the existence of a scalar field, the dilaton, the vacuum expectation value (vev) of which is the inverse of a coupling constant (squared). Until now, superstring theories had the phenomenological defect that the vev of dilaton was infinity, and the coupling constant of physical gauge theories was therefore zero. This is the runaway dilaton problem. I have found that if one assumes that the gauge group structure arising from the string theory is a product of simple groups, then with certain choices for the matter spectrum, the dilaton can be stabilized against runaway. The mechanism that results in this stabilization is based on recently developed methods for writing the exact non-perturbative superpotential of an $N = 1$ SUSY gauge theory.