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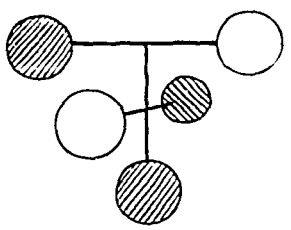
FEW BODY PROBLEMS IN NUCLEAR AND PARTICLE PHYSICS



PROBLEMES A PETIT NOMBRE DE CORPS DANS LA PHYSIQUE DU NOYAU ET DE PARTICULES ELEMENTAIRES

UNIVERSITE LAVAL, QUEBEC G1K 7P4 CANADA
AUGUST 27-31 AOUT 1974

RESUMES DES COMMUNICATIONS

SUMMARIES OF CONTRIBUTED PAPERS

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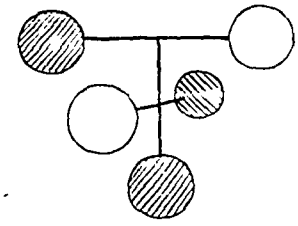

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J'ai le plaisir de remercier au nom du comité d'organisation de cette conférence, tous les organismes qui ont rendu possible sa tenue. L'appui de plusieurs entreprises privées a aussi été important pour en assurer son succès. L'aide de Mesdemoiselles Carmelle Beaulieu et Linda Guillot dans la préparation de ce volume pour l'imprimerie a été inestimable et je suis très reconnaissant pour leur collaboration et leur enthousiasme.

ACKNOWLEDGEMENTS

I am pleased to thank in the name of organizing committee of this conference all agencies and institutions that have made it possible. The support of several private enterprises has been also important for its success. The able help of Misses Carmelle Beaulieu and Linda Guillot in the preparation of this volume for the printer has been invaluable and I am very grateful for their collaboration and their enthousiasm.

R.J. Slobodrian

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RESUMES

I

PROBLEMES GENERAUX A PETIT NOMBRE DE CORPS

GENERAL FEW BODY PROBLEMS

UNE METHODE NOUVELLE DANS LA THÉORIE DE LA DIFFUSION A PLUSIEURS CORPS

D.J. Kouri*, Max-Planck-Institut für Strömungsforschung, 3400 Göttingen, République Féderale d'Allemagne, et F.S. Levin†, Département de Physique, Université Brown, Providence, R.I. 02912 USA.

Récemment, nous avons déduit un nouvel ensemble d'équations couplées pour les operateurs T et K, décrivant la diffusion à plusieurs corps. L'élement essentiel de la méthode est la matrice W de couplage des canaux, dont les éléments apparémment arbitraires sont déterminés par la condition que le noyau des equations couplées soit connexe. Les approximations unitaires pouvent être introduites avec simplicité, puisque les opérateurs T et K sont connectés par une équation d'Heitler et les éléments des opérateurs K sont réels. Aussi bien il n'y a pas des solutions spurieuses des équations couplées (il n'y a pas de maladie de Federbush). Finalement, les nouvelles equations ont la vraie structure unitaire.

Cette conférénce traitera d'une derivation des equations; des propriétés des matrices W et méthodes de choisir leurs eléments afin de garantir que le novau iteré des equations soit connexe; des aspects des solutions pour le cas géneral, compremant la formulation d'un operateur de potential optique dans le canal direct; des connexions avec autres formulations; et des applications numériques, particulièrement a le diffusion des électrons par les atomes d'hydrogène.

A NEW METHOD IN THE THEORY OF MANY-BODY SCATTERING

D.J. Kouri*, Max-Planck-Institut für Strömungsforschung, 3400 Göttingen, Federal Republic of Germany, and F.S. Levin†, Physics Department, Brown University, Providence, R.I. 02912

We have recently derived new sets of coupled equations for the T operators and for the K operators describing many-body scattering. The key to the method is the channel coupling array W, whose seemingly arbitrary elements are fixed by requiring the iterated kernel of the coupled equations to be connected. Unitary approximations may be introduced with relative ease, since the T and K operators are related by a damping equation and matrix elements of the K operators are real. In addition, the equations are free of spurious solutions and have the correct unitarity structure. This talk will be concerned mainly with a derivation of the equations; a discussion of the properties of the arrays W and of how their elements may be chosen so as to ensure connected iterated kernels; some aspects of the solutions in the N-channel case, including the formulation of a direct channel optical potential operator; connections with other formulations; and numerical applications, particularly to e^- + H scattering.

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† Work supported in part by the U.S. Atomic Energy Commission.

TRANSFORMATIONS CANONIQUES ET UN MODELE SOLUBLE POUR LE PROBLEME A TROIS CORPS LINEAIRES.

M. Moshinsky*, J. Patera et P. Winternitz, Centre de Recherches Mathématiques, Université de Montréal, Montréal, P.Q., Canada.

On résout de façon algébrique les équations de mouvements pour trois particules confinées sur une droite et interagissant par l'intermédiaire de forces à deux corps décrites par une somme de potentiels de la forme $V_{ik} = \alpha(x_i-x_k)^2+\beta(x_i-x_k)^{-2}$. Les fonctions d'ondes sont construites explicitement et un groupe de transformations canoniques est établi, qui fait apparaître un isomorphisme avec le problème de l'oscillateur harmonique. Le spectre contient une dégénérescence accidentelle décrite par un groupe SU(2). On considère aussi une généralisation du modèle contenant à la fois des forces à deux et à trois corps, qui a également une symétrie SU(2) et est donc explicitement solubles.

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CANONICAL TRANSFORMATIONS AND A SOLVABLE MODEL FOR THE LINEAR THREE-BODY PROBLEM.

M. Moshinsky*, J. Patera and P. Winternitz, Centre de Recherches Mathématiques, Université de Montréal, Montréal, P.Q., Canada.

An algebraic treatment is given for a model involving three particles constrained to a line, interacting through two-body forces described by a sum of potentials of the type $V_{ik} = \alpha(x_i-x_k)^2+\beta(x_i-x_k)^{-2}$. Wave functions are constructed explicitly and a group of canonical transformations is obtained mapping the problem onto that of a harmonic oscillator. The spectrum displays accidental degeneracy described by an SU(2) group. Generalizations are suggested involving both two and three-body forces, in which the problem still has an SU(2) symmetry and is hence explicitly solvable. /

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THE USES OF THE FEW BODY PROBLEM

R. D. Amado[+]
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The few body system is a rich source of information for hadron dynamics. How some of this information manifests itself and how the general constraints of quantum mechanics help or restrict its extraction will be discussed. Examples will include the theory of final state interactions, of meson-baryon resonances and of meson degrees of freedom in the nucleus.

[+]Supported in part by the National Science Foundation.

COULOMB EFFECTS IN NUCLEON-DEUTERON SCATTERING

J. A. Edgington and C. J. Oram, Queen Mary College, London, England.

Using a naive potential model of the N-d interaction we have evaluated, approximately, the "inner Coulomb corrections" to the nuclear phase shifts. We find an effect of magnitude typically 5%, due mainly to the rapid variation of the phase shifts with energy. We show that the differences observed experimentally between n-d and p-d cross sections and polarisations may in large part be ascribed to these corrections. Results for cross sections are given at 35.0 and 46.3 MeV, and for polarisations at 35 MeV.

A POSSIBLE CHECK OF EFIMOV RESONANCES

M. S. HUSSEIN

Instituto de Física - Universidade de São Paulo - C.Postal 8219, S.Paulo, S.Paulo, Brasil.

A suggestion is made where Efimov resonances, if they exist, would manifest themselves in the measured total and other cross-sections in the form of a damping width associated with the observed three-body resonance. Such a damping width is roughly proportional to the energy interval defined by the total width of the observed three-body resonance. An example is given namely, $NN \rightarrow NN\pi$.

GLAUBER REPRESENTATION FOR THE SCATTERING BY NONLOCAL POTENTIALS

B. S. BHAKAR

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Winnipeg, Canada

An eikonal approximation for nonlocal potential is derived when the impinging particles have high energies. We take as an example non-local separable potential whose exact solution is known. We derive an impact parameter representation by two methods. One method leads to an expression which is valid only at small angles and high energies whereas the other method leads to expression which is valid at all energies and angles. The two expressions can be shown to be identical in the small angle and high energy limit.

THREE-PARTICLE CALCULATIONS ABOVE BREAKUP THRESHOLD FOR SEPARABLE, ALMOST SEPARABLE AND LOCAL POTENTIAL

H. Ziegelmann
Institut für Theoretische Physik der Universität Tübingen, GFR

Three-particle calculations above breakup threshold have been performed for separable approximations to the Yukawa and the Malfliet-Tjon potential. In the case of the Yukawa potential the non-separable part of the interaction is quite important and has therefore been taken into account by the quasi-particle method. In the case of the Malfliet-Tjon potential the separable approximation gives results not far from the exact results of Kloet and Tjon. The Malfliet-Tjon potential can therefore be called "almost separable".

CALCULS DE TROIS CORPS AU-DESSUS DU SEUIL DE DESINTEGRATION POUR UN POTENTIEL SEPARABLE, PRESQUE SEPARABLE ET LOCAL

H. Ziegelmann
Institut für Theoretische Physik der Universität Tübingen, GFR

Nous avons calculé la diffusion de trois corps au-dessus du seuil de désintégration pour le potentiel de Yukawa et celui de Malfliet-Tjon par approximation séparable. Dans le cas du potentiel de Yukawa la partie non séparable est assez importante, et par conséquent, nous en avons tenu compte par la méthode des quasi-particules. Dans le cas du potentiel de Malfliet-Tjon l'approximation séparable donne des résultats qui correspondent à peu près aux résultats exacts de Kloet et Tjon. C'est pourquoi qu'ont peut appeler le potentiel de Malfliet-Tjon "presque séparable".

ON THE COMPARISON BETWEEN QUANTUM MECHANICS AND LOCAL HIDDEN VARIABLE THEORIES: BELL'S TYPE INEQUALITIES FOR MULTI-VALUED OBSERVABLES

A. BARACCA - Istituto di Fisica dell'Università - Firenze
S. BERGIA - Istituto di Fisica dell'Università - Bologna
M. RESTIGNOLI - Istituto di Fisica dell'Università - Roma

Bell pointed out that for dicotomic variables observable differences schould exist between quantum mechanics and local hidden variable theories; an experimental test seems to give evidence for a failure of quantum mechanics in polarization correlation measurements. In this paper we investigate the case of multi-valued observables. We propose a straightforward generalization of Bell's inequality; for a purely mathematical case of a spin-0 particle decaying into two equal spin-j particles we point out a difference with respect to the dicotomic case: the inequality may in fact be violated by the quantum mechanical mean values of the angular momentum correlations for the two subsystems only in the spin-$^1/_2$ case. For higher values this does no longer happen, while a discrepancy with respect to quantum mechanics may still be found by measuring the correlations between couples of well defined polarizations.

SUR LA COMPARAISON ENTRE LA MÉCANIQUE QUANTIQUE ET LES THÉORIES À VARIABLES CACHÉES: INÉGALITÉ À LA BELL POUR OBSÉRVABLES À PLUSIEURS VALEURS.

Bell a montre qu'il y a une différence obsérvable entre la mécanique quantique et les théories à variables cachées, et le test expérimental indique une violation de la première dans des mesures de correlation de polarization. On propose ici une simple généralization de la relation de Bell puor obsérvables à plusieurs valeurs. On montre que dans le cas (tout à fait mathématique) d'une particule de spin 0 qui se décompose en deux particules égales de spin j cette relation peut être violé par les valeurs moyen des correlations entre les moments angulaires de la mécanique quantique seulement pour j=$^1/_2$. Pour les valeurs plus hautes du moment angulaire la mécanique quantique peut tous-jour violer l'inégalité seulement si l'on mesure des correlations entre couples de polarizations des deux sous-systèmes.

THREE BODY BREAK-UP REACTIONS AND THE PADÉ APPROXIMANT

A.W. Thomas, Department of Physics,
University of British Columbia, Vancouver, B.C., Canada V6T 1W5.

Using only the analyticity properties of the half-off-shell t-matrix for three particle scattering (in the Amado model), we describe a simple way of calculating break-up amplitudes. This procedure involves little more work than the usual method of calculating the elastic scattering amplitude by contour rotation.

THREE-BODY MODEL OF THE N-T SYSTEM

Shinsho Oryu
Department of Physics, Faculty of Science and Technology,
Science University of Tokyo, Noda-city, Chiba, 278 Japan

The n-T elastic scattering amplitude was assumed to be made of a summation of finite Born terms multiplied by the weight factors depending upon the total energy only. Each of the factors was obtained by means of χ^2-minimization to the experimental elastic scattering cross section taking into account the constraint of the optical theorem. The shape of the experimental data was fairly well explained by the model though in the simplest case with only three terms and with the three-body model(n+n+d) of n-T system, at the neutron energy 14.1 MeV. By the analytical continuation of the amplitude, it can be shown that the break-up differential cross section is given by a simple calculation based on Faddeev's approach without solving the three-body and/or the four-body Faddeev equations numerically.

INTERPRETATION MICROSCOPIQUE DES REACTIONS INDUITE PAR DES PROTONS SUR ^{3}H.

C.L. Rao, S. Ramavataram and K. Ramavataram
Université Laval, Laboratoire de Physique Nucléaire,
Département de Physique, Québec G1K 7P4, Canada.

Les résonances de parité négative avec T = 1 au système de nombre de mass A = 4 ont été étudié théoriquement, dans un modèle de continuum aux excitations du type particle-trou. Les résultats du calcul aux voies couplées pour les réactions $^{3}H(p,\gamma)^{4}He$ et son inverse ainsi que la réaction $^{3}H(p,p)$ ^{3}H et la réaction $^{3}H(p,n)^{3}He$ sont présentés et comparés avec les résultats expérimentaux.

A MICROSCOPIC INTERPRETATION OF THE PROTON-INDUCED REACTIONS IN THE MASS-3 SYSTEM.

C.L. Rao, S. Ramavataram and K. Ramavataram
Université Laval, Laboratoire de Physique Nucléaire,
Département de Physique, Québec G1K 7P4, Canada.

The T = 1 negative parity resonances in the A = 4 system are studied in the framework of a continuum model of 1p-1h excitations. The results of the coupled-channels calculation for the reaction $^{3}H(p,\gamma)^{4}He$ and its inverse as well as those for the reactions $^{3}H(p,p)^{3}H$ and $^{3}H(p,n)^{3}He$ are discussed and compared with experiment.

P-MATRIX METHOD IN THE 3-BODY PROBLEM

W. Glockle, Institute for Theoretical Physics of the
Ruhr-University Bochum, 463 Bochum, Germany

The asymptotic form of the Faddeev amplitude in coordinate space is derived to various orders, allowing the definition of an interior and exterior region. Using the Faddeev equations and a suitable complete system of basis states for the interior region one can derive a set of equations directly for the on-shell 3-body T-matrix elements. This procedure is equally well suited for local and nonlocal pair interactions.

EXTENSION OF BRUECKNER'S THEORY FOR THE BOSON-NUCLEON-SYSTEM

K. B l e u l e r , University of Bonn, W-Germany

Boson exchange (in conjunction with the Δ-Resonance) leads to a satisfactory description of the nuclear force between free nucleons. Various recently descovered effects give an important support of the theory. It is stressed, however, that nuclear forces as derived from the free 2-nucleon system cannot authomatically been taken over into the treatment of nuclear matter. An enlarged theory treating Bosons and Nucleons on the same level is proposed.

ON THE STRUCTURE OF LIGHT NUCLEI

K. B l e u l e r, University of Bonn, W-Germany

The structure of various light nuclei is visualized with help of the concept of valence-particles. The latter are described by a special Hamiltonian (containing integral operators due to the Pauli principle) which englobes the important effect of core-polarization. Various examples, in particular the F^{19} nucleus, are discussed.

REACTIONS $^{3}H(^{3}He,d)^{4}He$ and $^{3}H(^{3}He,np)^{4}He$ AT LOW ENERGIES, BARSHAY-TEMMER THEOREM, AND ISOSPINSYMMETRY[+]

G. Schrieder, H. Genz and A. Richter
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W. von Witsch
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H. Paffe and B. Ruth
Fachbereich Physik der Universität, Marburg, Germany

Angular distributions of the reaction $^{3}H(^{3}He,\alpha)^{2}H$ have been measured between ($4.25 < E(^{3}He) < 9.85$) MeV in steps of 0.5 MeV. They are on the average 15% asymmetric about 90° c.m. contrary to the predictions of the Barshay-Temmer isospin theorem, and hence indicate a sizable isospin violation. All available data in this reaction at low energies show a strongly energy dependent isospin violation which might be due to isospin mixing between T=0 and T=1 states in the compound nucleus ^{6}Li. In order to test the origin of this isospin violation further, the energy dependence of the n-p, T=0 and T=1 final state interaction in the reaction $^{3}H(^{3}He, np)^{4}He$ has been studied. Preliminary results at ^{3}He - bombarding energies of 0.31, 1.63 and 1.93 MeV indicate so far no detectable energy dependence of the singlet to triplet contribution of the cross section. This contribution is on the average about 11%.

[+]Supported in part by Deutsche Forschungsgemeinschaft.

REACTION $^{3}H(^{3}He,d)^{4}He$ et $^{3}H(^{3}He,np)^{4}He$ AUX ENERGIES BASSES, LE THEOREME DE BARSHAY-TEMMER ET LA SYMETRIE D'ISOSPIN[+]

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W. von Witsch
Institut für Strahlen- und Kernphysik der Universität, Bonn, Allemagne

H. Paffe et B. Ruth
Fachbereich Physik der Universität, Marburg, Allemagne

Les distributions angulaires de la réaction $^{3}H(^{3}He,\alpha)^{2}H$ ont été mesurées dans le domaine d'énergie entre ($4.25 < E(^{3}He) < 9.85$) MeV en pas de 0.5 MeV. Elles sont asymétriques d'environ 15% par rapport à 90° c.m. contrairement aux prédictions du théorème de Barshay-Temmer et indiquent ainsi une violation considerable d'isospin. Toutes les expériences connues par cette réaction aux énergies basses montrent une forte violation d'isospin ce qui indique un mélange d'isospin dans des états intermédiaires de ^{6}Li avec T=0 et T=1. Pour tester l'origine de cette violation d'isospin la variation des interactions n-p, T=0 et T=1 dans l'état final a été étudiée en fonction de l'énergie pour la réaction $^{3}H(^{3}He,np)^{4}He$. Les résultats préliminaires aux énergies ^{3}He de 0.31, 1.63 et 1.93 MeV ne montrent pas une variation remarquable des contributions de singlet à triplet à la section efficace. Cette contribution est d'environ 11%.

[+]Ce travail a été appuyé en partie par la Deutsche Forschungsgemeinschaft.

HOW TO ESTIMATE BREAKUP AMPLITUDES IN NUCLEAR REACTION CALCULATIONS

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Experience shows that the wave function for scattering of compound systems can be obtained to a rather good approximation by variational methods in coordinate space. As long as the probability for breakup is small, this is true even if (as is usually done) no asymptotic part describing breakup is provided for in the trial wave function. It is shown here that it is possible to extract information on the breakup amplitude from the interior (and more reliable) part of such a wave function by use of the generalized Kato identity. Though this procedure is not expected to give rigorous results, it is of striking simplicity in practical application.

DOES THE FADDEEV THEORY REQUIRE OFF-SHELL INPUT?§

Bengt R. Karlsson+ and Enrique M. Zeiger

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We present new Faddeev-type equations for the three-body problem. Although obtained from the rigurous Faddeev theory, they only require two-body bound state wavefunctions and half-off-shell transition amplitudes as input. In addition, their "effective potentials" are independent of the three-body energy, and can easily be made real after an angular momentum decomposition. The equations are formulated in terms of physical transition amplitudes for three-body processes, except that in the breakup case the partial wave amplitudes differ from the corresponding full amplitudes by a Watson fsi factor.

§ Work supported in part by the U. S. Atomic Energy Commission.

+ Present address: Institute of Theoretical Physics, Fack, S-402 20, Göteborg 5, Sweden.

INTERACTION A TROIS CORPS A L'ETAT LIE. UNE NOUVELLE APPROCHE.

B.T. Darling et R.M. Shoucri
Département de Physique, Université Laval, Québec G1K 7P4, Canada

Une nouvelle approche du problème à trois corps avec masses et charges arbitraires permet de réduire le calcul de l'énergie E à la solution d'un système d'équations différentielles couplet à une variable de la forme

$$\left\{ \frac{d^2}{dR^2} + 2E - \frac{(K+3/2)(K+./2)}{R^2} \right\} X_K^v(R) = - \sum_{K',v'} U_{KK'}^{vv'} X_{K'}^{v'}(R).$$

R est la racine carrée du moment d'inertie du système par rapport à l'axe Z perpendiculaire au plan des trois corps. $U_{KK'}^{vv'}$ représente les éléments de matrice du potentiel d'intéraction par rapport à un système donné de fonctions orthonormées. Le moment cinétique intrinsèque des trois corps, ainsi que les forces d'échange apparaissant en physique nucléaire, sont négligés mais peuvent être pris en considération dans l'expression de $U_{KK'}^{vv'}$.

THREE-BODY INTERACTION IN A BOUND-STATE. A NEW APPROACH

B.T. Darling and R.M. Shoucri
Département de Physique, Université Laval, Québec G1K 7P4, Canada

A new approach to the problem of three bodies with arbitrary masses and charges allows the calculation of the energy E to be reduced to the solution of a coupled system of differential equations in one variable of the form

$$\left\{ \frac{d^2}{dR^2} + 2E - \frac{(K+3/2)(K+5/2)}{R^2} \right\} X_K^v(R) = - \sum_{K',v'} U_{KK'}^{vv'} X_{K'}^{v'}(R),$$

R is the square root of the moment of inertia of the system with respect to the Z axis perpendicular to the plane of the three bodies. $U_{KK'}^{vv'}$ are the matrix elements of the interaction potential with respect to a certain orthonormal set of functions. Spin effect as well as exchange forces appearing in nuclear physis, although neglected, can be taken into consideration in the expression of $U_{KK'}^{vv'}$.

II

INTERACTION NUCLEON-NUCLEON A TOUTES LES ENERGIES

NUCLEON-NUCLEON INTERACTION AT ALL ENERGIES

POTENTIEL NUCLEON-NUCLEON A COEUR MOU TENANT COMPTE DE L'ECHANGE DE DEUX PIONS ET DE ω

R. de TOURREIL[+], D.W.L. SPRUNG[++*], B. ROUBEN[†*]

Une version améliorée de l'interaction à coeur très mou est présentée. Elle inclut les effets d'échange des bosons connus π,ρ et ω . Le coeur et le reste de la portée intermédiaire sont traités de manière phénoménologique. Le potentiel reproduit très bien les données expérimentales du problème à deux corps - l'état lié et la diffusion jusqu'à 350 MeV. Les amplitudes du potentiel sont faibles, dans le sens où le rapport des énergies potentielles des composantes scalaires au deuxième et au premier ordre de la série des perturbations de la matière nucléaire est de l'ordre de 20 à 30 % et l'intégrale de défaut $\kappa = .077$ à $k_F = 1.4$ fm^{-1}. La composante tenseur dans le sous-espace triplet-pair est moins forte que celle d'autres interactions phénoménologiques, mais le facteur de forme du deuton est bien reproduit. Le pourcentage d'onde D dans le deuton est de 5.80 %.

SUPER-SOFT-CORE NUCLEON-NUCLEON INTERACTION INCLUDING TWO-PION EXCHANGE AND ω-EXCHANGE CONTRIBUTIONS

R. de TOURREIL[+], D.W.L. SPRUNG[++*], B. ROUBEN[†*]

An improved version of the super-soft-core interaction is presented. The known π,ρ and ω exchange contributions are incorporated, while the core and the remainder of the intermediate range are treated phenomenologically. The potential gives a high quality fit to the two-body bound-state and scattering data up to 350 MeV. The amplitudes are weak in the sense that in nuclear matter, the ratio of second-to first-order energy perturbations (for the scalar components) are in the ratio 20-30%. The wound integral $\kappa = .077$ at $k_F = 1.4$ fm^{-1}. The triplet-even tensor component is weaker than in other phenomenological potentials, but the deuteron form factor is well reproduced. The percentage D state is 5.80%.

* Recherche appuyée par le Conseil National de Recherche du Canada

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* Research supported by the National Research Council of Canada.

STUDY OF THE REACTION $pp \rightarrow \pi^+ d$ AT 576 MeV

D. Aebischer, B. Favier, G. Greeniaus*, R. Hess, A. Junod+
C. Lechanoine, J.C. Niklès, O. Rapin, C. Serre, O. Werren
University of Geneva, Switzerland

The reaction $pp \rightarrow \pi^+ d$ has been studied for small pion production angles in the center of mass by observing the π and d at small angles in the laboratory system using multiwire proportional chambers. The presence of a term in $\cos^4\theta_{CM}$ in the differential cross section, observed for the inverse reaction $\pi d \rightarrow pp$, has been confirmed.

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ETUDE DE LA REACTION $pp \rightarrow \pi^+ d$ A 576 MeV

D. Aebischer, B. Favier, G. Greeniaus*, R. Hess, A. Junod+
C. Lechanoine, J.C. Niklès, O. Rapin, C. Serre, O. Werren
Université de Genève, Suisse

La réaction $pp \rightarrow \pi^+ d$ a été étudiée pour des pétits angles de production du pion dans le centre de masse, en observant le π et le d à petits angles dans le système du laboratoire, à l'aide de chambres à fils en régime proportionnel. Ces mesures confirment la nécessité d'un terme en $\cos^4\theta_{CM}$ pour paramétriser la section efficace différentielle.

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* Boursier du Conseil National de Recherche canadien, à présent à l'Université de Genève, Suisse
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PRECISION FITS TO THE $^1S_0$ PROTON-PROTON PHASE SHIFTS

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Precision fits to the $^1S_0$ p-p phase shifts have been obtained with a number of equivalent local potentials. These potentials have shapes which seem to indicate that the real interaction is nonlocal.

DETERMINATION PRECISE DES DEPHASAGES DE L' ONDE $^1S_0$ POUR LA DIFFUSION PROTON-PROTON

M.W. Kermode, Department of Applied Mathematics and Theoretical Physics, The University, P.O. Box 147, Liverpool, L69 3BX, U.K.

La détermination précise des déphasages de l'onde $^1S_0$ pour la diffusion proton-proton est faite pour différents potentiels locaux equivalents. Les formes de ces potentiels semblent indiquer que l'interaction réelle est non locale.

DELTA FUNCTION POTENTIAL FOR THE $^3S_1$ - $^3D_1$ STATE

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A two nucleon interaction model is given in the form

$$\frac{M}{\hbar^2}\langle \alpha r L|V|\alpha' r' L'\rangle = \delta(r-r')\sum_{i=1}^{m}\frac{V_i^{\lambda LL'}}{r_i}\delta(r-r_i)$$

The parameters are given for the $^3S_1$ - $^3D_1$ state. The resultant deuteron properties and phase shifts are compared with experiment.

ÉTUDE DES VARIATIONS DE LA VALEUR PERMISE DE a_{nn} OBTENUE DE LA REACTION $\pi^- D \to \gamma nn$ SUIVANT DIVERSES FONCTIONS D'ONDE N-N QUI SONT ÉQUIVALENTES DANS LE SENSE UNITAIRE *

W. R. Gibbs and B. F. Gibson
Los Alamos Scientific Laboratory, Los Alamos, New Mexico 87544

and

G. J. Stephenson Jr. †
University of Maryland, College Park, Maryland 20742

Nous avons constaté un effet plus petit sur la valeur de a_{nn} obtenue de la reaction $\pi^- + D \to \gamma + n + n$ que sur la valeur de a_{pp} obtenue par Sauer de l'analyse de la diffusion elastique p-p, dû aux variations de la fonction d'onde N-N qui sont équivalentes dans le sense unitaire.

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*Ce travail a été appuyé en partie par le USAEC.

†A présent au Los Alamos Science Laboratory, Los Alamos, New Mexico 87544.

A STUDY OF THE VARIATIONS IN THE ALLOWED VALUE OF a_{nn} OBTAINED FROM THE REACTION $\pi^- D \to \gamma nn$ DUE TO DIFFERENT UNITARILY-EQUIVALENT N-N WAVE FUNCTIONS *

W. R. Gibbs and B. F. Gibson
Los Alamos Scientific Laboratory, Los Alamos, New Mexico 87544

and

G. J. Stephenson Jr. †
University of Maryland, College Park, Maryland 20742

We demonstrate that rank two unitary transforms of the short-range N-N wave function produce a much smaller effect on the value of a_{nn} extracted from the radiative capture reaction $\pi^- + D \to \gamma + n + n$ than that observed by Sauer on the value of the Coulomb-corrected a_{pp} extracted from p-p scattering.

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*Work supported in part by the U.S. Atomic Energy Commission.

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INFLUENCE OF THE NEUTRON'S CHARGE DISTRIBUTION ON NUCLEAR COULOMB ENERGIES

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J.S. O'Connell, National Bureau of Standards, Washington, D.C.

The electrostatic interaction energy of a deuteron was computed for a model in which the neutron charge distribution was taken as a superposition of two exponentials of total charge +e and -e. Because the interaction potential is of short range the result is sensitive to the interior deuteron wave function. For a Reid hard-core wave function the computed energy is 1 keV.

L'INFLUENCE DE LA DISTRIBUTION DE CHARGE DU NEUTRON SUR L'ENERGIE COULOMBIENNE DES NOYAUX

C.R. Heimbach, American University and Harry Diamond Laboratories,
J.S. O'Connell, National Bureau of Standards, Washington, D.C.

L'energie d'interaction electrostatique de le deutéron est calculeé pour un modèle dans lequel la distribution de charge pour le neutron étais un superposition de deux exponentialles, avec charge totale de +e et -e. Le résultat est sensitif à l'interieur de la function d'onde de le deutéron, parce'que le potentiel d'interaction entre le neutron et le proton a un domaine petit. Pour une function d'onde calculeé avec le potentiel "hard-core" de Reid l'energie d'interaction electrostatique est 1 keV.

POLARIZATION MEASUREMENTS IN p-p ELASTIC SCATTERING AT 462 MeV

D. Aebischer, B. Favier, G. Greeniaus*, R. Hess, A. Junod+,
C. Lechanoine, J.C. Niklès, D. Rapin, D. Werren

University of Geneva, Switzerland

The p-p analyzing power $P(\theta)$ has been measured in the angular range $2^{o} \leq \theta_{Lab} \leq 7^{o}$ at 462 MeV incident proton energy. The full azimuthal angular range was observed using multiwire proportional chambers placed directly in a 37% polarized beam.

* National-Research Council of Canada fellow
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+ Swiss Federal Institute of Technology, Zürich, Switzerland.

MESURES DE POLARISATION DANS LA DIFFUSION ELASTIQUE p-p A 462 MeV

D. Aebischer, B. Favier, G. Greeniaus*, R. Hess, A. Junod+
C. Lechanoine, J.C. Niklès, D. Rapin, D. Werren

Université de Genève, Suisse

Le pouvoir d'analyse $P(\theta)$ a été mesuré, pour la diffusion élastique p-p, dans la région angulaire $2^{o} \leqslant \theta_{LAB} \leqslant 7^{o}$ à 462 MeV d'énergie cinétique. Un système de chambres à fils en régime proportionnel placé directement dans un faisceau polarisé à 37% a permis d'observer la distribution de l'angle azimutal avec pleine efficacité.

* Boursier du Conseil National de Recherche canadien, à présent à l'Université de Genève, Suisse
+ Ecole Polytechnique Fédérale Suisse, Zürich.

PROTON-PROTON POTENTIAL WITH A THEORETICAL INTERMEDIATE RANGE PART DEDUCED FROM DISPERSION RELATIONS

M. Lacombe, B. Loiseau, J.M. Richard, R. Vinh Mau

Division de Physique Théorique*, Institut de Physique Nucléaire, Paris** et Laboratoire de Physique Théorique - Paris**

P. Pires, R. de Tourreil

Division de Physique Théorique*, Institut de Physique Nucléaire, 91406 Orsay

Nous avons construit un potentiel proton-proton dont la partie à longue et moyenne portée est obtenue à partir des déphasages pion-nucléon et pion-pion (1) et dont la partie à courte portée est déterminée de façon phénoménologique en ajustant les déphasages proton-proton jusqu'à 350 MeV et les paramètres à basse énergie (longueur de diffusion et paramètre de portée effective). Le potentiel trouvé comporte une composante non locale assez importante à petites distances.

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PROTON-PROTON POTENTIAL WITH A THEORETICAL INTERMEDIATE RANGE PART DEDUCED FROM DISPERSION RELATIONS

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P. Pires, R. de Tourreil

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A proton proton potential is constructed which possesses the long and intermediate range part obtained from pion-nucleon and pion-pion (1) phase shifts, the short range part is determined phenomenologically by fitting the proton-proton phase shifts up to 350 MeV and the low energy parameters (scattering length, effective range parameter). The calculated potential have significant non local components at small distances.

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NUCLEON-NUCLEON INTERACTION WITH COULOMB MODIFICATIONS

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A non-local separable nucleon-nucleon interaction model for S, P, and D partial waves is presented. The potential is realistic in the sense that it was constructed to reproduce all two-body nucleon-nucleon data. That applies especially to the coupled $^3S_1 - {}^3D_1$ state where we reached an accurate description of the deuteron properties E_D and Q with a D-state probability p_D = 2,64 % and an asymptotic D-/S-state wave function ratio η = 0.034; at the same time we maintained a good fit to the scattering data though we kept up a comparatively low rank of the potential. For the proton-proton interaction we took into account modifications of the short-range nuclear force which are due to the presence of the Coulomb potential. The calculation of infinite nuclear matter exhibits the saturation properties of the proposed potential model.

MOMENTUM SPACE CALCULATION OF NEUTRON-PROTON BREMSSTRAHLUNG[†]

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A calculation of the n-p bremsstrahlung process is carried out in momentum space. This is motivated by the fact that the exchange current is of a simple form in momentum space, hence no expansions of the operator in powers of the photon energy are needed.

[†]Work supported in part by the U. S. Atomic Energy Commission.

PARITY-VIOLATING n-p PHOTOCAPTURE AND THE SHORT RANGE TWO-NUCLEON INTERACTION

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We show that the photon polarization in parity-violating n-p photocapture is a direct measure of the short-range low energy two-nucleon (NN) wave function. The usual phenomenological local NN potentials are shown to predict polarizations smaller than experiment by two or three orders of magnitude $P(\text{expt}) = 1-(1.30 \pm 0.45) \times 10^{-6}$ We argue that the only way to obtain agreement with experiment is to insist that at low energies the NN interaction does not possess a strong repulsive core. We indicate that this is quite consistent with the NN scattering data, but implies a non-local NN interaction.

Precision Measurement of n-p Charge-Exchange Cross Section at 640 MeV.
L. C. NORTHCLIFFE, M. L. EVANS, G. GLASS, J. C. HIEBERT, MAHAVIR JAIN, Texas A&M U.*; H. C. BRYANT, C. CASSAPAKIS, S. COHEN, B. D. DIETERLE, D. M. WOLFE, U. of New Mexico*; B. E. BONNER, J. E. SIMMONS, LASL*; D. WERREN, SIN*; C. W. BJORK, P. J. RILEY, U. of Texas*--A measurement of the differential cross section for n-p elastic scattering in the charge-exchange region ($167° < \theta_{cm} \leq 180°$) at 640 MeV has been made at LAMPF. The monoenergetic neutron beam produced by the D(p,n) reaction at 0° was incident upon a liquid-hydrogen target and the recoil rrotons were momentum analyzed by a magnetic spectrometer, utilizing eight multi-wire proportional counter planes to define the proton trajectories. The time of flight through the spectrometer was used to distinguish between the recoil protons and deuterons from the reaction $n+p \rightarrow \pi^0+d$. The deuteron yield provides an absolute normalization of the n-p elastic cross section. The data are of high statistical accuracy ($\sim \pm 2\%$ in angular bins of width $\Delta\theta_{cm}=0.5°$). The results will be compared with previous measurements and with a phase-shift prediction. Extensive data obtained at 800 MeV will also be presented.

*Supported in part by the U.S. Atomic Energy Commission.

On time reversal violating nucleon-nucleon potentials

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Time reversal violating parity conserving nucleon-nucleon potentials are reconsidered in order to obtain more insight into their possible radial dependence.

No T-violation is possible from $J = 0$ - exchange. Natural parity exchange, $\pi = (-1)^J$, is allowed only if the exchanged particle or system is charged. It contributes only to singlet-triplet transitions. The explicit form of T-violating ρ_1 and A_1 exchange is given.

ANALYSIS OF RESULTS OF CALCULATIONS OF FEYNMAN GRAPHS FOR NUCLEON-NUCLEON SCATTERING

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The convergence of the series for various parts of the tangent matrix derived from the Lagrangian

$$\mathcal{L}' = i(4\pi)^{1/2} \cdot g\bar{\psi}\gamma_5 \tau\psi \cdot \phi + 4\pi(\phi \cdot \phi)^2$$

is discussed. A very good $\tan \delta(^3P_0)$ results from $g^2/4\pi = 15$ and $\lambda = 6$ which are close to the values derived for these coupling constants in other ways. It is pointed out that many graphs requiring renormalizations do not contribute, and a number of calculations which would improve our understanding of the possibility of getting good results from such an $\mathcal{L}'$ are suggested.

PRECISION MEASUREMENT OF P-P ABSOLUTE CROSS SECTION NEAR THE INTERFERENCE MINIMUM

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In an experiment designed to achieve p-p elastic scattering angular distributions below 6 MeV with an absolute accuracy better than .2 % first results are obtained at energies near the interference minimum. Although this energy region poses several problems to the measurement, the knowledge of the energy of the cross section minimum is of special importance because it may influence the value of the scattering length a_{pp} in the effective range expansion.
We obtained for the minimum energy $E_{min} = 382.75 \pm .11$ keV . This value is about two standard deviations above the result of Brolley et al. (1), namely $E_{min} = 382.43 \pm .20$ keV .
We presently intend to reduce the uncertainty in energy to about .05 keV including further measurements and additional experimental tests into the analysis.

Reference

(1) J.E.Brolley,Jr., J.D.Seagrave, and J.G.Beery
Phys.Rev. 135, B1119 (1964)

PROLONGEMENT HORS-COUCHE DE L'AMPLITUDE DE TRANSITION PROTON-PROTON

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La matrice T de transition nucléaire proton-proton est construite directement sans ajustement du potentiel. Quoiqu'elle soit obtenue à partir d'une fonction symétrique $\sigma^C(k_2k_1)$ dont les éléments diagonaux sont donnés par les déphasages expérimentaux proton-proton, la matrice T est purement nucléaire et ne contient aucun effet coulombien. La partie non-diagonale de $\sigma^C(k_2k_1)$ ne peut être déterminée par les expériences de diffusion élastique et doit être paramétrisée. La courte portée des forces nucléaires, ainsi que leur comportement asymptotique donné par l'échange d'un pion, donnent des contraintes sur cette paramétrisation qui sont discutées.

OFF-SHELL CONTINUATION OF THE PROTON-PROTON TRANSITION MATRIX

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H. Walliser
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Avoiding the usual potential fit, the nuclear porton-proton transition matrix T is directly constructed. T is purely nuclear without any Coulomb effects, though it is derived in its entirety from a symmetric function $\sigma^C(k_2\ k_1)$ whose diagonal elements are given by the experimental proton-proton phases. The off-diagonal part of $\sigma^C(k_2k_1)$ cannot be determined by elastic scattering experiments and has to be parametrized. Constraints on its parametrization due to the short range and the one-pion exchange tail of the nuclear force are discussed.

Localy Energy Dependent Phase Shift Analysis of Proton-Proton Scattering in the Energy Region 200 - 620 MeV.

J. BYSTRICKY, F. LEHAR

DPhPE CEN SACLAY FRANCE

We present preliminary results of our proton-proton phase shift analysis carried out on 5 energy intervals of about 80 MeV large from 200 up to 620 MeV. On each interval phase shifts are approximated by linear, quadratic or cubic functions of energy. Almost all known experimental data were used to determine polynomial coefficients. We give the most interesting phase-shift energy dependences as well as some predictions of experimental quantities.

Analyse en déphasage de la diffusion proton-proton localement dépendante en énergie entre 200 et 620 MeV.

J. BYSTRICKY, F. LEHAR

DPhPE CEN SACLAY FRANCE

Nous présentons des résultats préliminaires d'une analyse en déphasage faite dans cinq intervalles d'environ 80 MeV entre 200 et 620 MeV. Dans chaque intervalle les déphasages sont représentés par des fonctions linéaires, quadratiques ou cubiques de l'énergie. La quasi-totalité des données expérimentales connues ont été utilisées pour déterminer les coefficients des polynomes. Nous montrons en fonction de l'énergie les déphasages les plus intéressants ainsi que les prédictions de certaines quantités expérimentales.

AVERAGE VALUE OF THE NEUTRON-NEUTRON SCATTERING LENGTH FROM A CRITICAL COMPILATION OF PUBLISHED MEASUREMENTS

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A review is given of the experimental and theoretical methods, used to determine the neutron-neutron scattering length, and the results obtained up to now by these methods. From the existing experimental data the weighted average value and the standard deviation

$$\overline{a_{nn}} = (- 16.61 \pm 1.45) \text{ fm}$$

for the scattering length was extracted. The 95 %-confidence interval was obtained to be

$$(- 16.61 - 0.54) \text{ fm} < a_{nn} < (- 16.61 + 0.54) \text{ fm}.$$

III

INTERACTION MESON-NUCLEON ET MESON DEUTON. PROGRAMMES DES USINES A MESON

MESON-NUCLEON AND MESON-DEUTERON INTERACTIONS. MESON FACTORIES PROGRAMMES

LA DIFFUSION π-DEUTERON

D.V. Bugg, Queen Mary College, London, E.1., Angleterre.

Que se passe-t-il dans la diffusion πd qu'on ne peut pas comprendre légèrment de la connaissance de πN? Le modèle de Glauber est adopté comme théorie de référence, avec laquelle on confronte les données expérimentales des sections totales, diffusion élastique, et des réactions de fragmentation. Les données expérimentales sont éxaminées, avec attention en particulier aux résultats summis à la conférence. On discute les corrections à la théorie de Glauber-dûs à l'élargissement des resonances par l'effet de Doppler et par des chocs, et aussi les effets du principe de Pauli. Le choix des cinématiques des collisions πN dans le deutéron est établi par appel à l'éxperience.

Le rapport entre la théorie de diffusion multiple à basse énergie et la théorie de Glauber est résumé. Une mesure nouvelle de la longeure de diffusion, déterminé par le changement en position de l'état fondamental de l'atome mésonique, s'accorde avec les longeurs de diffusions πN et la théorie de diffusion multiple.

L'état de symétrie de charge et les effets de la barrière Coulombienne sont examinés. Enfin, le pic élastique vers l'arrière est discuté.

π-DEUTERON SCATTERING

D.V. Bugg, Queen Mary College, Mile End Rd., London, E.1., England.

What happens in πd scattering which cannot be understood directly from our knowledge of πN? The Glauber approximation is adopted as a reference theory against which to compare experimental data on total cross sections, elastic scattering, and break-up reactions. The experimental data are reviewed, and particular attention will be paid to new results submitted to the conference. Corrections to Glauber theory due to Doppler and collision broadening

/of

of resonances, and Pauli principle effects are described. The choice of kinematics for πN collisions in the deuteron is settled by appeal to experiment.

The connection between multiple scattering theory at low energy and the Glauber approximation is outlined briefly. A new measurement of the scattering length, from the strong interaction shift of the ground state in the mesic atom, agrees with πN scattering lengths and multiple scattering theory.

The status of charge independence and Coulomb barrier effects is mentioned. Finally, the backward peak in elastic scattering is discussed.

THE INTERACTION OF 48 MeV π^+ WITH DEUTERONS

D. Axen, G. Deusdieker, L. Felawka, Q. Ingram, R. Johnson, G. Jones, D. LePatourel, M. Salomon, and W. Westlund, University of British Columbia, and L. Robertson, University of Victoria, British Columbia, Canada.

The interaction of 47.7 MeV π^+ with deuterons was measured with a system energy resolution of 2 MeV over an angular range of 22.5 to 157.5 degrees to a statistical accuracy of about 6%. The pion scattering results are compared to treatments based on impulse approximation.

π^+P Elastic Scattering At 48 MeV

E.G. Auld, D. Axen, J. Beveridge, G. Duesdieker, L. Felawka, C.H.Q. Ingram, R.R. Johnson, G. Jones, D. LePatourel, R. Orth, M. Salomon, W. Westlund, University of British Columbia and L.P. Robertson, University of Victoria.

The differential cross-section for the elastic scattering of 47.9 MeV positive pions by protons has been measured over the angular range from 30° to 170°. The three isospin triplet phase shifts extracted from these data using a relativistic coulomb amplitude, $S_3 = -4.65^\circ \pm .45$, $P_{31} = -.53^\circ \pm .19$, $P_{33} = 5.07^\circ \pm .29$, are consistent with phase shift obtained from data at higher energy.

"SOME THEORETICAL ASPECTS OF LOW ENERGY π D SCATTERING"

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The fundamental importance of the π D system has been realised for many years. Its significance for multiple scattering theory is twofold. First, the π N interaction is relatively weak at low energy, which means that "the" multiple scattering series should converge. Second, because this is a three-body system, it is amenable to essentially exact solution (in spite of the notorious double counting problems). Thus, one should be able to compare the various multiple scattering prescriptions with the exact result. There is also considerable interest in the π N interaction itself, both on- and off-energy shell. Once again, the π D system is a very attractive testing ground for our ideas. Finally, one of the most important reasons for building the "meson factories", is the hope that the pion may serve as a new probe of nuclear structure. In this case, one might hope to learn something about the short-range deuteron wave function, or its D-state probability. This review will outline the most recent results in this rapidly growing field. Although the calculation of the π D scattering length will be used as the main example, care will be taken to mention the implications for more complicated nuclei, and higher energy.

UNITARITY CORRECTIONS TO PION-NUCLEUS SCATTERING LENGTHS

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An important contribution to pion-nucleus scattering length calculations comes from off-shell unitarity in the pion-bound-nucleon amplitude. It has not been previously noticed and is in addition to other binding energy corrections. How much this general result affects the pion-deuteron scattering length is seen explicitly by calculating the first term in the Faddeev multiple scattering series.

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*After September 1974, Los Alamos Scientific Laboratory, Los Alamos, N.M. 87544, USA.

Work supported in part by the U.S. Atomic Energy Commission

CORRECTIONS UNITAIRES AUX LONGUEURS DE DIFFUSIONS PION-NOYAUX

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Une contribution importante aux calculs de la longueur de diffusion pion-noyaux provient de l'unitarité hors-couche de l'amplitude pion nucleon lié. Cette contribution qui s'ajoute aux autres corrections pour l'énergie de liaison n'a pas été considérée jusqu'à présent. On peut montrer explicitement comment la longueur de diffusion pion-deuteron est affectée par ce résultat général en calculant le premier terme de la série de diffusion multiple de Faddeev.

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*Après septembre 1974, Los Alamos Scientific Laboratory, Los Alamos. N.M. 87544, USA.

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LONGUEURS DE DIFFUSION π-d, π-τ ET π-^{3}He CALCULEES A PARTIR DES DEPLACEMENTS ET DES LARGEURS DES NIVEAUX DES ATOMES PIONIQUES.

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Nous présentons d'abord une formule empirique pour les déplacements et les largeurs des niveaux des atomes pioniques, qui peut reproduire presque toutes les mesures expérimentales à ce jour. Ensuite, avec cette formule, nous prédisons les déplacements et les largeurs des états des deutérium, tritium et hélium pioniques qui n'ont jamais été mesurés directement. A partir des valeurs trouvées, nous calculons les longueurs de diffusion π-d, π-τ et π-He^3. Les résultats, en unités de μ^{-1}, sont $- 0.059 + 0.017\ i$, $-0.205 + 0.020i$ et $0.048 + 0.025i$.

SCATTERING LENGTHS OF π-d, π-τ AND π-^{3}He DERIVED FROM ENERGY LEVEL SHIFTS AND WIDTHS OF PIONIC ATOMS

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We present first an empirical formula for energy level shifts and widths of pionic atoms which can reproduce almost all experimental data up to date, and then with this formula, we predict energy level shifts and widths for pionic deuterium, tritium and helium which have never been measured directly. With these predicted values, scattering length of π-d, π-τ and π-^{3}He were calculated. The results are $- 0.059 + 0.017\ i$, $- 0.205 + 0.020i$ and $0.048 + 0.025\ i$ in unit of μ^{-1}, respectively.

Measurement of the 0° Neutron Spectrum from the Reaction $pp \rightarrow np\pi^+$ at T_p= 766 MeV.

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Using our recently developed medium energy neutron spectrometer[1] at the Nucleon Physics Laboratory at LAMPF, we have measured the 0° neutron spectrum above 80 MeV from the reaction $pp \rightarrow np\pi^+$ at an incident proton energy of 766 MeV. The instrumental resolution of the neutron momentum determination was less than 15 MeV/c. The spectrum exhibits a striking peak which preliminary examination reveals to be at a momentum of 970 MeV/c with a FWHM of 220 MeV/c, corresponding to an invariant mass in the $(p\pi^+)$ system of 1212 MeV and width of 84 MeV. Calculations are underway in an attempt to explain the observed spectrum.

*Supported in part by the U.S. Atomic Energy Commission.

[1]D. WERREN et al., LASL Report LA-5396-MS (1973).

NON-ADDITIVITE DES DEPHASAGES ET LA DIFFUSION PION-NOYAU A MOYENNE ENERGIE

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On étudie les corrections à l'approximation eikonale à moyenne énergie, dues à non-additivité des déphasages. En utilisent la théorie de la diffusion multiple avec le potentiel local et reposant sur l'approximation proposée dernièrement par les auteurs presents on calcule l'amplitude de la diffusion π -noyau vers l'avant. Ce calcul est comparé avec les prédictions du model de Glauber et avec l expansion eikonale en premier ordre. Le prolongement hors-couche de l'amplitude π -nucleon est uniquement determiné, etant en accord avec la théorie de la diffusion potentielle.

NON-ADDITIVITY OF PHASE SHIFTS AND THE PION-NUCLEUS SCATTERING AT MEDIUM ENERGIES

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We analyse the corrections to the eikonal approximation at medium energies, coming from the non-additivity of phase shifts. In the framework of the multiple scattering theory with the local potential, using the approximation recently proposed by the present authors we calculate the pion-nucleus forward scattering amplitude and compare it with the predictions of the Glauber model and with the first order eikonal expansion ; The off-shell continuation of the π -nucleon amplitudes is uniquely determined and consistent with the potential scattering theory.

CORRELATIONS NUCLEON-NUCLEON ET L'INTERACTION PION-NOYAU

L.S. Celenza, L.C. Liu et C.M. Shakin

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Nous étudions la diffusion des pions sur une paire de nucléons en corrélation en utilisant une théorie covariante développée récemment pour la diffusion pion-noyau. Dans cette théorie les effets hors-couche provenant des corrélations peut être traités sans ambiguité. Nous montrons que ces effets, absents dans l'approximation à diffuseur fixe, exigent la connaissance de l'amplitude de diffusion fondamentale pion-nucléon dans des régions où cette amplitude ne peut pas être parametrisée facilement à partir des résultats expérimentaux. En conclusion, pour obtenir une estimation valable des effets de corrélation dans l'interaction pion-noyau, l'aspect hors-couche de la dynamique du problème devra être examiné avec grande attention.

NUCLEON-NUCLEON CORRELATIONS AND THE PION-NUCLEUS INTERACTION

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The scattering of pions from a correlated pair of nucleons is studied in a recently proposed covariant theory for pion-nucleus scattering. In this theory the off-shell effects arising from the correlations can be treated unambiguously. It is shown that these effects, absent in a fixed-scatterer approximation, require knowledge of the fundamental pion-nucleon scattering amplitude in regions which are not readily parametrized using on-shell scattering data. We conclude that any reliable estimate of correlation effects in pion-nucleus interaction requires that serious consideration be given to the off-shell aspects of the dynamics.

OPTICAL MODEL ANALYSIS OF PION ELASTIC SCATTERING BY ^{3}He

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Joint Institute for Nuclear Research, Dubna, USSR

In the framework of the multiple scattering theory, the first order optical potential was derived. The potential contains spin and isospin dependent terms and terms arising due to the inclusion of the Fermi motion as well. Pion elastic cross sections were calculated for ^{3}He nucleus, using this optical model, at energies 97 and 154 MeV. Especially for π^+ mesons reactions, good qualitative agreement was found between experimental and theoretical cross sections. Different behaviour of π^+ and π^- elastic cross sections was explained.

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L'ANALYSE DE LA DIFFUSION ELASTIQUE DES PIONS SUR ^{3}He EN UTILISANT LE MODELE OPTIQUE

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Le potentiel optique en premier ordre a été déduit en utilisant la théorie de la diffusion multiple. Le potentiel contient des termes dépendants du spin et de l'isospin et un autre terme quis apparaît si l'on introduit le mouvement Fermi. Les sections efficaces pour la diffusion élastique des pions sur les noyaux ^{3}He en utilisant le modèle optique ont été calculées pour les énergies de 97 et 154 MeV. Surtout pour les réactions des mésons π^+ il y a un accord satisfaisant entre les sections efficaces théorique et les données expérimentales. On a expliqué le comportament différent des sections efficaces élas - tique π^+ et π^-.

RELATIVISTIC THREE-BODY MODEL OF π-d SCATTERING

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A relativistic generalization of the author's three-body boundary-condition formalism has been applied to π-d elastic scattering. The present calculation considers the $\ell = 1$, $J = 2$ state, ignoring the P_{31} π-N interaction and the d-state of the deuteron. In the spin-independent approximation the result may be identified as the π-d p-wave amplitude. The input is essentially the "exact" N-N and π-N phase-shifts. The results indicate that the corresponding π-d phase-shift is quite small, the "resonance" arising from a rapid increase in inelasticity below the NΔ threshold. Although single scattering dominates, the convergence of the multiple-scattering series is rather slow.

[+] Alfred P. Sloan Foundation Fellow.

IV

RADIATION DE FREINAGE NUCLEAIRE. INTERACTIONS SUR COUCHE ET HORS COUCHE D'ENERGIE

NUCLEAR BREMSSTRAHLUNG. ON-SHELL AND OFF-SHELL INTERACTIONS

Nuclear Bremsstrahlung from Few Body Systems

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A review will be given of the experimental and theoretical situation for the bremsstrahlung emitted in the scatterings $d + p$, $p + \alpha$, $He^3 + \alpha$ and $\alpha + \alpha$. The effect of resonances in the compound system will be discussed. In particular for $\alpha - \alpha$ bremsstrahlung it is shown how the bremsstrahlung cross section can be used to measure the B(E2) between the low lying levels of ^8Be.

Two possible applications of nuclear bremsstrahlung as a tool for studying nuclear reactions will be discussed. In one, the aim is to measure the time of the reaction and so determine whether the reaction is compound or direct. In the other, the aim is to distinguish between different microscopic models for elastic scattering by studying the corresponding bremsstrahlung processes.

DEUTERONS FROM THE ELECTRODISINTEGRATION OF ^3He

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The two body electrodisintegration process of ^3He has been studied at incident electron energies of 46, 73 and 103 MeV. Doubly differential cross sections for deuterons $d^2\sigma/d\Omega dE_d$ at fixed angles and fixed energies have been measured. The results have been compared with a theoretical calculation using the Irving-Gunn wave function for the ground state and a plane wave for the final state. The comparison showed reasonable agreement similar to the photodisintegration process.

DEUTÉRONS PROVENANT D' ÉLECTRODÉSINTÉGRATION DE L' ^3He

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Le processus d' électrodésintégration en deux corps de l' ^3He a été étudié pour des énergies de l'électron incident de 46, 73 et 103 MeV. La section efficace différentielle $d^2\sigma/d\Omega dE_d$ pour deutérons à angles et à énergies fixes a été mesurée. Les résultats ont été comparés avec le calcul théorique utilisant la fonction d'onde Irving-Gunn pour l'état fondamental et une onde plane pour l'état final. La comparaison a montré un accord raisonnable semblable à celui du processus de photodésintégration.

* Work supported in part by the Atomic Energy Control Board of Canada

RADIATION DE FREINAGE DANS L'INTERACTION p-p à 6.92 MeV

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La radiation de freinage nucléaire a été mesurée à 6.92 MeV d'énergie dans le système du laboratoire à $\theta_L = 3^o$, dans la géométrie d'Harvard. Le résultat expérimental est une section efficace $d^2\sigma/dEd\Omega = 1.7 \pm 0.7$ µb sr^{-2}, corrigée par non-coplanarité. Ce résultat se compare assez bien avec certains calculs de Dahlblom et Green donnant une section efficace de 1.7 µb sr^{-2}, et avec le résultat du calcul avec une formule due à Signell et valide pour les basses energies.

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BREMSSTRAHLUNG IN THE p-p INTERACTION AT 6.92 MeV

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The nuclear bremsstrahlung has been measured at 6.92 MeV Lab at $\theta_L = 38^o$ in the Harvard geometry. The experimental result is a cross section $d^2\sigma/dEd\Omega = 1.7 \pm 0.7$ µbsr^{-2}, corrected for non-coplanarity. This result compares reasonably well with theoretical calculations by Dahlblom and Green, which gave 1.1 µbsr^{-2}, and also with an estimate using a formula due to Signell for low energies.

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CONTRAINTES HORS-COUCHE PROVENANT DE LA SYMETRIE DE CHARGE DES FORCES NUCLEAIRES

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Une famille de potentiels équivalents proton-proton est construite à partir du potentiel de Reid à coeur mou. Ces potentiels sont obtenus par modification du comportement hors-couche mais reproduisent les données expérimentales proton-proton. Cependant, la plupart d'entre eux ne rendent pas compte de la longueur de diffusion neutron-neutron ^1S_o et doivent donc être rejetés si la symétrie de charge est imposée. Une règle simple est donnée permetant d'effectuer des modifications du comportement hors-couche du potentiel compatible avec la symétrie de charge.

THE CHARGE SYMMETRY OF THE NUCLEAR FORCE AS OFF-SHELL CONSTRAINT

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Equivalent proton-proton potentials are generated. They are obtained from the Reid soft-core potential by off-shell changes which preserve the fit to the proton-proton data exactly. Most of the potentials are, however, unable to account for the experimental ^1S_o neutron-neutron scattering length. They therefore have to be discarded, if charge symmetry is required to hold. A simple rule is given, how off-shell changes consistent with charge symmetry can be performed.

BREMSSTRAHLUNG FROM LOW ENERGY PROTON-PROTON SCATTERING

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The p-p Bremsstrahlung cross sections were measured at 11 and 13 MeV using the equal angle Harvard geometry with $\theta_{lab} = 30^o$. Both values lie significantly below the exact nonrelativistic Hamada-Johnston potential model calculations and the predictions of the model independent Feshbach-Yennie approximation.

LA RADIATION DU NOYAU PROJECTILE DANS LES ÉNERGIES RELATIVISTIQUES

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La radiation de freinage de coupes transversales a été calculée en utilisant un modèle optique potentiel dans la théorie de Glauber à décrire la interaction nucléaire. La radiation de freinage est faite à premier ordre en e, dans une calculation relativistique de mesure invariante. L'échange des mesons scalairs ou pseudoscalairs dans l'amplitude nucléaire aboutit à tres petites différences de la radiation de freinage de coupe transversale. La radiation ressemble le patron du dipole classique changé relativistiquement pour 200 à 800 MeV protons sur le carbon. La plus grande coupe transversale coplanar se trouve quand l'angle gamma est égal à un demi-angle éparpillé du proton.

PROJECTILE NUCLEUS BREMSSTRAHLUNG AT RELATIVISTIC ENERGIES

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Bremsstrahlung cross sections have been calculated using an optical model potential in Glauber theory to describe the nuclear interaction. The bremsstrahlung is done to first order in e, in a relativistic, gauge invariant calculation. Assuming exchange of scalar or pseudo-scalar mesons in the nuclear amplitude results in very small differences in the bremsstrahlung cross section. The radiation resembles a relativistically shifted classical dipole pattern for 200 to 800 MeV protons on carbon. The maximum coplanar cross section found is when the gamma angle is one half the proton scattering angle.

V

INTERACTIONS A L'ETAT FINAL

FINAL-STATE INTERACTIONS

LA REACTION $^{9}Be+^{3}He \rightarrow \alpha+\alpha+\alpha$ ET LE NIVEAU D'ENERGIE DU ^{12}C VERS 33.5 MeV D'EXCITATION.

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A l'aide de la réaction $^{9}Be(^{3}He, \alpha)\ ^{8}Be^{*}$, il est possible d'atteindre cette énergie en supposant la formation d'un noyau composé de ^{12}C, quand des ^{3}He d'énergie 9.44 MeV et 9.94 MeV sont envoyés sur du ^{9}Be, c'est-à-dire qu'on peut traverser un niveau de ^{12}C prévu à 33.5 MeV. Deux alphas de l'état final sont détectés de manière à déterminer entièrement la cinématique de la réaction. En supposant un mécanisme séquentiel pour les calculs théoriques, une formule de section efficace a été obtenue précédemment pour des réactions analogues. En utilisant cette expression avec différentes valeurs de J^{π} pour le spin et la parité du noyau composé de ^{12}C, il a été possible de reproduire les spectres expérimentaux pour certaines valeurs de J^{π}.

THE $^{9}Be+^{3}He \rightarrow \alpha+\alpha+\alpha$ REACTION AND THE ENERGY LEVELS OF ^{12}C AROUND 33.5 MeV EXCITATION

The reaction $^{9}Be(^{3}He,\alpha)^{8}Be^{*}$ at 9.44 and 9.94 MeV laboratory energy of ^{3}He projectiles allows to cover the 33.5 MeV energy level. Two final state alphas are detected and thus the kinematics is unique for the three alpha system. A theoretical formulation for the cross-section was derived in previous work assuming a sequential process for analogous reactions. Using the resulting expression with different values of J^{π}, spin and parity of the ^{12}C compound nucleus, it was possible to reproduce the experimental spectra with some values of J^{π}, excluding definitely others.

UNE ÉPREUVE TREIMAN-YANG DE LA REACTION D+P→P+P+N A L'ENERGIE DE 12.2MeV

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La reaction $^{1}H(d,pn)p$ était examiné en case du point de l'exchange nucleaire de la diffusion quasi-libre. Une épreuve Treiman-Yang avait fait a l'energie du deuteron de 12.2MeV. a basse vitesse du particle de l'exchange. Les resultats correspondants avec les angles TY, $\varepsilon = 0^{o}$, 40^{o}, 58^{o}, 108^{o}, 132^{o}, s'accordent avec la criterion Treiman-Yang.

A TREIMAN-YANG TEST FOR THE D+P→P+P+N REACTION AT 12.2MeV

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The $^{1}H(d,pn)p$ reaction was examined for dominance of the nucleon exchange pole in the vicinity of the kinematic region for quasi-free scattering. A Treiman-Yang test was carried out at an incident deuteron energy of 12.2MeV. and at low momentum transfer. The results, corresponding to TY-angles, $\varepsilon = 0^{o}$, 40^{o}, 58^{o}, 85^{o}, 108^{o}, 132^{o}, were found to satisfy the TY-criterion.

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LA CAPTURE DE μ^--MESONS PAR LES NOYAUS DE ^{4}He

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On etudie l'emission du neutron dans la capture de μ^--mesons polarisés par les noyaux dans la reaction du type ^{4}H $(\mu^-, n\nu)^3$H. On recherche le spectre énergetique des neutrons et l'asymmetrie des distributions angulaires des neutrons. L'interaction dans l'etat final est decrite à l'aide du modèle optique. Il est montré que les résultats quantitatifs sont sensibles aux formes des fonctions d'ondes qui décrivent le mouvement du neutron et du noyau de reoul.

MUON CAPTURE IN ^{4}He

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The neutron emission in polarized muon capture by ^{4}He is considered. The capture rate, neutron energy spectrum and asymmetry of angular distribution are calculated for the reaction ^{4}He $(\mu^-, n\nu)^3$H. The final state interaction is described by the optical potential deduced from the analyses of data on scattering experiment. The quantitative results are shown to be sensitive to the form of the potential.

CASSURE DU DEUTERON DANS LA REACTION n + D⟶n + p + n

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Une étude du spectre des protons issus de la réaction n + D⟶n + p + n a été réalisée pour une énergie des neutrons incidents de 14,1 MeV et un angle moyen de détection $\langle\theta\rangle = 3°$.

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BREAK UP OF DEUTERON IN THE REACTION n + D⟶n + p + n

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A study of the protons spectrum produced by the n + D⟶n + p + n reaction has been done with 14.10 MeV energy incident neutrons and a mean detection angle of $\langle\theta\rangle = 3°$.

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PAULI REPULSIVE CORE IN α+α SCATTERING

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A repulsive core is introduced into the α+α effective interaction potential. This core represents reasonably well effects which would arise from antisymmetrization between the two α clusters. The strength and shape of this core are determined from a requirement on the α+α relative motion at small distances. A folded, attractive potential is combined with this repulsive core to yield a good fit to the α+α phase shifts from 2 to 15 MeV (c.m.). This type of α+α potential should be quite useful in considering α cluster models of nuclei, and the general ideas associated with the construction of the repulsive core should be applicable to other systems.

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FINAL STATE INTERACTIONS IN MUON CAPTURE BY DEUTERONS

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We examine the final-state interaction (FSI) effects in $\mu^- + d \to n + n + \nu$. In the final state only the ^1S_o state is corrected for the FSI, since we assume all higher partial waves are non-interacting. A set of ^1S_o n-n wave-functions is derived from four-parameter Bargmann potentials. The corresponding phase shifts change sign between 200 MeV and 300 MeV. We take into account the D-state of the deuteron and relativistic corrections. We found that the numerical integrations involved in computing the capture rates are sensitive to the number and distribution of the sample points. Our results show that the FSI effect increases the capture rates by roughly 12%. We find $\Gamma_{1/2} = 374.5 \pm 1.1\ \text{sec}^{-1}$, $\Gamma_{3/2} = 8.44 \pm 0.02\ \text{sec}^{-1}$, and $\Gamma = 130.6 \pm 0.4\ \text{sec}^{-1}$ for a pseudoscalar coupling constant $g_p = -8.54$. Here the uncertainty shows how the capture rate varies over our set of ^1S_o wave-function models. Similarly for $g_p = -10.27$, we find $\Gamma_{1/2} = 361.5 \pm 1.0\ \text{sec}^{-1}$, $\Gamma_{3/2} = 10.02 \pm 0.02\ \text{sec}^{-1}$, and $\Gamma = 127.25 \pm 0.30\ \text{sec}^{-1}$. We calculate the neutron spectrum $d\Gamma_{1/2}/dE_n$ also. An investigation of the effects of unitarily transformed wave-functions is underway. The ^1S_o contribution to $\Gamma_{1/2}$ is $232\ \text{sec}^{-1}$ for the untransformed model and $156\ \text{sec}^{-1}$ with a transformed model.

* On sabbatical leave from Département de Physique, Université Laval, Québec.

AN APPLICATION OF THE CLUSTER MODEL REACTION THEORY TO THE d(α,α)n p BREAK UP PROCESS

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The ^{6}Li scattering system has been described in the framework of the cluster model reaction theory. Under the assumption of sequential decay, cross sections for the d(α,α)n p process have been calculated. The comparison of the theoretical results with recent experimental data shows good agreement for those kinematical situations, where the sequential decay mechanism is the dominant factor.

The n-p FSI Angular Distribution in Deuteron Breakup at 23 MeV

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The n-p final state interaction was studied as a function of angle. The results are compared with calculations using potentials that differ in their on-shell behavior only, or in their off-shell behavior only. It is concluded that further study of final state angular distributions can lead to improved knowledge of nuclear off-shell effects.

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INTERACTION DANS L'ETAT FINAL DANS LES REACTIONS A TROIS NUCLEONS A 156 MeV

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L'étude simultanée des réactions D (p, 2p) n et D (p, pn)p effectuée à Orsay en utilisant le faisceau de protons de 156 MeV confirme l'existence des interactions dans l'état final p-n et p-p pour leur énergie relative presque zéro. Les sections efficaces différentielles expérimentales de ces interactions dans l'état final p-n et p-p sont interprétées par certains calculs théoriques dans le cadre de l'approximation des équations de Faddeev.

FINAL STATE INTERACTION IN THREE NUCLEON REACTIONS

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The simultaneous investigation of the D (p, 2p) n and D (p, pn) p reactions effectedat Orsay using the 156 MeV proton beam and a liquid target confirms the existence of p-n and p-p final state interaction for their relative energy almost zero. The experimental differential cross-sections of such final state interactions are compared with various theoretical predictions in the frame of approximate solutions of Faddeev equations.

Quasifree and Final State Processes in $^4He + {}^3H$ at $E_{^4He} = 70$ MeV

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A 70 MeV α-beam bombarded a ^3H-Ti self-supporting target, and kinematically complete data were obtained for the $^4He + {}^3H$ reactions to final state systems with at least two charged particles. The spectral data are frequently dominated by final state interaction structure, but some quasifree enhancements have been observed. The reaction $^3H(\alpha,\alpha d)n$ has a pronounced quasifree scattering enhancement. These data are analyzed in the PWIA in the same manner as described previously, and the square of the momentum form of the wave function is extracted for the quasifree reactions. FSI spectral structure is observed from the reactions $^3H(\alpha,\alpha d)n$, $^3H(\alpha,\alpha p)2n$, $^3H(\alpha,tt)p$, $^3H(\alpha,ht)n$, $^3H(\alpha,dd)t$, $^3H(\alpha,dt)d$, and $^3H(\alpha,pt)t$.

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Overlapping FSI and QFS in N-d Break-up

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Consideration of N-d break-up kinematics shows that it is possible for one N-N pair to be in their final-state interaction (fsi) region while another pair is in their quasi-free scattering (qfs) region. This overlap of two dominant processes is unavoidable for example in the usual forward p spectra from d(n,p)2n. Clearly then to analyse the n-n fsi we need to understand both fsi and qfs. Recently general theories for both these processes were formulated. Combining these theories in the simplest way we analyse the overlap and construct a simple wave function description. We also obtain a corresponding simple expression for forward N-d elastic scattering. These results explain significant features of both the observed n-n fsi peak and forward N-d elastic scattering.

INTERACTION FINALE DANS LA DECOMPOSITION DE $^{6}He^{*}$(1.80 MeV)

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Le mode de désintégration du premier niveau excité de ^{6}He a été étudié par la réaction $^{7}Li(t,\alpha_1)^{6}He^{*}$ (1.80 MeV) à E_t = 2.4 MeV . Le spectre de coincidence entre les particules α_1 et celles provenant de la décomposition $^{6}He \rightarrow \alpha + 2n$ a été lissé par une somme de polynômes d'ordre 4. L'intéraction finale neutron - neutron avec une longueur de diffusion a_{nn} = -16 fm ne permet d'expliquer que 70% des évènements, les autres étant attribués au passage par ^{5}He .

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FINAL STATE INTERACTION IN THE DECAY OF $^{6}He^{*}$(1.80 MeV)

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The decay mode of the first excited state of ^{6}He was studied with the $^{7}Li(t,\alpha_1)^{6}He^{*}$(1.80 MeV) reaction at E_t = 2.4 MeV . The spectrum of α_1 particles in coincidence with α particles from the $^{6}He \rightarrow \alpha + 2n$ decay was fitted with a sum of polynomials of order 4. The neutron - neutron final state interaction with a diffusion length a_{nn} = -16 fm accounts for 70% of the events, the rest being attributed to a sequential decay trough ^{5}He .

* On leave from University of Leningrad (U.R.S.S.)

RESONANCE ANALYSIS OF THE ^{3}Hpp 3-BODY FINAL STATE

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AECL, Chalk River, Ontario, and R.E. Warner, Oberlin
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Three-body final state interaction studies have been carried out using the Chalk River MP tandem accelerator with the reaction ^{2}H(^{3}He,^{3}Hp)p at incident ^{3}He energies of 26 and 36 MeV. The experiments were kinematically complete and data have been obtained at several geometries where the ^{3}H - p FSI could be observed at small relative energies. Peaks were observed in the yields that corresponded to a resonance in the ^{4}He compound nucleus. The data have been analyzed by a modification of the Watson-Migdal theory in which the effective range approximation is replaced by an R-matrix s-wave resonant scattering amplitude. The resonance energy and reduced width in the CM system, obtained from a least squares fit, are E_1 = 114 ± 30 keV and γ_1^2 = 250 ± 80 keV, corresponding to an excitation energy of 19.93 MeV in ^{4}He.

ANALYSE DE LA RESONANCE DE L'ETAT FINAL A 3 CORPS DE ^{3}Hpp

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College, Oberlin, Ohio.

Nous avons étudié l'intéraction de l'état final à 3 corps par la réaction ^{2}H(^{3}He,^{3}Hp)p à des énergies de faisceau incident de ^{3}He de 26 et 36 MeV délivré par l'accélérateur MP Tandem de Chalk River. Les expériences étaient cinématiquement complètes et les résultats ont été obtenus à différentes géométries où l'intéraction de l'état final ^{3}H-p pouvait être observée à des énergies relatives petites. Des pics apparaissent dans les courbes de rendement et correspondent à une résonance dans le noyau composé ^{4}He. Les donneés ont été analysées dans le cadre de la théorie de Watson-Migdal dans laquelle l'approximation de portée effective est remplacée par une amplitude de diffusion résonante de la matrice R (ondes-s). L'énergie de la résonance, E_1 = 114 ± 30 keV et la largeur réduite (dans le systéme du centre de masse), γ_1^2 = 250 ± 80 keV sont obtenues par un ajustement en chi-2 et correspondent à une énergie d'excitation dans ^{4}He de 19.93 MeV.

$^{9}Be(\tau,\alpha)\alpha\alpha$ ET $^{10}B(d,\alpha)\alpha\alpha$: MECANISME DE REACTION ET LARGEUR DES ETATS DU ^{8}Be.

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Les spectres continus ont été mesurés à plusieurs énergies au dessous de 10 MeV dans le système du laboratoire. Son analyse a été faite avec un formalisme adéquat pour un système à trois corps dans l'état final. Les distributions angulaires trouvées pour l'état fondamental et le premier état excité du ^{8}Be ont été analysés dans le cadre des théories de transfert direct dans l'approximation de Born à l'aide des ondes distordues (DWBA). L'accord entre la théorie et l'expérience est satisfaisant du point de vue de la forme des distributions angulaires, mais la normalisation est inadéquate. Dans le cas du premier état excité du ^{8}Be, les calculs pour les deux réactions prédisent une variation observable de la largeur apparente de cet état non-lié, approximativement 6% à 90^{o} dans le système du centre de masse.

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$^{9}Be(\tau,\alpha)\alpha\alpha$ AND $^{10}B(d,\alpha)\alpha\alpha$: REACTION MECHANISM AND WIDTH OF ^{8}Be STATES.

The continuous spectra have been measured at several energies below 10 MeV in the Laboratory system. The analysis has been made with a formalism adequate for a three body system in the final state. The angular distributions for the ground state and for the first excited state of ^{8}Be have been analysed in the frame of direct reaction theories using distorded waves (DWBA). The agreement between theory and experiment is satisfactory from the point of view of the shape of the angular distributions, but the normalization is inadequate. For the first excited state of ^{8}Be the calculations for both reactions predict a measurable variation of the width: approximately 6% at 90^{o} in the centre-of-mass system.

UNE RECHERCHE SUR LA DESINTEGRATION BETA DU DIPROTON DANS $^{3}He(\tau, {}^{2}He)^{4}He$

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La réaction $p + p \rightarrow {}^{2}H + e^{+} + \nu$ a lieu dans les étoiles à des énergies cinétiques très basses, et sa section efficace est très faible. Dans cette recherche on a généré un nombre considérable de paires p - p en intéraction nucléaire ou ^{2}He par la réaction d'un faisceau d'$^{3}He^{++}$ à 12.56 MeV sur une cible gazeuse d'^{3}He, et on a cherché les deutons d'énergie élevée produits par la désintégration bêta du diproton. Deux groupes de particules satisfaisant aux critères d'identification des deutons ont été observés à des énergies proches de celles recherchées. Les sections efficaces sont très basses, dans l'ordre du nanobarn. Néanmoins la plupart des mesures semblent correspondre à la cinématique d'un système de masse 1 + 5.

A SEARCH ON THE BETA-DECAY OF THE DIPROTON IN $^{3}He(\tau, {}^{2}He)^{4}He$

The reaction $p + p \rightarrow {}^{2}H + e^{+} + \nu$ takes place in stars at very low kinetic energies, and its cross section is very low. Here we have produced a considerable number of p - p pairs or ^{2}He systems in nuclear interaction through the reaction of a $^{3}He^{++}$ beam at 12.56 MeV on a gaseous ^{3}He target, and we have searched for deuterons at high energies produced by the beta decay. Two groups of particles were found satisfying the criteria of identification of deuterons at energies close to those searched for. The cross sections are very low, in the order of nanobarns. Nevertheless the kinematics seems to imply that in their majority they belong to a system of mass 1 + 5.

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Calculations of Pion Deuteron Break-up at Low Energies

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and

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We have made calculations of differential cross sections for the $\pi d \to \pi pn$ process at energies below the 3-3 resonance. The calculations take into account the fermi motion dependence of the pion nucleon amplitudes and the final state interaction of the two nucleons. The resonant character of the P.33 amplitude is used to define its off-energy-shell extension. We have also examined the effects of kinematical ambiguities present in the definition of the relative meson-nucleon energy.

Our results are compared to the experimental measurements of pion deuteron cross sections at 85 MeV and 142 MeV.

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Calculs concernant la Dissociation Pion Deuteron à Energies Faibles

Nous avons calculé les sections efficaces différentielles pour le precessus $\pi d \to \pi pn$ à des énergies en-dessous de le résonance 3-3. Les calculs prenent en considération le fait que les amplitudes pion nucleon dépendent du mouvement de Fermi et l'interaction des deux nucleons dans l'état final. Le caractère résonant de l'amplitude P.33 est utilisé pour définir son extension en dehors de la couche d'énergie. Nous avons aussi étudié les effets des ambiguités cinématiques présentes dans la définition de l'énergie rélative meson-nucleon.

Nos results sont comparés avec les mesures expérimentales concernant les sections efficaces pion deuteron à 85 MeV et 142 MeV.

LA REACTION $^{3}He(\tau,\alpha)2p$ ET LA DETERMINATION DE LA LONGUEUR DE DIFFUSSION p-p.

Maria L. V. Ligatto de Slobodrian, Université Laval, Laboratoire de Physique Nucléaire, Département de Physique, Québec G1K 7P4, Canada.

Les spectres des particules alpha dans la réaction $^{3}He(\tau,\alpha)2p$ à 43.7 et 53 MeV ont été calculés dans le contexte de la théorie des intéractions à l'état final. On a confirmé que les résultats expérimentaux sont bien reproduits en utilisant la somme incohérente des intéractions p-p et p-α(^{5}Li). On montre que, par ailleurs les particules alpha provenant de l'état fondamental du ^{5}Li sont présents dans les spectres des particules alpha, même dans la région du pic dû à l'intéraction p-p. L'omission de la contribution du ^{5}Li(p-α), introduit une erreur dans le calcul de la longueur de diffussion de l'intéraction p-p d'au moins .2fm.

THE REACTION $^{3}He(\tau,\alpha)2p$ AND THE DETERMINATION OF THE PROTON-PROTON SCATTERING LENGTH.

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The spectra of alpha particles for the reaction $^{3}He(\tau,\alpha)2p$ at 43.7 and 53 MeV have been calculated in the framework of the theory of the final state interactions . The results confirm that the experimental data are well reproduced taking only into account the incoherent p-p and p-α(^{5}Li) interactions. Moreover, the α particles from the decay of the ground state of ^{5}Li are shown to be present throughout the α-particle spectra, even in the region of the p-p enhancement peak. The usual neglect of such fact introduces an error in the calculation of the p-p scattering length of at least .2fm.

P-P Final State Interaction in the $^2H(p,pn)p$ Reaction

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The production of a p-p final state interaction from the reaction $^2H(p,pn)p$ was measured at 22.1, 35.7, and 41.1 MeV. A coincidence measurement at a single pair of angles was performed, where the neutron counter was kept fixed at 70^o, and the proton counter was adjusted to allow the protons to interact at minimal energy. A comparison with similar data on the n-p final state interaction is presented.

L'Interaction p-p à L'Etat Final Suivant la Réaction $^2H(p,pn)pp$

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On a mesuré, aux énergies incidentes de 22.1, 35.7, et 41.1 MeV, les effets d'une interaction a l'état final entre les deux protons produits dans la réaction $^2H(p,pn)p$. On à détecté le neutron et un des protons en se servant d'un détecteur des neutrons fixé à 70^o et d'un détecteur des protons placé successivement à des angles choisis à fin que les deux protons interaquissent à des petites energies relatives. Les résultats obtenus sont comparés aux resultats d'une expérience analogue pour L'interaction p-n.

DOUBLE-FINAL STATE INTERACTIONS IN THE $^2H(^2H,pp)nn$ REACTION

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and G.C. Ball, W.G. Davies, A.J. Ferguson and J.S. Forster, AECL, Chalk River Nuclear Laboratories, Chalk River, Ontario, Canada KOJ 1JO

The 2p + 2n four-body final state of the $^2H(^2H,pp)nn$ reaction has been studied under conditions where the p-p and n-n pairs both emerge with low relative energies ε_{pp} and ε_{nn}. A CD_2 target was bombarded with 23.2 MeV deuterons from the upgraded Chalk River MP tandem accelerator and p-p coincidences were recorded between two independent counter telescopes at geometries of ($\theta_1 = +18^\circ$, $\theta_2 = +36^\circ$) and(25°, 43°). An enhancement relative to phase space at low ε_{nn} and a depression at low ε_{pp} were observed at both geometries. Theoretical calculations that included phase space times Watson-Migdal factors, using accepted values of the effective range parameters for the singlet p-p and n-n interaction, give reasonably good fits to the data for $\varepsilon_{nn} < 4$ MeV and $\varepsilon_{pp} < 1.5$ MeV. Calculations using an antisymmetrized DWBA theory are in progress.

† Research supported by the National Science Foundation

†† NSF Undergraduate Research Participant.

INTERACTIONS DOUBLES DANS L'ETAT FINAL DE LA REACTION $^2H(^2H,pp)nn$

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L'état final à quatre corps 2p + 2n de la réaction $^2H(^2H,pp)nn$ a été étudié sous les conditions où les paires p-p et n-n émergent avec des énergies relatives petites, ε_{pp} et ε_{nn}. Une cible de CD_2 a été bombardée par des deutérons de 23.2 MeV provenant de l'accélerateur MP Tandem de Chalk River; les coincidence p-p ont été détectés par deux ensembles indépendents de compteurs-télescopes correspondant à des géométries de ($\theta_1 = +18^\circ$, $\theta_2 = +36^\circ$) et (25°, 43°). Nous avons observé dans le cas des deux géométries, une augmentation relative à l'espace de phase pour ε_{nn} petit et une diminution pour ε_{pp} petit. Des calculs théoriques renfermant le produit de l'espace de phase par les facteurs de Watson-Migdal en utilisant les valeurs acceptées des paramètres de portée effective pour l'intéraction singlet p-p et n-n, donnent des ajustements raisonnables des valeurs expérimentales pour $\varepsilon_{nn} < 4$ MeV et $\varepsilon_{pp} < 1.5$ MeV. Des calculs utilisant la théorie D.W.B.A. antisymmétrisée sont en cours.

† Research supported by the National Science Foundation

†† NSF Undergraduate Research Participant.

THREE ALPHA BREAKUP OF THE 11.83 MeV STATE OF THE ^{12}C NUCLEUS

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The breakup of the 11.83-MeV state of the ^{12}C nucleus into three alpha particles has been investigated by means of the $^{12}C(n,n)3\alpha$ reaction. The kinematical conditions were such as to avoid the overlap of the competing reaction channels present in previous experiments. From the alpha-alpha correlation spectra the spin and parity of the 11.83 MeV state of the ^{12}C nucleus has been deduced.

LA DÉSINTÉGRATION DU NIVEAU 11.83 MeV DU NOYAU ^{12}C EN TROIS PARTICULES ALPHA

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La désintegration du noyau ^{12}C (niveau 11.83 MeV) en trois particules alpha a été étudiée à l'aide de la réaction $^{12}C(n,n)3\alpha$. Les conditions cinématiques permettent d'éviter les autres voies de sortie présentes dans les expériences précédentes. Le spin et parité du niveau 11.83 MeV ont été extraits des spectres de correlation α-α.

LA SECTION EFFICACE QUADRUPOLAIRE DE LA REACTION $^4He(\gamma,n)^3He$ +

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Nous présentons les résultats obtenus sur le calcul de la section efficace E2 de la réaction $^4He(\gamma,n)^3He$. L'élément de la matrice est calculé en utilisant une méthode dispersive qui tient compte de l'interaction dans les états finaux. Fonctionnes d'onde de Gauss sont utilisées pour l'^4He et l'^3He; nous supposont l'existence d'un état 2^+, T=0 à une énergie d'excitation de ~ 30 MeV, avec une largeur de 3.2 MeV. L'élément de matrice, qui est composé d'une partie isoscalaire et une partie isovectorielle a été calculé en corrégeant, avec une interaction dans les états finaux, la seule partie isoscalaire de l'amplitude. La section efficace obtenue montre une résonance caractéristique en comparaison de la section efficace de Born. Il n'y a pas au moment des résultats expérimentaux.

+ Appuyé en partie par I.N.F.N.

THE ELECTRIC-QUADRUPOLE PART OF THE $^4He(\gamma,n)^3He$ REACTION +

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We have estimated the E2 part of the $^4He(\gamma,n)^3He$ reaction. The exact matrix element is calculated by using a dispersive approach. Gaussian wave functions are assumed for the ^4He and the ^3He nuclei. A 2^+, T=0 state in ^4He at ~ 30 MeV of excitation with a width of 3.2 MeV is supposed to exist. The exact matrix element which takes into account the n-^3He interaction, is composed of an isoscalar and an isovector part, and is corrected, for the final state interactions, the isoscalar amplitude. A characteristic resonating behaviour of the corrected cross section with respect to the Born approximation is obtained. Experimental results are not available up to now with which to compare our curves.

+ Supported in part by I.N.F.N.

INTERACTIONS A L'ETAT FINAL DANS LA CAPTURE DES MUONS PAR LES DEUTONS

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Nous étudions les effets de l'interaction à l'état final dans la réaction $\mu^- + d \to n + n + \nu$. Dans l'état final, seul l'état ^1S_o est corrigé pour ces effets, puisque nous présumons une interaction nulle pour toutes les autres ondes partielles. Un ensemble de fonctions d'onde du type n-n pour l'état ^1S_o est obtenu des potentiels à quatre paramètres du type Bargmann. Les déplacements de phase correspondante changent de signe entre 200 MeV et 300 MeV. Nous tenons compte de l'état D du deuton ainsi que des corrections relativistes. Nous trouvons que les intégrations numériques dans le calcul des taux de capture sont sensibles au nombre et à la distribution des points de l'échantillonnage. Nos résultats montrent que l'effet de l'interaction à l'état final augmentent les taux de capture de 12%, approximativement. Nous obtenons $\Gamma_{1/2} = 374.5 \pm 1.1$ sec^{-1}, $\Gamma_{3/2} = 8.44 \pm 0.02$ sec^{-1}, et $\Gamma = 130.6 \pm 0.4$ sec^{-1} pour une constante de couplage pseudoscalaire $g_p = -8.54$. Les incertitudes indiquées donnent la variation du taux de capture en fonction de nos modèles ^1S_o. De la même façon, pour $g_p = -10.27$, nous trouvons $\Gamma_{1/2} = 361.5 \pm 1.0$ sec^{-1}, $\Gamma_{3/2} = 10.02 \pm 0.02$ sec^{-1}, et $\Gamma = 127.25 \pm 0.30$ sec^{-1}. Nous calculons aussi le spectre de neutrons $d\Gamma_{1/2}/dE_n$. Nous poursuivons actuellement une étude des effets de transformations unitaires sur les fonctions d'onde. La contribution de l'état ^1S_o à $\Gamma_{1/2}$ est de 232 sec^{-1} pour le modèle sans transformation et de 156 sec^{-1} pour le modèle avec transformation.

* En congé sabbatique du Département de Physique, Université Laval, Québec.

THE ^{4}He(d,pα)n REACTION AT LOW ENERGY

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Correlation cross section of the ^{4}He(d,pα)n reaction was measured at E_d = 9.0 MeV, the lowest energy up to now. Strong peaks are observed corresponding to the ground state of ^{5}He. The data are analyzed with the spectator model, the plane wave impulse approximation and the modified off-energy-shell impulse approximation. The N-α final state interaction is shown to play more important a role at lower energy, and the importance of the final n-p interaction or the spin dependent force which are negligible at higher energies, is suggested.

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Neutron Spectra from Proton Bombardment of Deuterium at 647 and 800 MeV. C. BJORK, P. RILEY, U. of Tex.; B. BONNER, J. SIMMONS, K. WILLIAMSON, LASL*; D. WERREN, U. Geneva and SIN; H. BRYANT, C. CASSAPAKIS, S. COHEN, B. DIETERLE, C. LEAVITT, D. WOLFE, U. of New Mex.*; M. EVANS, G. GLASS, J. HIEBERT, MAHAVIR JAIN, L. NORTHCLIFFE, Tex. A&M U.*--Using our recently developed medium energy neutron single arm, dipole magnet, multi-wire proportional chamber spectrometer[1] and liquid deuterium target at the Nucleon Physics Laboratory at LAMPF, we have measured 0° neutron spectra from 647 and 800 MeV proton bombardment of deuterium. The charge exchange peaks in the neutron spectra were measured to be approximately 13 MeV FWHM, which includes our experimental resolution. The integrated peak to valley ratio for the "quasi-elastic" neutrons is about 30:1. Information will be presented on data analysis, flux normalization and theoretical predictions taking into account the final state p-p interaction.

*Supported by the U.S. Atomic Energy Commission.

[1]D. WERREN et al., LASL Report LA-5396-MS (1973).

FINAL STATE INTERACTION IN THREE NUCLEON SYSTEM*

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Vector to vector spin-transfer parameters for slightly inelastic p-d scattering are discussed in the context of recent theoretical and experimental developments.

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INTERACTION A L'ETAT FINAL DANS LE SYSTEME A TROIS NUCLEONS*

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Les paramètres de transfert vectoriel de spin pour la diffusion p-d faiblement inélastique seront discutés dans le contexte de récents développements théoriques et expérimentaux.

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The Watson factorization model and the exact three body theory in the case of neutron-proton final state interaction in the reaction p d → p p n .

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A recently measured angular distribution attributed to the neutron-proton final state interaction at zero relative energy in the reaction p d → p p n with an incident beam of 52 MeV deuterons is analyzed with an exact three-body theory using spindependent separable potentials for relative S-states of two nucleons. This analysis is compared with an earlier analysis by means of a Watson factorization ansatz including singlet and triplet neutron-proton final state interaction.

COMPLETE MEASUREMENTS OF THE DEUTERON BREAKUP BY PROTONS AT E_p=8.5 MeV

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Double-differential cross-sections $d^3\sigma/d\Omega_1 d\Omega_2 dE_1$ for the reaction D(p,2p)n were measured at E_p = 8.5 MeV and for different angular settings. Good precision and resolution were aimed at. Generally experimental points are lying high in comparison with theoretical values calculated by the Ebenhöh three nucleon code with Yamaguchi interaction.

VI

ETATS LIES ET DE DIFFUSION. FORCES A PLUSIEURS CORPS

BOUND AND SCATTERING STATES. FEW-BODY FORCES

CRITERION FOR THE VALIDITY OF THE UNITARY POLE APPROXIMATION AND CALCULATION OF CORRECTION TERMS

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A criterion for the validity of the unitary pole approximation (UPA) is given. Applying it to the Malfliet-Tjon potentials I and III we show the reason why the UPA is successful in this case. Our approach represents also an efficient method for calculating correction terms. It yields results which are in excellent agreement with calculations using the unitary pole expansion.

INFLUENCE OF THE HIGHER PARTIAL WAVES OF LOCAL POTENTIALS ON THREE-NUCLEON OBSERVABLES

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The three-nucleon system for the soft-core potentials of Malfliet and Tjon is investigated by means of the quasiparticle method. One of the advantages of this method is that all the higher partial waves of the two-body potentials are automatically included. The triton binding energy and the scattering of neutrons off deuterons in the doublet channel are calculated in first quasi-Born approximation and compared to other calculations performed recently. It is found that for the above mentioned soft-core potentials the contributions of the higher subsystem partial waves is appreciable but much smaller than for purely attractive Yukawa potentials.

LA FORCE À QUATRE CORPS DANS LA MATIÉRE NUCLÉAIRE

D. W. E. Blatt and R. G. L. Hewitt, Department of Theoretical Physics, University of Sydney, N.S.W. 2006, Australia and B. H. J. McKellar, School of Physics, University of Melbourne, Parkville. Victoria 3052, Australia.

Nous avons calculé la contribution de la force à quatre corps à l'énergie de liaison de la matière nucléaire. La force en question a son origine dans l'échange d'un pion du nucléon 1 avec le nucléon 2, le pion étant dispersé par les nucléons 3 et 4 pendant son trajet. Les corrélations à courte portée entre les quatre nucléons ont été tenu compte en tronquant à courte portée. L'effet de l'échange des nucléons 3 et 4 est aussi inclus. En tronquant à 0,8 fm la contribution à l'énergie est une attraction de 0,06 MeV. Ce resultat est à comparer avec une contribution d'une attraction de 1,3 MeV pour la force à trois corps correspondante.

FOUR BODY FORCES IN NUCLEAR MATTER

D. W. E. Blatt and R. G. L. Hewitt, Department of Theoretical Physics, University of Sydney, N.S.W. 2006, Australia and B. H. J. McKellar, School of Physics, University of Melbourne, Parkville. Victoria 3052, Australia.

We have calculated the contribution of four body forces to the binding energy of nuclear matter. The particular four body force used arises from the exchange of a pion from nucleon 1 to nucleon 2, the pion scattering off 3 and 4 on the way. Short range correlations between all four nucleons were taken into account using a cutoff at short distances. The effect of exchanging the spectator nucleons 3 and 4 is also included. For a cutoff of 0.8 fm the contribution to the energy is 0.06 MeV attraction. This is to be compared with a contribution of 1.3 MeV attraction from the corresponding three body force.

LA VOIE ELASTIQUE $^3He + ^3He$ ET LE MODELE OPTIQUE

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On a abordé l'étude expérimentale de la voie élastique $^3He + ^3He$ comme première étape vers l'interprétation adéquate des voies inélastiques de ce système, par exemple $^3He(^3He,\alpha)2p$ et son miroir $^3H(^3H,\alpha)2n$. Une analyse au moyen d'un modèle optique habituel révèle la nécessité de le modifier pour tenir compte de la structure de l'espace de spin particulier à ce système, et aussi de l'identité du projectile et de la cible.

THE ELASTIC CHANNEL $^3He + ^3He$ AND THE OPTICAL MODEL

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The study of the elastic channel of the $^3He + ^3He$ interaction has been undertaken as a first step for a more adequate interpretation of the inelastic channels of this system, for example $^3He(^3He,\alpha)2p$ and $^3H(^3H,\alpha)2n$, mirror of the former. An optical model analysis along conventional lines has revealed the need of modifying it in order to account for the structure of the spin space proper to this system, and also the identity of the projectile and the target.

The $\frac{1}{2}^+$ Three Nucleon state for a Super Soft-core Potential.

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A variational calculation of the $J = \frac{1}{2}^+$ three nucleon state using the super soft-core potential of Cogny, Pires and de Tourreil is reported. The results for the binding energy and charge form factor minimum are in good agreement with those obtained by Cignoux and Laverne. Whilst the binding energy is in good agreement with experiment, there is a considerable discrepancy between the predictions and experiment for the N - d scattering length and the charge form-factors.

ANALYSE THEORIQUE EN DEPHASAGES DANS LA DIFFUSION ELASTIQUE (n-d)

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Une analyse des déphasages (n-d) entre 3 et 15 MeV a été faite à l'aide d'interactions non locales séparables dans le formalisme de Lovelace incluant un terme tenseur et les ondes P à deux corps. Comparaison est donnée avec les analyses sans couplage de Arvieux et celle de Schmelzbach qui inclut tous les degrés de liberté du problème. Nos résultats sont généralement en bon accord avec l'expérience pour les déphasages quartet. On retrouve la grande sensibilité des observables aux ondes P à 2 corps et on montre l'importance du couplage entre moments orbitaux impairs.

THEORETICAL PHASE-SHIFT ANALYSIS IN THE (n-d) ELASTIC SCATTERING

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A phase shift analysis in the (n-d) elastic scattering between 3 and 15 MeV has been done in the Lovelace formalism with non local separable interactions including a tensor term and the two-body P-waves. Comparison is given with other analyses by Arvieux (neglecting the coupling) and by Schmelzbach including all degrees of freedom. Our results are in general in good agreement with the experimental quartet phase shifts. The strong sensitivity of observables to the 2-body P-waves is refound while is shown of great importance the coupling between odd orbital momenta.

NUCLEON-DEUTERON BREAKUP CALCULATIONS WITH CHARGE DEPENDENT POTENTIALS

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In several analyses of nucleon-deuteron breakup reactions an approximate inclusion of charge dependence is used. A comparison has been made between these "hybrid" calculations and exact charge dependent ones. It turns out that this approximation is not in all cases valid; differences up to 20 percent may occur in specific kinematical situations.

TRITON BINDING ENERGY AND THE DEUTERON WAVE FUNCTION

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The triton binding energy has been calculated with separable tensor potentials that have the same deuteron wave function as realistic phase-equivalent potentials, given by Haftel and Tabakin. The variation of the binding energy is only 0.3 MeV, comparable with the differences found with the phase-equivalent potentials.

THE MESONIC EXCHANGE CHARGE FORMFACTORS OF ^{3}He AND ^{3}H

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Exchange corrections to the charge formfactors of ^{3}He and ^{3}H are calculated for the same diagrams which give the dominant exchange contributions to the magnetic formfactors. Due to these effects, for ^{3}He the dip in the one-body formfactor is moved towards lower q^2 considerably. In the region of the secundary maximum the exchange effect is the dominant contribution and the result is compatible with experiment. In the range of $q^2 = 8$ fm^{-2} the corrected formfactor is substantially lower than experiment.

OPTICAL MODEL ANALYSIS OF p-^3He SCATTERING*

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Elastic scattering cross section and polarization data for p-^3He scattering in the energy range 5.5 - 156 MeV are analysed using the optical model potential. Reasonably good fits are obtained but the model fails to reproduce the large angle cross sections. This discrepancy is partially removed upon the inclusion of Majorana exchange terms in the potential. Moreover, these exchange terms substantially improve the agreement with the polarization data.

*Work supported in part by the Atomic Energy Control Board of Canada.

DIFUSION ELASTIQUE p-^3He ET LE MODÈLE OPTIQUE*

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Les sections efficaces et polarisations dans la diffusion élastique p-^3He à des énergies de bombardement comprises entre 5.5 et 156 MeV sont analysée au moyens du potentiel optique. Nous avons obtenu des assez bon accords, mai le modèle ne donne pas les sections efficaces aux angles élevés. Cette problem est partiellement resolvé si on inclue dans le potentiel les terms d'échange de Majorana. Du plus, ces terms d'échange amelioré d'un facon substentiel l'accord avec la polarization.

*Ce travail a été appuyé en partie par la Commission de Contrôle de l'Énergie Atomique.

Effective Three-Nucleon Interaction

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The Hilbert space of the three-baryon system is split up into two orthogonal subspaces. One of the subspaces is spaned by the three-nucleon states, while the other subspace contains excited baryon states (resonances). This later subspace is eliminated by the help of the usual projection operator technique. The elimination of the non-nucleonic degrees of freedom gives rise to an additional term in the kernel of the Faddeev equations. This new term can be interpreted as an effective three-body interaction. If one adopts a separable representation for the two-body t-matrices then the effective three-nucleon interaction can be represented also by a separable expression.

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L'interaction effective de trois nucléons

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L'espace de Hilbert de trois baryons est divisé en deux sousespace orthogonaux. Le premier sousespace contient les fonctions d'état de trois nucléons, l'autre contient les états excités (resonances). Au moyen de la technique de l'opérateurs de projection le deuxieme sousespace est éliminé. L'élimination des degrés de liberté non-nucléonique produit un terme additionnel dans le noyau de l'equation de Faddeev. On peut interpréter ce terme nouveau comme une interaction de trois corps. En introduisant une representation séparable pour le matrice T de deux corps, on peut représenter l'interaction de trois nucléons aussi par une expression séparable.

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UNITARITY MODIFICATIONS OF THE COUPLED CHANNEL T AND K OPERATOR EQUATIONS FOR MANY-BODY SCATTERING

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Modifications in the recently proposed coupled-channel T and K operator equations describing many-body scattering are discussed. The analysis is based on a careful examination of the discontinuity equation for the matrix of channel resolvent operators $\mathcal{G}(Z)$ and also on the use of Cauchy's theorem to relate real and imaginary parts of $\mathcal{G}(Z)$. In the original equations, $\mathcal{G}_{ij}(Z) = \delta_{ij}\, G_j(Z)$, where $G_j = (Z - H_j)^{-1}$ and H_j is the jth channel Hamiltonian. The change involves the replacement $\mathcal{G}(Z) \rightarrow \tilde{\mathcal{G}}(Z)$, with $\tilde{\mathcal{G}}_{ij}(Z) = \mathcal{G}_{ij}(Z)P(j)$, where P(j) projects only on to the bound internal states in channel j. As a consequence, only bound i ernal states in each channel need be used as an expansion basis for solving many-body scattering problems, except in the free-particle channel (j = 0), where n-body plane wave states are required.

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†Work supported in part by the U.S. Atomic Energy Commission

MODIFICATIONS UNITAIRES DES EQUATIONS CANALS COUPLÉS POUR LES OPERATEURS T ET K POUR LA DIFFUSION A PLUSIEURS CORPS

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Une discussion est présenté des modifications unitaires des equations canals couplés pour les óperateurs T et K descrirant la diffusion a plusieurs corps que nous avons proposé récemment. L'analyse est fondé sur une inspection soigneuse de l'equation de la discontinuité de la matrice $\mathcal{G}(Z)$ des operateurs resolvants pour chaque canal, et aussi par l'usage de la théorème de Cauchy de etablir une rélation entre les parties réelles et imaginaires de $\mathcal{G}(Z)$. En les équations originelles, $\mathcal{G}_{ij}(Z) = \delta_{ij}G_j(Z)$, ou $G_j(Z) = (Z - H_j)$ et H_j est l'Hamiltonien pour le canal j. La change est $\mathcal{G}(Z) \rightarrow \tilde{\mathcal{G}}(Z)$, avec $\tilde{\mathcal{G}}_{ij}(Z) = \mathcal{G}_{ij}(Z)P(j)$, ou P(j) projets seulement sur les etats liés intérieures dans le canal j. En conséquence, seul les etats liés intérieures sont réquéri comme une base d'expansion dans chaque canal afin de résoudre la probleme de la diffusion a plusieurs corps, sauf que le canal des particules libre (j = 0), ou les ondes planes sont uses.

Description of High-Energy Scattering on Composite Targets Without Eikonal Approximations

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Starting from the multiple scattering series applied in the adiabatic approximation with non-overlapping potentials, expressions have been derived for amplitudes for multiple scattering of energetic particles from nuclei. Glauber amplitudes are in any order shown to be related to on-shell contributions of intermediate propagators. Off-shell parts of opposite phase produce non-vanishing corrections which are of importance in regions where amplitudes for scattering of different multiplicity interfere and for increasing angles. Calculations and comparison of results for proton scattering (E_p = 0.6, 1.0 GeV) on ^{3}He, ^{4}He are presented.

How good is the adiabatic assumption for scattering on a composite target?

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The adiabatic, fixed scatterers approximation for scattering on a D target in different kinematical situation is tested by comparison with an exact solution. For forward angles the 'impulse' kinematics is preferable above the 'fixed scatterer' kinematics, whereas in the backward hemisphere both underestimate the exact cross section. Part of the discrepancy is shown to be due to neglect of exchange which is possible if the projectile is a nucleon.

Application of Partial Wave Dispersion Relations to a Treatment of the Coupled $n+^4He$, $d+^3H$ Channels

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The N/D method for solving partial wave dispersion relations has been applied to the nuclear 5-body problem. As input serve experimentally derived vertex parameters appearing in single and double cluster exchange driving terms. Qualitative agreement is found for the $s_{1/2}$, $p_{3/2}$, $p_{1/2}$ partial wave phases for elastic $n-^4He$ scattering, whereas also the sharp resonance in the $d_{3/2}$ phase has been reproduced. The theory reproduces qualitative agreement for the $^3H(d,n)^4He$ and $^3H(d,d)^3H$ differential cross sections.

Search for 3-Body Forces With $^1H + ^2H$ at $E_p = 23$ MeV

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The $^2H(^1H,2p)n$ reaction at $E_p = 23$ MeV is used to investigate a particular kinematic condition to see if it indicates a sensitivity to possible three-body forces. This condition is one in which the neutron is at rest in the CM system where a unique colinear alignment of the three nucleons exists. A kinematically complete experiment was performed at two angle pairs 57.8°-57.8° and 50.0°-66.1°. In order to analyze the results, we used the predictions of the Faddeev equation obtained from the Ebenhöh code using separable potentials. To achieve maximal sensitivity, the experimental results were divided by the theoretical calculations. At both angle pairs investigated, a statistically significant deviation of the ratio was observed at the position where $E_n(CM) = 0$. This may indicate evidence for a three-body force, or it may be that this is a particularly sensitive place to observe effects of the separable potentials used in the analysis.

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ELECTROMAGNETIC FORM FACTORS OF ^3He*

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The charge and magnetic form factors of ^3He are calculated in the impulse approximation using a wave function obtained from a complete solution of the Faddeev equations with the full Reid soft-core potential. For the charge form factor of ^3He, the relativistic corrections to the order $(1/M^2)$ in the impulse approximation are calculated and found to be small even at large momentum transfer squares $\lesssim 25$ fm^{-2}. The magnetic form factor of ^3He is calculated using both the magnetic spin and convection currents. The convection current contribution is found to be small. The S-D matrix elements contribute significantly.

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TOTAL REACTION CROSS SECTIONS FOR p-^{3}He AND p-^{4}He

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and

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Total reaction cross sections (σ_R) for the p-^{3}He and p-^{4}He systems have been measured at ten and sixteen energies respectively, in the energy range 15 to 50 MeV. The data are compared with other experimental nucleon-induced reaction results. The additional information provided by the p-^{3}He data enables extension of the current resonating group calculations to include an imaginary potential and makes an extension of the phase shift analyses to include imaginary phases more feasible. Comparing the p-^{4}He results with resonating group calculations, phase shift analyses, and optical model σ_R predictions shows the accuracy of the phase shift results, but points to improvement for the model dependent work.

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LES SECTIONS EFFICACES DE REACTION TOTALES POUR LES SYSTEMES p-^{3}He ET p-^{4}He

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Les sections efficaces de reaction totales (σ_R) pour les systèmes p-^{3}He et p-^{4}He ont éte mesurées respectivement dix et seize fois à des énergies incidentes de 15 à 50 MeV. Ces valeurs de σ_R sont comparées à d'autres informations expérimentales sur des réactions produites par des nucléons. Les resultats obtenus pour le système p-^{3}He pourront nous permettre d'obtenir avec une plus grande précision le potential imaginaire dans des calculs de groupes résonnants pour les systèmes de quatre nucléons. En plus, l'extension des analyses des déphasages aux phases complexes sera plus maniable. Les valeurs expérimentales de σ_R pour le système p-^{4}He sont confrontées aux valeurs calculées, à partir des théories des groupes résonnants, des déphasages, et du modèle optique. Cette comparaison met en relief la précision de l'analyse des déphasages et indique que les théories dependents des modèles specifiques ont besoin d'approfondissement.

* A présent au Radiation Laboratory, Aberdeen Proving Grounds, Aberdeen, Maryland 21005

† A présent au Foster Radiation Laboratory, McGill University, Montreal, Quebec.

DIFFERENTIAL CROSS SECTION MEASUREMENTS AND PHASE SHIFT ANALYSIS FOR p-^{4}He ELASTIC SCATTERING BETWEEN 20 AND 55 MeV

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Differential cross section angular distributions have been measured for p-^{4}He elastic scattering in 2.5^0 or 5.0^0 steps in the angular range 10^0 to 170^0 cm at proton energies of 21.85, 23.90, 25.75, 28.10, 30.35, 32.15, 34.25, 36.90, 39.75, 42.45, 44.05, 44.95 and 47.65 MeV. The relative error on the data points is typically ±2%, and the error in the absolute scale is less than ±3%. A phase shift analysis has been carried out in the energy range 20-55 MeV using the data of the present work, selected polarization and differential cross section angular distributions from the literature, total reaction cross sections and a single angular distribution of the spin-rotation parameter.

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MESURES DE LA SECTION EFFICACE DIFFERENTIELLE ET ANALYSE DES DEPHASAGES POUR LA DIFFUSION ELASTIQUE p-^{4}He ENTRE 20 ET 55 MeV

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On a mesuré des distributions angulaires de la section efficace differentielle tout les 2.5^0 (ou 5.0^0) entre 10 et 170 degrés c.m. aux energies incidentes de 21.85, 23.90, 25.75, 28.10, 30.35, 32.15, 34.25, 36.90, 39.75, 42.45, 44.05, 44.95 et 47.65 MeV. Les erreurs relatives sur les sections efficaces sont typiquement de ±2% et l'erreur sur la normalisation absolue est moins de 3%. On a fait également une analyse des déphasages pour la gamme d'énergie de 20 à 55 MeV en joignant, aux mesures du présent travail, des distributions angulaires de la section efficace et de la polarisation choisies de la litérature, des sections efficaces de réaction totales et une distribution angulaire du paramètre de rotation.

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SUPPRESSION DE $V_{\Sigma\Sigma}$ DANS UN POTENTIEL ΛN $^3S_1$-$^3D_1$ SÉPARABLE

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Un modèle potentiel á 2 chaines de l'interaction $(\Lambda N, \Sigma N) \leftrightarrow (\Lambda N, \Sigma N)$ avec une forme simple de tenseur potentiel a été employé pour calculer la longueur de la diffusion, a, et la distance effective, r_0, de la diffusion ΛN $^3S_1$-$^3D_1$, comme fonctions du paramétre suppression ε de la chaine Σ et du parametre suppression γ du potentiel Σ. Les paramétres modéles ont été determinés pour que a et r_0 de $(\varepsilon=1, \gamma=1)$ et $(\varepsilon=0, \gamma=1)$ égalent les valeurs du plus récent potentiel Λp meson-théorétique de Brown, Downs, et Iddings. Il a été alors démontré que indépendement des formes de chacun des modèles potentiels, pour chaque $\nu \neq 1$ fixe, il n'a pas pu être possible de faire égaler avec les valeurs correspondantes de ce même potentiel meson-théorétique.

SUPPRESSION OF $V_{\Sigma\Sigma}$ IN A SEPARABLE $^3S_1$-$^3D_1$ ΛN POTENTIAL

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A two-channel potential model of the $(\Lambda N,\Sigma N)\leftrightarrow(\Lambda N,\Sigma N)$ interaction with a simple form of tensor potential was used to calculate the ΛN $^3S_1$-$^3D_1$ scattering length, a, and effective range, r_0, as functions of the Σ-channel suppression parameter ε and the Σ-potential suppression parameter γ. The model parameters were determined so that a and r_0 at $(\varepsilon=1, \gamma=1)$ and $(\varepsilon=0, \gamma=1)$ matched the values from the most recent meson-theoretic Λp potential of Brown, Downs, and Iddings. It was then shown that, independent of the shapes of any of the model potentials, for any fixed $\nu \neq 1$, a and r_0 at $(\varepsilon=1, \nu)$ could not be made to match the corresponding values of this same meson-theoretic-potential.

T=3/2 PHOTODISINTEGRATION OF ^3He[†]

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The photodisintegration of ^3He leading to the T=3/2 component of the final state has been recalculated within the context of an exact three-body theory using separable, s-wave potentials. Comparison with other calculations is presented.

[†]Work supported in part by the U. S. Atomic Energy Commission

T=3/2 PHOTO-DÉSINTÉGRATION DU ^3He[†]

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La photo-désintégration du ^3He au component T=3/2 de l'état final est calculé de nouveau, utilisant une théorie à trois corps avec des potentiels s, séparable. Nous comparons nos résulats avec d'autres calculs.

[†]Ce travail appuyé en partie par la Commission à L'Energie Atomique États-Unis.

THE PHILLIPS PLOT FOR PHASE EQUIVALENT SEPARABLE POTENTIALS

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The n-d doublet scattering length ^2a and triton binding energy E_T have been calculated for phase equivalent separable potentials, constructed by inversion of the $^1S_0$ and $^3S_1 - {}^3D_1$ experimental nucleon-nucleon scattering data. It is shown that the calculated points lie, within our numerical accuracy, on the Phillips line. We obtain off-shell effects of the order of 1.5 MeV in E_T and 1.2 fm in ^2a by varying the singlet potential with a fixed triplet interaction. Although the lines representing the linear relations between E_T and ^2a and P_D are shifted by these off-shell variations, the corresponding points all lie on the same Phillips line as the other points (fixed singlet potential). For a P_D of 4.5% the experimental values of ^2a and E_T are reproduced.

LE GRAPHIQUE DE PHILLIPS POUR DES POTENTIELS ÉQUIVALENTS EN PHASE ET SÉPARABLES

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Nous avons calculé la longueur de diffusion n-d doublet ^2a, et l'énergie de liaison du triton E_T pour des potentiels équivalents en phase et séparables, construits par une inversion des donnees nucléon-nucléon expérimentales $^1S_0$ et $^3S_1 - {}^3D_1$. On montre que les points calculés se situent sur la ligne de Phillips dans les limites de notre précision numérique. On obtient des effets "off-shell" de 1.5 MeV pour E_T et 1.2 fm pour ^2a, par des variations du potential singulet avec une interaction triplet fixe. Quoique les lignes qui représentent les rélations linéaires entre E_T et ^2a et P_D soient déplaceés par ces variations "off-shell", les points qui correspondent avec ces potentiels sont tous situés sur la même ligne de Phillips que les autres points (potentiel singulet fixe). Les valeurs expérimentales de ^2a et E_T sont réproduites pour un P_D de 4.5%.

SCATTERING-EQUIVALENT MULTICHANNEL SYSTEMS AND MANY-BODY FORCES

A. W. Sáenz and W. W. Zachary*

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Department of Physics, Princeton University, Princeton, N. J. 08540

We have rigorously derived necessary and sufficient conditions for nonrelativistic multichannel scattering systems corresponding to unitarily equivalent Hamiltonians to have the same scattering amplitudes. Thus, beginning with a scattering system with local short-range two-body interactions and total Hamiltonian H one can construct a scattering system equivalent to the first in this sense and with (in general) nonlocal many-body interactions and total Hamiltonian unitarily equivalent to H. The theory provides one with a general practical procedure for determining the effects of many-body forces on few-nucleon electromagnetic form factors while keeping strictly constant all elastic scattering and breakup amplitudes.

*On leave from the Naval Research Laboratory.

UPA AT POSITIVE ENERGIES FOR HARD CORE POTENTIALS

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We examine the accuracy of the UPA to the t-matrix at positive energies for a potential containing hard core and squarewell shape outside. We find that the UPA is not particularly successful at positive energies. Surprisingly, however, at higher postive energies the agreement between UPA t-matrix and exact t-matrix is comparatively better.

LES SECTIONS EFFICACES DIFFÉRENTIELLES DE DIFFUSION ÉLASTIQUE ET INÉLASTIQUE DES NEUTRONS DE 14.1 MEV PAR TRITONS

Shoji Shirato, Yasuhiko Suda and Shizuo Tsuruta* (Department of Physics, St. Paul's (Rikkyo) University, Nishi-Ikebukuro, Tokyo, Japan) and Shinsho Oryu (Department of Physics, Science University of Tokyo, Noda, Chibaken, Japan)

Des mesures de les n-t sections efficaces différentielles de diffusion élastique et inélastique à 14.1 MeV ont été faites à 5 angles entre 0° et 40° en employant un téléscope compteur. Les résultats obtenus pour la diffusion élastique ont été bien reproduits par le modèle optique. Les spectres mesurées et la distribution angulaire des deuterons émergeant alors la réaction $^{3}H(n,d)2n$ sont comparés avec le calcul basé sur la forme de Faddeev en utilisant un modèle des trois corps (n+n+d) et des potentiels séparables. La forme des spectres observées est expliquée en bon accord avec le calcul en présence de la interaction des n-n dans l'état final.

* A présent au Japan Atomic Power Company, Otemachi, Chiyodaku, Tokyo, Japan.

DIFFERENTIAL CROSS SECTIONS FOR ELASTIC AND INELASTIC SCATTERING OF 14.1 MEV NEUTRONS BY TRITONS

Shoji Shirato, Yasuhiko Suda and Shizuo Tsuruta* (Department of Physics, St. Paul's (Rikkyo) University, Nishi-Ikebukuro, Tokyo, Japan) and Shinsho Oryu (Department of Physics, Science University of Tokyo, Noda, Chibaken, Japan)

The n-t elastic and inelastic differential cross sections at 14.1 MeV were measured at five angles up to 40° with a counter telescope. The elastic data obtained were well reproduced by the optical model. The measured spectra and angular distribution of deuterons from the $^{3}H(n,d)2n$ reaction were compared with the calculation based on the Faddeev approach using the separable potentials and the three-body (n+n+d) model. The shape of the observed spectra was fairly well explained by this calculation taking into account the n-n final-state interaction.

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FORMULA DE LA DIFFUSION n-d DE BASSE ÉNERGIE

T.Sasakava

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La fonction de Jost utilisé à la théorie de la diffusion potentielle est donné de l'extension au probleme à trois corps. On a trouvé que l'amplitude de la diffusion n-d de basse énergie est exprimé par une fonction F comme T=Im F/F. La fonction F est parametrisé approximatifment comme $F=\{1-(g/z)[\tan^{-1}3z/2 - \tan^{-1}z/2 + (i/2)\ln((1+9z^2/4)/(1+z^2/4))]+az^2 + i(bz + cz^3)\}^{-1}.[d + ifzE^2(\ln E - i\pi)/\pi]$. Cette fonction satisfait la unitarité à trois corps. Cette fonction est la fonction entière d'en haute moitié du complexe k-plan. (k;la numero de la onde du neutron découlant.) En supposant que f est petit, les valeurs des a,b,c et g qui donnons l'énergie de liaison du triton et le comportment expérimental du k cot δ sont donné.

LOW ENERGY FORMULA OF n-d SCATTERING

T.Sasakava

Tohoku University, Department of Physics, 980-Sendai, Japan

The Jost function of the potential scattering theory is extended to the treatment of the three-body system. It is found that the n-d scattering amplitude at low energy is expressed by a function F as T= Im F/F. The function F is approximately parametrized as $F = \{1 - (g/z)[\tan^{-1}3z/2 - \tan^{-1}z/2 + (i/2)\ln((1+9z^2/4)/(1+z^2/4))] + az^2 + i(bz + cz^3)\}^{-1}\cdot[d + ifzE^2(\ln E - i\pi)/\pi]$. This function satisfies the three-body unitarity. This is an entire function on the upper-half of the complex k-plane (k; the wave number of the incident neutron). With the assumption that f is small, a set of values of a,b,c and g which yield the correct trition binding energy and the experimental behavior of k cot δ are given.

Unitary Three-Body Transformations and Three-Body Forces

Michael I. Haftel

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A three-body unitary transformation method for the study of three-body forces is presented. The proposed method generates from an "unaltered" Hamiltonian of the three-body system with only two-body forces alternate three-body Hamiltonians. These alternate Hamiltonians have two-body forces, which may differ off-shell from the original two-body forces, and three-body forces. The resulting Hamiltonians preserve the three-body spectrum and scattering predictions, but alter the three-body wave functions. A special case - a separable rank-two hyperspherical transformation - is applied to the calculation of the trinucleon charge form factor. The influence of this unitary transformation on the form factor at various q^2 is illustrated. Starting with a potential that gives nearly the correct binding energy of ^{3}He, three-body forces whose expectation values are at least 2 MeV (attraction) seem to be required to achieve reasonable fits to experiment with this transformation.

THE DEPENDENCE OF THE TRITON BINDING ENERGY ON THE ASSUMED TWO-NUCLEON CORE

I.R. Afnan and J.M. Read, School of Physical Sciences, The Flinders University of South Australia, Bedford Park. 5042. Australia.

The dependence of the triton binding energy on the type of core assumed for the two-nucleon interaction is investigated for potentials of the Reid and Hamada-Johnston form. It is shown that such *local* potentials, constrained to have the one-pion-exchange tail, and to give a correct value of the deuteron quadrupole moment, underbind the triton by some 1.5 MeV, irrespective of the type of core assumed. Thus, unless one is prepared to postulate a very large contribution from three-body forces, it is not possible to reconcile the calculated values of E_T with experiment, using this type of potential.

NON-COPLANAR p-D BREAKUP CROSS SECTIONS*

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University of Alberta, Edmonton, Alberta, Canada

D.I. Bonbright, A.M. McDonald, W.T.H. van Oers, and J.W. Watson
University of Manitoba, Winnipeg, Manitoba, Canada

W.M. Kloet
University of Maryland, College Park, Maryland, U.S.A.

J.A. Tjon
University of Utrecht, Utrecht, The Netherlands

Calculations and preliminary measurements of proton-deuteron breakup cross sections have been made at 39.5 MeV along constant relative energy loci such as those described by Jain, Rogers and Saylor. Calculations using s-wave local and separable NN potential models are found to be quite sensitive to the model parameters in regions of destructive interference minima. Preliminary data along one of the constant relative energy loci do not agree with any of the s-wave model calculations. Additional measurements are currently in progress.

TRINUCLEON RESULTS FOR SEVERAL ONE-BOSON EXCHANGE POTENTIALS

I.R. Afnan and J.M. Read, School of Physical Sciences, The Flinders University of South Australia, Bedford Park, 5042, Australia.

Several one-boson exchange potentials (OBEP) were used in the Faddeev equations to determine the triton binding energy E_T and the n-d doublet scattering length ^2a. It was found that both E_T and ^2a for these potentials are significantly closer to the experimental results than the corresponding values obtained using phenomenological interactions. This improvement in the calculated binding energy and scattering length is attributed to the explicit non-locality inherent in the OBE form. The results also suggest that it is not necessary to introduce contributions from three-body forces in order to obtain agreement between theory and experiment.

*Work supported in part by the Atomic Energy Control Board of Canada.

FORMULA DE LA DIFFUSION n-d DE BASSE ÉNERGIE

T.Sasakawa
Université Tohoku, Département de Physique, 980-Sendai, Japon

La fonction de Jost utilisé à la théorie de la diffusion potentielle est donné de l'extension au problème à trois corps. On a trouvé que l'amplitude de la diffusion n-d de basse énergie est exprimé par une fonction F comme T=Im F/F. La fonction F est parametrisé approximatifment comme $F = \{1 - (g/z)[\tan^{-1}3z/2 - \tan^{-1}z/2 + (1/2)\ln((1 + 9z^2/4)/(1 + z^2/4))] + az^2 + i(bz + cz^3)\}$. $[d + ifzE^2 (\ln E - i\pi)/\pi]$. Cette fonction satisfait la unitarité à trois corps. Cette fonction est la fonction entière d'en haute moitié du complexe k - plan. (k ; la numéro de la onde du neutron découlant.) En supposant que f est petit, les valeurs des a,b,c et g qui donnons l'énergie de liaison du triton et le comportment expérimental du $k \cot \delta$ sont donné.

LOW ENERGY FORMULA OF n - d SCATTERING

T.Sasakawa
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The Jost function of the potential scattering theory is extended to the treatment of the three-body system. It is found that the n-d scattering amplitude at low energy is expressed by a function F as T = Im F/F. The function F is approximately parametrized as
$F = \{1 - (g/z)[\tan^{-1} 3z/2 - \tan^{-1} z/2 + (i/2)\ln((1 + 9z^2/4)/(1 + z^2/4))] + az^2 + i(bz + cz^3)\}$. $[d + ifzE^2 (\ln E - i\pi)/\pi]$. This function satisfies the three-body unitarity. This is an entire function on the upper-half of the complex k-plane (k; the wave number of the incident neutron). With the assumption that f is small, a set of values of a,b,c and g which yield the correct trition binding energy and the experimental behavior of $k \cot \delta$ are given.

Bounds States for a Three Body System

Brasio Ferreira and Vera L. V. Baltar
Pontifícia Universidade Católica do Rio de Janeiro

and

Antonio Carlos Antunes
Universidade Federal do Rio de Janeiro

We study the binding energies and the wavefunctions of the J=0 bound states for a system of three identical particles interacting in pairs through potentials of the form $\lambda\delta(r-a)$, where r is the distance between two particles. Efimov bound states are found, and described as functions of the coupling intensity.

Etats Liés d'un Système à Trois Corps

Nous étudions les énergies de liaison et les fonctions d'onde des états liés avec J=0 pion pour un système de trois particules identiques intéragissant par paires avec des potentiels de la forme $\lambda\delta(r-a)$ où r est la distance entre deux particules. Etats liés d'Efimov sont trouvés et décrits en fonction de l'intensité du couplage.

MESURE PRÉCISE DE LA SECTION EFFICACE DIFFÉRENTIELLE N-D À ÉNERGIES BASSES

L Amtén, L Gonczi, A Johansson, L Nilsson et B Sundqvist
Tandem Accelerator Laboratory, University of Uppsala, Suède

Une technique de recul pour mesurer le quotient entre les sections efficaces différentielles n-d/n-p est discutée. La méthode a été utilisée pour obtenir une section efficace à 180° et $E_{n,lab}$ = 8,10 MeV de 246,9 ± 2,1 mb/sr. Cette valeur expérimentale, qui dépend à un degré faible de la forme angulaire supposée pour la section efficace n-d, est 13 % plus grande que la valeur calculée avec potentiels séparables à deux nucléons, mais selon les résultats de Kloet et Tjon elle paraît d'être d'accord avec une valeur obtenue avec leurs potentiels locales.

PRECISE MEASUREMENT OF THE ELASTIC N-D DIFFERENTIAL CROSS SECTION AT LOW ENERGIES

L Amtén, L Gönczi, A Johansson, L Nilsson and B Sundqvist
Tandem Accelerator Laboratory, University of Uppsala, Sweden

A recoil technique to measure the n-d/n-p differential cross section ratio is discussed. The method has been used to obtain an n-d cross section at 180° and $E_{n,lab}$ = 8.10 MeV of 246.9 ± 2.1 mb/sr. This experimental value, which depends slightly on the angular form assumed for the n-d backward cross section, is 13 % larger than the value calculated with two-nucleon separable potentials, but according to the results of Kloet and Tjon it seems to be in agreement with a value obtained with their local potentials.

DIFFUSION A HAUTE ET MOYENNE ENERGIE

J.J. BENAYOUN, Institut des Sciences Nucléaires, BP N° 257 38044 Grenoble, France

La diffusion élastique d'hadrons par une cible à deux corps est étudiée en appliquant la relation de fermeture sur les états propres de la cible par comparaison avec les équations de Faddeev. Les interactions sont supposées séparables. Nous examinons le domaine d'application de cette approximation en faisant varier l'énergie incidente, le rapport de masse du projectile, sur la masse de la cible ainsi que la fonction d'onde de la cible. Nous insistons sur le fait que cette approximation ne conduit pas à l'approximation des diffuseurs fixes si l'on utilise des potentiels séparables.

SCATTERING FROM A TWO-BODY BOUND STATE AT HIGH AND INTERMEDIATE ENERGY

J.J. BENAYOUN, Institut des Sciences Nucléaires, BP n° 257 38044 Grenoble, France

We study the elastic scattering of hadrons from a two-body target within the framework of target closure by comparison with the Faddeev equations using separable potentials. We investigate the region of applicability of this approximation by varying the incident energy, the ratio of the projectile mass to the target mass and the target density. We emphasize that the target closure approximation does not lead to the fixed scatterer approximation with separable potentials.

VII

PHENOMENES DE POLARISATION — POLARIZATION PHENOMENA

LA DETERMINATION DE LA CONSTANTE DE COUPLAGE DU VERTEX (tdn) A L'AIDE DE LA SOLUTION DES EQUATIONS DE FADDEEV

V.B.Belyaev, B.F.Irgasiev*, Yu.V.Orlov**

La constante de couplage G^2 et le facteur de forme pour le vertex t → d+n sont calculés a l'aide de la fonction d'onde obtenue de la solution des équations de Faddeev avec un potentiel de Bressel-Kerman-Rouben modifié. Le résultat pour la constante de couplage $G^2 = 1.fm$ coincide pratiquement avec les données expérimentales. Pour estimer précisement G^2 il est nécessaire de calculer avec soin la fonction d'onde a trois nucléons surtout pour la région non physique des moments.

* Phys. Department Taschkent State University.
** Nuclear Research Institute of Moscow State University.

DETERMINATION OF THE COUPLING CONSTANT FOR THE VERTEX (tdn) FROM THE SOLUTION OF THE FADDEEV EQUATIONS

V.B.Belyaev, B.F.Irgasiev*, Yu.V.Orlov**

The coupling constant G^2 and the form factor for the vertex t, d+n are calculated using the wave function found by solving the Faddeev equations with the modified Bressel-Kerman-Rouben potential. The result for the coupling constant $G^2 = 1.fm$ actually coincides with the experimental data. For accurate G^2 evaluation one should carefully calculate the three-nucleon wave function especially for the momentum unphysical region.

* Phys. Department Taschkent State University.
** Nuclear Research Institute of Moscow State University.

POLARIZATION OF NEUTRONS FROM THE D(α,n) REACTION*

H. D. Knox, R. G. Graves, and L. C. Northcliffe, Cyclotron Institute, Texas A & M University, College Station, Texas 77843

and

H. Nakamura and H. Noya, Department of Physics, Hosei University, Tokyo, Japan

The polarization of neutrons from the D(α,n) reaction has been measured at E_α = 39.4 MeV. Predictions of the polarization and the differential cross section for this reaction have been obtained using the modified impulse approximation and these predictions are compared to the data from the present polarization experiment and to earlier differential cross section data. Generally good fits were obtained although the theory predicts smaller polarizations than were measured.

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*Work supported in part by the National Science Foundation

ASYMMETRY IN THE ^{1}H(d,2p)n REACTION STUDIED WITH 12.2MeV POLARISED DEUTERONS

C. O. Blyth, N. T. Okumusoglu, N. Berovic and J. S. C. McKee. Department of Physics, The University of Birmingham, B15 2TT. England.

Asymmetry measurements from the reaction ^{1}H(d,2p)n at 12.2MeV polarised deuteron energy are compared with those of Arvieux et al (1970) at higher energy.

L'ASYMMETRIE DE LA REACTION ^{1}H(d,2p)n EST ÉTUDIÉE A MOYEN DES DEUTERONS POLARISÉS

C. O. Blyth, N. T. Okumusoglu, N. Berovic and J. S. C. McKee. Department de Physique , L'Universite de Birmingham, B15 2TT, Angleterre.

Les asymmetries de la reaction ^{1}H(d,2p)n sont presentées a l'energie de 12.2MeV. des deuterons polarisés. Les resultats ont comparés de ceux d'Arvieux et al (1970).

PRELIMINARY MEASUREMENT OF THE PROJECTILE SPIN DEPENDENCE IN THE REACTIONS $\vec{d} + {}^3He \rightarrow p + t + p$ AND $\vec{d} + {}^3He \rightarrow p + {}^3He + n$ REACTIONS

H. O. Meyer, Gerald G. Ohlsen, R. A. Hardekopf, P. W. Keaton, and J. W. Sunier,
Los Alamos Scientific Laboratory, Los Alamos, New Mexico 87544*

The deuteron spin dependence for the kinematically complete experiments $d + {}^3He \rightarrow p + t + p$ and $d + {}^3He \rightarrow p + {}^3He + n$ has been measured. Coplanar symmetric angles of 30° and a deuteron bombarding energy of 15 MeV were used. Fairly large tensor polarization effects and small vector polarization effects are observed.

*Supported by the U.S. Atomic Energy Commission.

POLARIZATION TRANSFER IN PROTON-DEUTERON ELASTIC SCATTERING*

F. N. Rad, J. Birchall, H. E. Conzett, and R. Roy
Lawrence Berkeley Laboratory, University of California, Berkeley, California 94720

The polarization transfer coefficient $K_y^{y'}(\theta)$ in N-d scattering has been measured at E_d = 45.4 MeV, θ_{Lab} = 38°, 41°, and 44°. Our results are in good agreement with the recent three-body calculations using a perturbation technique with rank-1 separable potentials.

*Work supported by the U. S. Atomic Energy Commission.

TRANSFERT DE POLARISATION DANS LA DIFFUSION PROTON-DEUTON*

F. N. Rad, J. Birchall, H. E. Conzett and R. Roy
Lawrence Berkeley Laboratory, University of California, Berkeley, California 94720

La mesure du coefficient de transfert de polarisation $K_y^{y'}(\theta)$ dans la diffusion N-d a été effectuée à E_d = 45.4 MeV pour θ_{Lab} = 38°, 41° et 44°. Les résultats sont en accord avec des calculations récentes utilisant, pour le système à trois corps, des potentiels séparables de rang un dans un contexte de perturbation.

*Travail supporté par U. S. Atomic Energy Commission.

POLARIZATION TRANSFER IN THE $D(\vec{p},\vec{n})pp$ REACTION AT $\theta = 0°$ FOR PROTON BOMBARDING ENERGIES FROM 10.5 TO 15 MeV

R. L. Walter, P. W. Lisowski, R. C. Byrd, Duke University and Triangle Universities Nuclear Laboratory+ and T. B. Clegg, University of North Carolina and TUNL+

The polarization of neutrons produced in the $D(\vec{p},\vec{n})$ pp reaction initioted with transversely polorized proton beams from 10.5 to 15 MeV wos investigoted ot $\theta = 0°$. The polarization was measured as a function of neutron energy over the continuous distribution of energies. For all proton energies, the polarization transfer coefficient $K_y^{y'}$ had obout the same mognitude for similar regions of the neutron spectrum, i.e. $K_y^{y'} \simeq -0.2$ for the highest energy group (f.s.i.) and $K_y^{y'} \simeq +0.5$ for the central peak in the continuum distribution.

SCATTERING OF POLARIZED NEUTRONS FROM ^{3}He AT 8 AND 12 MeV

P. W. Lisowski, R. L. Walter, Duke University and Triongle Universities Nuclear Laboratory+ and C. E. Busch, and T. B. Clegg, University of North Carolina and TUNL+

Using the high polarization transfer capability of the $D(\vec{d},\vec{n})^3$He reaction to provide a source of monoenergetic polarized neutrons, the asymmetry in scattering 8 and 12 MeV polarized neutrons from ^{3}He was obtained over the angular range from 60° to 160° c.m. The 8 MeV data show larger asymmetry values than had been reported previously by Behof et al. However both sets of the newer data are in close agreement to the asymmetry results for the mirror reaction T(p,p)T. Phase shifts near to those for T(p,p)T obtained by Hardekopf et al. were determined by searching available cross-section and polorization data for the region from 3 to 24 MeV. These phase shifts provide a convenient parameterization of the available ^{3}He + n data but the solution is known nat to be unique.

POLARIZATION TRANSFER IN THE $D(\vec{d},\vec{n})^3$He REACTION AT $\theta = 0°$

P. W. Lisowski, G. Mack, and R. L. Walter, Duke University and Triangle Universities Nuclear Laboratory+ and C. E. Busch and T. B. Clegg, University of North Carolina and TUNL+

The vector polarization transfer coefficient $K_y^{y'}$ and the tensor analyzing power A_{zz} have been measured for the $D(\vec{d},\vec{n})^3$He reaction at $\theta = 0°$ over an incident deuteron energy range from 1 to 15 MeV in 0.5 MeV steps. The results agree with the previous $D(\vec{d},\vec{n})^3$He measurements of Simmons et al. and are nearly identical to the $D(\vec{d},\vec{p})$T measurements of Clegg et al. in the region of overlap. The present results provide an accurate and complete set of the observables necessary to use the $D(\vec{d},\vec{n})^3$He reaction as a source of polarized neutrons. Above 3 MeV the data may be parameterized as follows:

$$A_{zz}(0°) = -0.462$$

$$K_y^{y'}(0°, E_d) = 0.662 - 0.003E_d.$$

+ Work supported in part by the U. S. Atomic Energy Commission

STUDY OF ^{4}He WITH THE POLARIZED PROTON CAPTURE REACTION

H. F. Glavish, J. R. Calarco, G. King, D. G. Mavis, V. K. C. Cheng, E. Kuhlmann and S. S. Hanna, Department of Physics, Stanford University, Stanford, California 94305 USA*

Angular distributions have been measured for the capture reaction ^{3}H(p,γ)^{4}He with polarized and unpolarized protons at energies E_p = 6.0, 9.8, 14.0 and 16.0 MeV. Unique S-matrix elements for P and D wave capture, corresponding to E1 and E2 radiation, respectively, have been determined from the data. These results, in conjunction with the phase shifts from ^{3}H + p elastic scattering, should help to resolve the open question of the distribution of singlet strength in the two postulated T = 1, 1^- levels of ^{4}He at 27.4 and 30.5 MeV, and provide further information on the E2 strength in ^{4}He.

* Supported in part by the National Science Foundation.

POLARIZATION TRANSFER IN THE $(\vec{d},\vec{n})$ BREAKUP REACTION ON ^{2}H, ^{4}He and Ta

R. L. Walter, P. W. Lisowski, Duke University and Triangle Universities Nuclear Laboratory+ and T. B. Clegg, University of North Carolina and TUNL+

The amount of polarization transferred to the neutrons produced when purely vector-polarized deuterons undergo breakup on targets of ^{2}H, ^{4}He and Ta has been measured at 0° reaction angle. Targets of ^{2}H and ^{4}He were used for deuteron energies of 8.7, 11.4 and 14.4 MeV. Tantalum was used near E_d = 14 MeV. The transverse polarization transfer coefficient $K_y^{y'}$ was obtained as a function of continuum neutron energy. For ^{4}He, $K_y^{y'}$ approached a value of about 0.6 for neutrons with energies near that of a broad peak in the continuum and decreased on the low energy side of the peak. For ^{2}H, $K_y^{y'}$ was slightly lower than for ^{4}He. For Ta, a large polarization transfer was observed over much of the neutron energy range, however no breakup peak was discernible.

+ Work supported in part by the U. S. Atomic Energy Commission

POLARIZATION IN n-d ELASTIC SCATTERING FOR 50.0 MeV NEUTRONS†

A.L. Sagle, M.W. McNaughton, N.S.P. King, F.P. Brady, Crocker Nuclear Laboratory, University of California, Davis, and B.E. Bonner, P-DOR Los Alamos Scientific Laboratory.

Preliminary results are presented for the polarization of 50.0 MeV neutrons scattered from deuterons at three angles in the region of the polarization minimum. The results are in good agreement with p-d results at the same energy.

†Supported by the National Science Foundation

LA POLARIZATION DES NFUTRONS DE 50 MeV DIFFUSÉ PAR DEUTONS†

A.L. Sagle, M.W. McNaughton, N.S.P. King, F.P. Brady, Crocker Nuclear Laboratory, University of California, Davis, and B.E. Bonner, P-DOR Los Alamos Scientific Laboratory.

On donne les resultats préliminaires pour la polarization des neutrons de 50 MeV diffusés par deutons a trois angles vers la region du minimum de la polarization. Ces résultats sont de bonne accord avec ceux de p-d a la même energie.

† Ce travail a été appuyé par la "National Science Foundation"

POSSIBLE TESTS OF TIMEREVERSAL INVARIANCE IN POLARIZED $p\text{-}^3H$ OR $p\text{-}^3He$ SCATTERING

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The possibility of time reversal tests in (low energy) polarized $p\text{-}^3H$ and $p\text{-}^3He$ scattering, so called P=A tests, to an accuracy of the order of 10^{-3} are pointed out and discussed. The sensitivity of the test to the two time reversal violating (TV) scattering amplitudes important at low energy, $\langle {}^3S_1|S^{TV}|{}^3D_1\rangle$ and $\langle {}^3P_1|S^{TV}|{}^1P_1\rangle$, is calculated and found to be reasonable for $p\text{-}^3He$ scattering where their phase is determined by unitarity. The types of T-violating nucleon-nucleon interactions entering these matrix elements and the expected sensitivity to them are mentioned briefly.

UNE ETUDE THEORIQUE DU POUVOIR D'ANALYSE A(0) DES RAYONS γ VENANT DE LA REACTION $(\vec{p},\gamma)$ SUR LES NOYAUX LEGERS

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Département de Physique, Québec G1K 7P4, Canada.

Le pouvoir d'analyse A(θ) des rayons γ venant de la réaction (p,γ) sur les noyaux légers, comme une fonction d'énergie de protons a été calculé par la méthode de voies couplées de particle-trou. Il s'avère que le calcul réussi à reproduire les aspects principaux des résultats expérimentaux dans une manière satisfaisante surtout au cas d'oxygène-16. Pour les cas de carbone-12 la théorie indique qu'il est nécessaire d'inclure des configurations autre que celle de 1p-1h pour obtenir la meilleure accord avec l'expérience.

A THEORETICAL STUDY OF THE ANALYSING POWER A(0) IN $(\vec{p},\gamma)$ REACTIONS IN LIGHT NUCLEI

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The energy dependence of the analysing power A(θ) in the region of the giant dipole resonance is studied using the 1p-1h coupled-channels model of the photo-nuclear reactions. It is shown that the theory can reproduce the observed trends quite satisfactorily including the striking minimum observed in $A(45^{o})$ in ^{16}O at E_{p}(lab) of 7-8 MeV. Comparison between theory and experiment in ^{12}C indicates the direction in which the theoretical model can be improved.

POLARISATION MEASUREMENTS IN NEUTRON-DEUTERON ELASTIC SCATTERING

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N.M. Stewart, Bedford College, London, England.

By scattering a beam of polarised neutrons, having a continuous energy spectrum, from a liquid deuterium target we have measured the polarisation asymmetry in n-d scattering between 50 and 120 MeV, and in the angular range $70^{o} < \theta_{cm} < 170^{o}$. Preliminary results at 70, 80 and 90 MeV are compared with p-d asymmetries at 50 MeV and 140 MeV; no gross discrepancies between the two systems are apparent.

LINEAR RELATIONS BETWEEN THE RANK-1 POLARIZATIONS OF A NUCLEAR REACTION

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Linear relations between the rank-1 polarizations of a two-body nuclear reaction between light nuclei are discussed. Simple relations are obtained for observables in the same channel if only two reaction matrix elements are assumed to be nonzero. For polarizations in the incoming and outgoing channel the relations depend on the spin configurations of the two elements and are thus more complex. In both cases information on dominant elements may be obtained by applying these criteria in a preliminary evaluation of experimental data.

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RELATIONS LINEAIRES ENTRE LES POLARISATIONS VECTORIELLES D'UNE REACTION NUCLEAIRE

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Des relations linéaires entre les differentes polarisations vectorielles d'une réaction entre des noyaux légers sont discutées. Si l'influence de seulement deux éléments de la matrice de collision est considérée, des relations simples entre les observables dans le même canal sont obtenues. En comparant une polarisation du canal d'entrée à une du canal de sortie, les relations dépendent de la configuration des spins des deux éléments et, par conséquence, sont plus complexes. Des informations sur les éléments dominants peuvent être obtenues en appliquant ces critères dans une évaluation qualitative des données expérimentales.

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TRANSPARENCY TO VECTOR POLARIZATION TRANSFER IN DEUTERON STRIPPING REACTIONS

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For certain deuteron polarizations, when the spin transfer is pure $s = \frac{1}{2}$, it is shown that deuteron stripping reactions are transparent to vector polarization transfer and the outgoing nucleon polarization independent of scattering angle and deuteron incident energy. DWBA calculations including contributions from $s = \frac{3}{2}$ through spin-orbit distortion and deuteron D-state effects show that polarization transfer, in such deuteron polarizations, is still considerably transparent in the angular region of the stripping cross section main peak. This is potentially a useful method of producing fast polarized neutrons (or protons) with known polarization.

TRANSPARENCE AU TRANSFERT DE POLARIZATION VECTORIELLE DANS LES REACTIONS (d,p) ET (d,n)

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On prouve que dans certainnes polarizations des deuterons, quand le transfert de spin est exclusivement $s = \frac{1}{2}$, les reactions (d,p) et (d,n) sont transparentes au transfert de polarization vectorielle et la polarization du nucleon emergent est independante de l'angle de diffusion et de l'energie du deuteron incident. Des calculs DWBA, avec des contributions de $s = \frac{3}{2}$ resultantes de distortion spin-orbite et de l'etat D du deuteron, ont montré que le transfert de polarization dans ces états là est encore considérablement transparente dans la région angulaire du maximum principal de la section efficace. Cesi peut être utile comme méthode pour la production de neutrons (ou protons) rapides polarisés avec polarization connue.

POLARIZATION AT 50 MeV NEUTRONS FROM THE $T(d,\vec{n})^4He$ REACTION†

A.L. Sagle, M.W. McNaughton, N.S.P. King, F.P. Brady, Crocker Nuclear Laboratory, University of California, Davis, and B.E. Bonner, P-DOR, Los Alamos Scientific Laboratory.

An absolute measurement of the neutron polarization in the $T(d,\vec{n})^4He$ reaction was made for E_n = 50 MeV. The technique used was first proposed by Barschall and the measured value is 0.49± 0.03 which is in agreement with the deuteron analyzing power in the charge symmetric reciprocal reaction $^4He(\vec{p},d)^3He$.

† Supported by the National Science Foundation.

LA POLARIZATION DE 50 MeV NEUTRONS DE LA $T(d,\vec{n})^4He$ REACTION†

A.L. Sagle, M.W. McNaughton, N.S.P. King, F.P. Brady, Crocker Nuclear Laboratory, University of California, Davis, and B.E. Bonner, P-DOR, Los Alamos Scientific Laboratory.

On donne la mésure absolue de la polarization des neutrons de la reaction $T(d,\vec{n})^4He$ à E_n = 50 MeV. On employe la technique de Barschall. La résultat est 0.49 ± 0.03 que agrée avec la deuton "analysing power" de la charge-symmetric reciprocal reaction $^4He(\vec{p},d)^3He$.

† Cé travail a été appuyé par la National Science Foundation.

MESURES DES PARAMETRES DE POLARISATION ET DE ROTATION DE SPIN DANS LA DIFFUSION ELASTIQUE PROTON-PROTON A 3,83 GeV/c.

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Résumé

Le paramètre de polarisation P dans la diffusion élastique proton-proton a été mesuré à 3,83 GeV/c dans l'intervalle $0,35 \leq |t| \leq 3.0$ $(GeV/c)^2$ c'est à dire $29° \leq \theta_{CM} \leq 95°$. La polarisation à faible quadrimoment transfére est égale à $P \cong +0,18$. La variation en fonction de t montre un minimum à $-t \simeq 1,0$ $(GeV/c)^2$ suivi par un maximum à $-t \cong 1,5$ $(GeV/c)^2$. Une variation semblable en fonction de t avec minimum et maximum aux environs des mêmes valeurs a été observée à des impulsions plus élevées jusqu'à 45 GeV/c.

A la même énergie la combinaison C=0,999 R + 0.07 A des paramètres de rotation de spin R et A a été mesurée dans l'intervalle $0,18 \leq |t| \leq 0,57$ $(GeV/c)^2$. La valeur moyenne de C ($\simeq$R) est $C = -0,275 \pm 0.058$. La comparaison avec les expériences à 6 et 15,75 GeV/c, réanalysées par la même méthode, montre une dépendance en t et une valeur moyenne semblables aux trois énergies. Ces résultats sont proches des prédictions correspondantes à l'échange prédominant du Poméron sans retournement d'hélicité dans la voie s.

MEASUREMENTS OF POLARIZATION AND SPIN ROTATION IN PROTON-PROTON ELASTIC SCATTERING AT 3.83 GeV/c.

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Abstract

The polarization P in proton-proton elastic scattering has been measured at 3.83 GeV/c, in the region of $0.35 \leq |t| \leq 3.0$ $(GeV/c)^2$, i.e. $29^\circ \leq \theta_{CM} \leq 95^\circ$. The polarization at small t is equal to $P \simeq + 0.18$. The t-dependence shows a minimum at $-t \simeq 1.0$ $(GeV/c)^2$ followed by a maximum at $-t \simeq 1.5$ $(GeV/c)^2$. A similar t-dependence with minima and maxima at about the same t-values has been observed at all higher momenta up to 45 GeV/c.

At the same energy the combination $C = 0.999\ R + 0.07\ A$ of the spin rotation parameters R and A has been measured in the interval $0.18 \leq |t| \leq 0.57$ $(GeV/c)^2$. The average value of C ($\simeq$ R) is $C = -0.275 \pm 0.058$. Comparison with the results at 6 and 15.75 GeV/c, reanalized by the same method, shows consistency with a similar t- dependence, and the same average value, at all three energies. These values are not far from the predictions for predominant Pomeron exchange without helicity flip in the s-channel.

VIII

CORRELATIONS A COURTE PORTEE. DIFFUSION QUASI-LIBRE

SHORT RANGE CORRELATIONS. QUASI-FREE SCATTERING

HOW ACCURATELY CAN r_{nn} BE DETERMINED FROM QUASIFREE SCATTERING?

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The sensitivity of the n+d breakup cross-section calculation to the value of the scattering parameters r_{nn} and a_{nn} is presented. From the results a possibility of measuring r_{nn} with considerable precision is suggested.

A QUELLE PRECISION PEUT r_{nn} ETRE DETERMINEE A PARTIR DE LA DIFFUSION QUASILIBRE

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La sensibilité de la section efficace de cassure n+d théorique aux variations des paramètres de diffusion r_{nn} et a_{nn} est examinée. Les résultats de cette étude permettent de proposer une possibilité de détermination du paramètre r_{nn} avec une précision considérable.

ATTENUATION AND p-p AND p-n QUASI-FREE SCATTERING IN DEUTERON BREAKUP

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A new attenuation model is used to explain the difference in QFS cross sections for the two kinematically-equivalent modes of deuteron breakup under proton bombardment.

EFFECT OF SHORT RANGE CORRELATIONS IN PION PHOTOPRODUCTION FROM NUCLEI

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A formalism for taking the effect of short range correlations in pion photoproduction from nuclei has been developed. A preliminary study of positive pion photoproduction from oxygen at 260 MeV incident photon energy (maximum momentum transfer involved is 1.9 fm^{-1}) reveals that there are no significant correlation corrections.

MULTIPLICITY SCALING AND COMPOUND POISSON DISTRIBUTIONS

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SUMMARY

It is pointed out that the assumption of the Compound Poisson Distribution for the multiplicity distribution is identical in content to the assumption of the K.N.O Scaling independent of the nature of the scaling weight function.

Quasi-Free Contributions in the p, d, and ^{16}O Induced Reactions on ^{6}Li

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Three body reactions induced by p, d, and ^{16}O on ^{6}Li were measured at low energies. The contributions from different quasi-free reactions were observed in coincidence spectra. These results were compared with predictions of plane wave impulse approximation calculations.

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QUASI-FREE SCATTERING IN THE $^{6}Li(e,e'\alpha)^{2}H$ AND $^{6}Li(e,e'd)^{4}He$ REACTIONS

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The cross sections for the e-α and e-d quasi-free scattering (QFS) on ^{6}Li are calculated with the microscopic model. The plane wave QFS model predicts the ratio of $n_d/n_\alpha = 1.0$, in contrast with that of 0.53 extracted from the observed cross sections for the e-α and e-d QFS on ^{6}Li, where n_α and n_d are the so called the effective numbers of α and d clusters in the nucleus. The final-state interaction effects cannot explain the ratio different from unity, since the effects are largely cancelled by the oscillatory structure of the α-d intercluster wave function in ^{6}Li. In order to explain this ratio, it should be assumed that the α and d intracluster wave functions in ^{6}Li are considerably different from corresponding free particle wave functions and also that the structure of the α intracluster wave function differs completely from that of the d cluster.

QUASI FREE pp AND pd SCATTERING ON ^{4}He AT 155 MeV

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Institut de Physique Nucléaire, Orsay, France

The energy sharing spectra for the three body ^{4}He(p, 2p) and ^{4}He(p, pd) reactions have been obtained at $\theta_1 = 40.2°$ $\theta_2 = 40.4°$ for the QFS_{pp} and at $\theta_1 = 40°$, $\theta_2 = 60°$ for the QFS_{pd} A DWIA calculation using an Eckart form wave function to describe the proton in ^{4}He has been performed for the ^{4}He(p, 2p) reaction The distorted density probability for zero recoil momentum extracted from different energy experiments (between 65 and 590 MeV) is compared to the calculation Reasonable agreement is obtained if the calculation is multiplied by 0.5 There seems to be a discrepancy between the 480 MeV and 590 MeV data.

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REACTIONS QUASI ELASTIQUES p-p ET p-d SUR ^{4}He A 155 MeV

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Les spectres en énergie des sections efficaces triplement différentielles des réactions ^{4}He(p, 2p) et ^{4}He(p, pd) ont été mesurés à $\theta_1 = 40.2°$ et $\theta_2 = 40.4°$ pour le QFS_{pp} et $\theta_1 = 40°$, $\theta_2 = 60°$ pour le QFS_{pd}. Un traitement DWIA à l'aide d'une fonction d'Eckart pour décrire le proton dans ^{4}He est proposé pour la première réaction. La densité de probabilité (distordue) d'avoir un proton d'énergie nulle dans l'^{4}He est extraite de différentes expériences entre 65 et 590 MeV. La comparaison aux calculs DWIA donne un excellent accord si les calculs DWIA sont multipliés par un facteur 0 5. Un désaccord apparaît entre les résultats expérimentaux à 480 MeV et 590 MeV.

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THE (p,2p) AND (p,pd) REACTIONS ON ^{3}H AND ^{3}He AT 45 MeV

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The (p,2p) and (p,pd) reactions on ^{3}H and ^{3}He have been studied at 45 MeV in a symmetric and asymmetric coplanar geometry at many pairs of angles favoring quasi-free p-p and p-d scattering. Momentum distributions of the d and [nn] systems in ^{3}H and d and d* systems in ^{3}He have been extracted within the framework of the plane wave impulse approximation. A comparison of the continua of the ^{3}H(p,2p)nn reaction with four-body differential phase space distributions indicates the presence of pseudo two-body processes, namely the p-d* quasi-free scattering process and the p + t → d* + d* reaction.

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LES REACTIONS (p,2p) ET (p,pd) SUR ^{3}H ET ^{3}He A 45 MeV

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On a étudié les réactions (p,2p) et (p,pd) sur ^{3}H et ^{3}He à 45 MeV et à un grand nombre de paires d'angles symétriques ainsi qu'asymétriques. La géométrie coplanaire et le choix de paires d'angles ont permis de favouriser les diffusions quasi-libres (p,p) et (p,d). On a déduit, sur la base du formalisme de l'approximation d'impulsion en ondes planes, les distributions de la quantité de mouvement du d et du système [nn] dans ^{3}H et du d et du d* dans ^{3}He. On a comparé également le continuum de la réaction ^{3}H(p,2p)nn et les distributions correspondantes calculées à partir de l'espace de phase differentiel à quatre corps. Cette étude démontre que sont présents des processus à deux corps. où l'une des deux particules est quasi-liée: la diffusion quasi-libre p-d* et la réaction p + t → d* + d*.

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MESURE DE LA COINCIDENCE NEUTRON-PROTON DANS LA REACTION p + D⟶p + p + n A BASSE ENERGIE ET SA RELATION A LA DIFFUSION QUASI-LIBRE

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La mesure de la section efficace de la réaction p (D, p n) p pour θ_p =19°5 et θ_n= - 30° dans la gamme d'énergie 6,8 - 11,8 MeV a été effectuée . Les résultats expérimentaux sont comparés aux calculs théoriques fondés sur l'approximation de Born en ondes planes, compte étant tenu de l'antisymétrie des fonctions d'ondes, de la distinction entre les potentiels nucléon-nucléon triplet et singulet et de la conservation de l'isospin . Par un facteur de correction voisin de l'unité, la courbe théorique reproduit d'une façon satisfaisante la courbe expérimentale, surtout au voisinage du maximum . Nous en concluons que la diffusion quasi-libre de deux nucléons joue un rôle prépondérant . La comparaison des mesures de coincidence p, n et p, p met en évidence le rôle nécessaire des deux potentiels triplets et singulets et fournit une évaluation du rapport de leur intensité .

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NEUTRON-PROTON COINCIDENCE MEASUREMENTS IN THE p + D⟶p + p + n REACTIONS AT LOW ENERGY AND ITS RELATION TO THE QUASI-FREE SCATTERING

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Measurement of the cross-section for the p(D,p n)p reaction at angles θ_p=19°5 and θ_n=-30° has been carried out with incident proton energies comprised between 6.8 to 11.8 MeV . These results are analysed in terms of the plane wave Born approximation using asymmetrical waves fonctions, nucleon-nucleon triplet and singlet potentials and isospin conservation . With a normalization factor of about unity, theoretical and experimental results are in good agreement near the maximum of the peak. We conclude that the mass of the process can be explained by the quasi-free scattering of two nucleons . Comparison of measurements p,n and p,p coincidence gives the ratio of the triplet singlet potentials .

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REACTION DE CASSURE DE ^{3}He PROVOQUEE PAR LES PROTONS DE 156 MeV

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Le "break-up" de ^{3}He a été étudié à Orsay en utilisant un faisceau de protons de 156 MeV et une cible liquide de ^{3}He. Les formes des spectres des sections efficaces différentielles $d^3\sigma/d\Omega_1 d\Omega_2 dE_1$, en fonction de E_1 pour les réactions (p, 2p) et (p, pn) obtenues à $\theta_1 = 40^\circ$ et $\theta_2 = -44^\circ$ sont presque identiques dans la région des pics quasi-élastiques (jusqu'à une énergie cinétique de la particule (ou quasi-particule) de recul d'environ 10 MeV. Le rapport des sections efficaces expérimentales divisées par les sections efficaces de diffusion de deux nucléons libres pour ces deux réactions, $(d^3\sigma(p, 2p)/d\sigma_{pp}) / (d^3\sigma(p, pn)/d\sigma_{pn})$, est $2,0 \pm 0,1$. Le spectre de $d^3\sigma/d\Omega_1 d\Omega_2 dE_1$ pour la réaction ^{3}He (p, dp) à $\theta_1 = 40^\circ$, $\theta_2 = -70^\circ$ présente un pic autour de la région où l'énergie relative p-d est minimum, indiquant une interaction possible dans l'état final p-d.

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PROTON INDUCED ^{3}He BREAK-UP AT 156 MeV

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The ^{3}He break-up was studied at Orsay using the 156 MeV proton beam and a liquid ^{3}He target. The shape of the (p, 2p) and (p, pn) quasi-free scattering (QFS) spectra at $\theta_1 = 40^\circ$ and $\theta_2 = -44^\circ$ are found to be almost coincide with each other for the kinematic energy of the spectator particle (or quasi-particle) less than 10 MeV. The ratio of the QFS peak cross sections divided by the free two-nucleon scattering cross section $(d^3\sigma(p, 2p)/d\sigma_{pp}) / (d^3\sigma(p, pn)/d\sigma_{pn})$ is 2.0 ± 0.1. The ^{3}He (p, dp) energy-sharing spectrum at $\theta_d = 40^\circ$ and $\theta_p = -70^\circ$ shows a peak around the minimum p-d relative energy indicating a possible p-d final state interaction.

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CASSURE DU DEUTERON DANS LA REACTION d+D → n+p+d

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Dans le but d'etudier la quasi diffusion libre dans la reaction d+D → n+p+d à basse énergie nous avons effectué une série de mesures pour des énergies du deuteron incident allant de 6,7 à 11,7 MeV par pas de 1 MeV et un couple d'angle de détection $\theta_p = \theta_d = 19°,5$ et $\theta_n = -30°$.

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BREAK-UP OF THE DEUTERON IN THE REACTION d+D → n+p+d

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In order to study the quasi-free scattering mechanism in the d+D → n+p+d reaction at low energies we have performed a series of measurements for incident deuterons in the energy range 6,7 to 11,7 MeV by steps of 1 MeV and a couple of detection angles $\theta_p = \theta_d = 19°,5$ and $\theta_n = -30°$.

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Quasifree Processes in the Reactions $^3H + {}^3He$ for $E_{^3He} = 50$, 65, and 78 MeV

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In the interaction between ^3H and ^3He, there are a number of three-particle breakup combinations possible. We have performed a series of kinematically complete experiments at ^3He bombarding energies of 50, 65 and 78 MeV in which charged particle pairs are detected and conditions are chosen favoring the observation of quasifree processes. The data are analyzed in terms of the Plane-Wave-Impulse-Approximation and the ratio of experimental and theoretical cross sections is extracted. The lack of change of this ratio as a function of bombarding energy for quasifree scattering processes and a decrease in this ratio for the quasifree reaction processes suggest the possibility of new outgoing channels available to the final state particles as the beam energy increases.

*National Research Council - Naval Research Laboratory Research Associate

IX

MODELES HADRONIQUES COMPOSES
STRUCTURE SUBNUCLEONIQUE

COMPOSITE HADRON MODELS. SUBNUCLEON
STRUCTURE

A KHURI TREIMAN MODEL OF $\eta \to 3\pi$ AND $K \to 3\pi$ DECAYS II

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The long standing hypothesis that the gross features of $\eta \to 3\pi$ and $K \to 3\pi$ decays can be explained quantitatively in terms of a point production vertex and $\pi - \pi$ final state interactions is further investigated. We present some new calculations which take better account of relativistic corrections and Coulomb corrections. The improved models of $\pi - \pi$ interactions currently available are also used.

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* On leave of absence from University of Kent, Canterbury, England.

UN MODELE DE KHURI TREIMAN POUR LES DESINTEGRATIONS $\eta \to 3\pi$ et $K \to 3\pi$

Nous poussons l'étude de l'hypothèse longtemps acceptée que les caractéristiques générales des désintégrations $\eta \to 3\pi$ et $K \to 3\pi$, peuvent être décrites quantitativement à partir d'un vertex de production local - en un point - et de l'interaction des particules dans l'état final. Nos nouveaux calculs améliorent le traitement des effets relativistes et de Coulomb. Nous utilisons également des modèles améliorés de l'interaction $\pi - \pi$ qui sont maintenant disponibles.

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* En congé de l'Université du Kent, Canterbury, Angleterre.

CALCULATION OF THE ω IN A RELATIVISTIC 3π MODEL

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A relativistic generalization of the author's boundary-condition formalism has been applied to the 3π system. Numerical results have been obtained for the 0^- and 1^- states with I=0,1,2. The only resonance indicated is found in the 1^-, I=0 channel with a mass of 700 - 800 MeV, depending on the off-shell input. This is identified with the ω (784). The nature of the calculation then implies that the ω is an immediate consequence of the ρ. The success of this model as compared to earlier dynamical formulations poses some interesting theoretical questions concerning the applicability of a local hamiltonian framework in such systems.

CALCUL SUR LA RESONANCE ω DANS UN MODELE RELATIVISTE DE SYSTEMES A 3π

L'auteur applique une généralisation relativiste de sa propre méthode aux conditions limites, à un système de 3π. Des résultats numériques existent pour les états 0^- et 1^- avec I = 0, 1, 2. La seule résonance que l'on y trouve est dans le canal 1^-, I = 0, correspondant à une masse variant de 700 à 800 MeV, suivant les effets hors couche utilisés. Nous l'identifions à la résonance ω, à 784 MeV, qui devient, dans ces calculs, une conséquence directe de la résonance ρ. Le succès de ce modèle, comparé aux formalismes dynamiques antérieurs, pose certaines questions intéressantes sur le plan théorique concernant l'usage d'une interaction locale pour décrire un tel système.

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*Alfred P. Sloan Foundation Fellow.
Boursier de la Fondation Alfred P. Sloan.

MEDIUM ENERGY PHENOMENOLOGY OF COMPOSITE HADRONS

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It is argued that the composite structure of hadrons should be reflected in oscillatory behavior of their relative wave functions at short distance, rather than extinction as assumed in conventional models. Application of this idea to the N-N system leads to the prediction $r_o = 3/2\ R_c$, where r_o and R_c are the boundary-condition and hard core radii; this is verified empirically to within a few percent. Extension of this reasoning to π-π scattering enables one to deduce a simple unified picture of s- and p- wave scattering for $M_{\pi\pi} \gtrsim 1.4$ GeV. Other observable consequences of this picture will be discussed.

DESCRIPTION PHENOMENOLOGIQUE D'HADRONS COMPOSE DANS LE DOMAINE DES ENERGIES MOYENNES.

Nous soutenons que la structure composée des hadrons devrait être la réflexion d'un comportement oscillatoire de leurs fonctions d'ondes relatives à courtes distances et non pas de l'extinction de ces dernières, tel que supposé dans les modèles conventionnels. Une application de cette notion au problème N-N permet de prédire que $r_o = 3/2\ R_c$, où r_o et R_c sont les rayons respectivement assignés à la condition limite et au coeur dur; un résultat vérifiable empiriquement à quelques pour-cents près. Une extension de ce raisonnement nous permet d'établir une description simple et unifiée de la diffusion dans les états s- et p- d'un système π-π à des énergies $M_{\pi-\pi} \gtrsim 1.4$ GeV. Nous discutons également de certaines conséquences additionnelles du modèle.

[ψ]Alfred P. Sloan Foundation Fellow.
Boursier de la Fondation Alfred P. Sloan.

X

PROCESSUS DE PRODUCTION COHERENTE ET PROCESSUS A PLUSIEURS PARTICULES. REACTIONS DE CASSURE

MULTIPARTICLE AND COHERENT PRODUCTION PROCESSES. BREAK-UP REACTIONS

ELECTRODESINTEGRATION

^{3}H(p,pn) Knockout Reaction at 45.4 MeV

D.J. Roberts, D. Bonbright, S.A. Elbakr, W.T.H. van Oers,

and J.W. Watson

Cyclotron Laboratory, University of Manitoba,
Winnipeg, R3T 2N2, Canada

The reactions H(p,pn)d and H(p,pn)d* have been studied at 45.4 MeV under conditions where quasi-free scattering may be observed. Protons and neutrons were measured in coincidence at 35 degrees on opposite sides of the beam. A comparison with ^{3}He(p,pp)d and ^{3}He(p,2p)d* is given.

La Réaction de Knockout ^{3}H(p,pn) à 45.4 MeV

D.J. Roberts, D. Bonbright, S.A. Elbakr, W.T.H. van Oers,

et J.W. Watson

Cyclotron Laboratory, University of Manitoba,
Winnipeg, R3T 2N2, Canada

On a étudié les réactions ^{3}H(p,pn)d et ^{3}H(p,pn)d* à une energie incidente de 45.4 MeV. On a détecté les neutrons et les protons en coincidence rapide et à des angles respecivesde 35^{o} à droite et à gauche de la direction du faiseau:géométrie qui permet d'observer la diffusion quasi-libre. Les resultats obtenus sont comparés aux resultats correspondants pour les réactions ^{3}He(p,pp)d et ^{3}He(p,pp)d*.

Separable Potential Models for Use in Deuteron Breakup Calculations

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Naval Research Laboratory, Washington, D. C. 20375

In this paper, we introduce four S-wave separable potentials for use in deuteron breakup calculations. Two different off-shell momentum dependences are obtained by using different form factors. An energy dependent modification of the two-nucleon T matrix is used so that we can assure phase shift equivalence or match experimental two-nucleon cross sections. This feature also allows the adjustment of the triton binding energy.

Sensitivity of Deuteron Breakup Amplitudes for Several Potentials

M. I. Haftel and E. L. Petersen
Naval Research Laboratory, Washington, D. C. 20375

The sensitivity of deuteron breakup amplitudes in various spin and angular momentum states to various potentials is investigated. If potentials differ only off-shell, only the $\underset{\sim}{L} = 0$, $S = \frac{1}{2}$ M_{D_2} amplitude is sensitive to changes in the potential. On-shell changes between potentials affect the amplitudes in all spin and angular momentum states. The reasons for the observed sensitivities are discussed in terms of spin, statistics and angular momentum.

Potential-Dependence of Quasifree Scattering in Deuteron Breakup

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and
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Georgetown University, Washington, D. C. 20007
and Naval Research Laboratory

Quasifree scattering is examined in light of the four potentials discussed in the previous two papers. The predictions are independent of off-shell changes, but strongly dependent on on-shell changes. None of the four potentials do a completely satisfactory job of describing experimental data.

*Partially supported by NSF.

D(p,n) AND H(d,n) CROSS SECTIONS AT 21.9, 42.8 AND 45.8 MeV***

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Absolute neutron production cross sections for the D(p,n) and H(d,n) reactions at E_p = 21.9 MeV and E_d = 42.8 MeV have been measured at 0 and 18 degrees in the laboratory. The 0 degree cross section for the D(p,n) reaction at E_p = 45.8 MeV has also been measured. Spectra were obtained for neutron energies from about 7 MeV to the maxima. The spectra have significant structure which can be attributed to well known processes as quasi-free scattering and final state interactions. Theoretical curves based on a solution to the Faddeev equations using a separable S-wave spin-dependent nucleon-nucleon potential but without Coulomb force fit the data reasonably well. A calculation by Oryu based on the Faddeev formalism with Coulomb force compares favorably with the 45.8 MeV D(p,n) data. The data at 21.9 and 42.8 MeV are related to our previous breakup neutron polarization measurements taken at the same angle ard nearly the same energies.

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***Work supported by the National Science Foundation.

Examination of Off Energy Shell Effects in Deuteron Breakup

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Various regions of phase space are examined in which deuteron breakup should be sensitive to off-shell effects. It is shown that regions of very high sensitivity in general have very low cross sections. The exception to this is the final state region in which observable effects occur with measurable cross sections. The size of the effect varies with energy, being low at low energies (14 MeV) but increasing as the energy is raised.

ELECTRODISINTEGRATION OF ^{3}He

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and

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Washington, D.C. 20234, U.S.A.

Electron beams of incident energies from 65 MeV to 110 MeV were scattered from gaseous ^{3}He in a 10-atmosphere target, and from an identical empty target. The spectra of electrons scattered through 92.5° were measured by a magnetic spectrometer up to an excitation energy of 40 MeV. The radiation unfolded data show a change of slope near the break-up thresholds.

*Work supported in part by the Office of Naval Research under Contract N00014-67-A-0230-0009.

ELECTRODESINTEGRATION DE ^{3}He

P.T. Kan, G.A. Peterson, Z.M. Szalata, D.V. Webb and F.J. Kline
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and

S.P. Fivozinsky, J.W. Lightbody, Jr. and S. Penner
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La diffusion d'électrons par ^{3}He a été etudiée pour des énergies incidentes de 65 MeV jusqu'à 110 MeV, utilisant une cible de ^{3}He gazeux à une pression de dix atmosphères. Le spectre en énergie des électrons diffusés à un angle de 92,5° a été obtenu, jusqu'à une énergie d'excitation de 40 MeV. Tenant compte des déconvolutions radiatives nécessaires, les resultats présentent un décroissement de dérivée dans la région des énergies critiques.

*Ce travail à été subventioné partiellement par l'ONR sous le contrat numéro N00014-67-A-0230-0009.

THE TWO-BODY ELECTRO- AND PHOTO-DISINTEGRATION OF ^{3}HE

J.L. Matthews†, R.O. Owens and G. Ticcioni
Department of Natural Philosophy, Glasgow University, Scotland

The differential and total cross sections for the ^{3}He(γ,d)p and ^{3}He(e,d)e'p reactions have been measured over the photon (real or virtual) energy range 11-66 MeV. The results for the two processes will be compared and discussed in terms of recent theoretical calculations.

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PHOTODISINTEGRATION CROSS SECTIONS OF ^{6}Li

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The role of the valence nucleous in the independent particle shell model is assumed to be important. A long-range dynamical correlation has been invoked in the harmonic oscillator type single particle wave function of these nucleons. The calculated charge root mean square radius is found in good agreement with the experimental value as obtained from high energy electron scattering from ^{6}Li.[1] The integrated cross section and integrated bremsstrahlung weighted cross section have been calculated and are found consistent with observed data.[2]

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1. L. R. Suelzle, et.al., Phys. Rev. 162, 992 (1967)

2. Costa et.al., Nuovo Cim. 42B, 382 (1966)

DÉSINTÉGRATION DES DEUTONS PAR PARTICULES α À $E_{\alpha,lab}$ = 15.0 MeV

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Les calculs-Faddeev sur le système à trois nucléon ont eu du succès d'expliquer les probabilités differentes de diffusion. Il serait très intéressant d'étendre ce genre de comparaisons à des autres systèmes de trois corps. Avec cette intention, une exploration de la réaction d(α,pα)n à une énergie α de 15 MeV a été commencée. Cette énergie devait être suffisamment grande que le système A = 6 peut être décrit comme trois particules, une α particule et deux nucléons. Résultats de mesures cinématiquement complets ont été obtenus.

DEUTERON BREAKUP BY α-PARTICLES AT $E_{\alpha,lab}$ = 15.0 MeV

L Glantz, A Johansson, I Koersner and B Sundqvist
Tandem Accelerator Laboratory, University of Uppsala, Sweden

Faddeev calculations on the three-nucleon system have been very successful in explaining various scattering probabilities. It should be of great interest to extend this type of comparisons to other three-body systems. In this spirit, an investigation of the d(α,pα)n reaction at an α particle energy of 15 MeV has been started. This energy should be sufficiently low that the A = 6 system can be well described as three particles, i e an α particle and two nucleons. Results from kinematically complete measurements have been obtained.

XI

EFFETS. RELATIVISTES

RELATIVISTIC EFFECTS

THRESHOLD ELECTRODISINTEGRATION OF THE DEUTERON CAUSED BY BACKWARD SCATTERING OF ELECTRONS

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USSR Academy of Sciences, Vavilov str. 42, Moscow 117333
USSR

Using a new relativistic integral representation for the matrix element of electromagnetic current in terms of experimental phase shifts alone (representation of Shirokov) the cross section of the threshold electrodisintegration of the deuteron caused by backward scattered electrons is calculated for the S-wave deuteron in the interval of the four-momentum transfers squared $0.16 \leq q^2 \leq 5$ fm^{-2}. Nucleon-nucleon interaction in the deuteron and the final state interaction are taken into account in the unified manner and exactly. The effects of the meson exchange currents and the inelastic n-p channels are neglected. The calculated cross section coinsides with the experimental one.

RELATIVISTIC CORRECTIONS TO THE DEUTERON MAGNETIC MOMENT

Franz Gross, Department of Physics, College of William and Mary, Williamsburg, Virginia 23185.

We have evaluated the corrections to the deuteron magnetic moment coming from the small relativistic components of the deuteron wave function, and find that they alone are sufficient to bring the observed magnetic moment into agreement with a 6½% D state. The corrections are found to be very sensitive to the short range nuclear force because the longer range part (which depends on one pion exchange) cancells exactly.

CORRECTIONS RELATIVISTES AU MOMENT MAGNÉTIQUE DU DEUTERIUM

Franz Gross, Department of Physics, College of William and Mary, Williamsburg, Virginia 23185.

Nous avons évalué les corrections au moment magnétique du Deuterium provenant des petites composantes relativistes de la fonction d'onde. Nous observons qu'a elles seulles elles sont suffisantes pour amener le moment magnétique observé en agréement avec une probabilité de 6 1/2% d'etat D. Les corrections apparaissent très sensibles aux forces nucléaires à courte portée. Ceci est du au fait que les forces a longue portée (qui dépendent de l'échange d'un Pion) sont exactement supprimées.

RADIATIVE NEUTRON CAPTURE NEAR THRESHOLD

Edward Dressler,† Department of Physics, American University, Washington, D. C.
and
Franz Gross, Department of Physics, College of William and Mary, Williamsburg, Virginia

The surprisingly large "pair" term corrections to threshold radiative neutron capture, previously calculated by Riska and Brown, and Gari and Huffman, are calculated in a new way in which they appear as relativistic corrections to the impulse approximation arrising from the small negative energy components of the wave functions of the two nucleon system. Looking at these corrections from this point of view suggests not only that these small negative energy components are observable in non-relativistic processes, but also that the size of these corrections may ultimately depend on, or give information about, a consistent relativistic treatment of the nuclear force problem.

†Supported in part by AEC Laboratory Graduate Fellowship Grant AT-(40-1)-3807, Present address, Department of Physics, University of Saskatchewan, Saskatoon, Saskatchewan, Canada.

CAPTURE RADIATIVE DE NEUTRONS A PROXIMITÉ DU SEUIL

Edward Dressler,† Department of Physics, American University, Washington, D. C.
and
Franz Gross, Department of Physics, College of William and Mary, Williamsburg, Virginia

Les termes de corrections dites de "paire" a la capture radiative des neutrons a l'énergie de Seuil, calculés précedement par Riska et Brown ainsi que par Gari et Huffman et dont l'importance surprend, sont calculés ici d'une manière nouvelle dans la quelle ils apparaissent en tant que corrections relativistes a l'approximation d'impulsion provenant des petites composantes d'energie négative de la fonction d'onde du système des deux nucléons. L'examen de ces corrections selon ce point de vue suggère non seulement que ces petites composantes d'energie negatives sont observables dans les processus non relativiste mais aussi que l'importance de ces corrections peut dependre, d'un traitement relativiste consistent du problème des forces nucléaires ou du moins fournir des informations a son sujet.

†Supporté partiellement par le fond AT-(40-1)-3807 de bourses de doctorat de l'AEC. Présente adresse: Department of Physics, University of Saskatchewan, Saskatoon, Saskatchewan, Canada.

DES CORRECTIONS RELATIVISTES A BASSE ENERGIE DANS UN MODÈLE QUASI-POTENTIEL

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++ Département de Physique, Université Laval, Québec, G1K 7P4, Canada.

Nous étudions les corrections relativistes à basse énergie dans la diffusion nucléon-nucléon. Nous utilisons à cet effet l'équation quasi-potentielle de Todorov, qui est une équation d'ondes relativiste à deux corps dans une espace à 3 dimensions. Lorsque l'on passe à la limite où une des masses des 2 particules devient beaucoup plus grande que l'autre (limite statique), ou lorsque l'énergie devient très grande (limite "eikonale"), les résultats obtenus montrent que l'équation de Todorov inclut, dans une certaine mesure, l'effet de diagrammes croisés (crossed graphs). Nous utilisons comme potentiel le terme habituel de premier ordre et un terme du second ordre qui inclut des effets de retard. Nous donnons les résultats prédits par l'équation de Todorov pour les angles de déphasage dans la diffusion neutron-proton, où nous utilisons le potentiel de Kermode. Ce potentiel égal 0 à l'origine des coordonnées et devient répulsif jusqu'à une distance de 0.57 fm. Le potentiel de Kermode a un minimum plus profond que le potentiel de Reid à coeur mou, mais devient rapidement moins attractif à des distances intermédiaires. Nous étudions dans quelle mesure ces différences de forme effectuent la valeur des corrections relativistes à basse énergie. Nous trouvons que les déphasages angulaires à basse énergie diffèrent de ceux prédits par l'équation de Lippmann-Schwinger dans une proportion de 25% au moins. Ces résultats sont semblables à ceux obtenus avec le potentiel de Reid. Nous tentons également de définir l'importance des corrections relativistes en ajustant les constantes de couplage ou la portée du potentiel.

LOW ENERGY RELATIVISTIC CORRECTIONS IN A QUASI-POTENTIAL MODEL

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++ Département de Physique, Université Laval, Québec, G1K 7P4, Canada.

We continue our investigation of a quasi-potential approach to low energy relativistic corrections in nucleon-nucleon scattering. Our approach is based on the Todorov equation which is a three-dimensional, two-body, relativistic wave equation. The static limit and the eikonal limit of the Todorov equation indicate that the equation includes some of the effects of crossed graphs. Our potential term has the normal first-order potential and a second-order term which includes retardation effects. We present phase-shift results for the $^1S_0$ neutron-proton potential of Kermode. This potential is zero at the origin and then repulsive until 0.57 fm. The Kermode potential has a deeper minimum but it quickly becomes less attractive at intermediate distances than the $^1S_0$ Reid soft-core potential. We investigate how these shape differences affect conclusions on low-energy relativistic corrections that are based on the $^1S_0$ Reid potential. We find that our low energy phase-shifts differ by 25% or less from those obtained with the Lippmann-Schwinger equation. These results are quite similar to those for the $^1S_0$ Reid potential. We attempt to characterize the relativistic corrections by modifying the coupling constants or the ranges of the potential.

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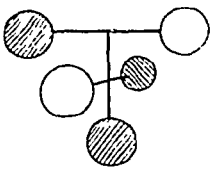
RESUME RECU APRES LA DATE LIMITE

RESUME RECEIVED AFTER DEADLINE

B.T. DARLING AND M. SHOUCRI

INTERNATIONAL CONFERENCE INTERNATIONALE

FEW BODY PROBLEMS
IN NUCLEAR AND
PARTICLE PHYSICS



PROBLEMES A PETIT NOMBRE
DE CORPS DANS LA PHYSIQUE
DU NOYAU ET DE PARTICULES
ELEMENTAIRES

UNIVERSITE LAVAL, QUEBEC G1K 7P4 CANADA
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RESUMES RECUS TROP TARD POUR LES IMPRIMER

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PRINTING

SECTION II

NN POTENTIALS FROM ONE - BOSON EXCHANGES WITH HARD CORES.

M.M. Nagels†, T.A. Rijken†, and J.J. de Swart,

Institute for Theoretical Physics, University of Nijmegen, The Netherlands.

A precision fit to 1128 pp and np data up to 330 MeV laboratory kinetic energy and the low energy parameters is presented. The phaseshifts are calculated with local OBE potentials and hard cores at short distances in the Schrödinger equation. A very satisfactory value of χ^2/data = 2.33 and good low energy parameters are obtained with realistic values of the coupling constants.

† F.O.M. research assiociate

OBE - Models and Regge Poles

T.A. Rijken †

Institute for Theoretcial Physics, University of Nijmegen, The Netherlands.

OBE - Models are discussed in the framework of the Analytic S-matrix Theory using the "New Strip Approximation". Explicit formulae for the Nucleon-Nucleon potential due to Pomeron-exchange are given.

† F.O.M. research associate

Two-Pion-Exchange Nucleon-Nucleon Potential*

A. D. Jackson, D. O. Riska and B. J. VerWest
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New York, Stony Brook, N. Y. 11794, USA

A nucleon-nucleon (NN) potential is constructed from the one-pion, two-pion and one-omega-meson exchange contributions to the field theoretical amplitude. The potential is regularized by using the relativistic eikonal approximation. The NN scattering phase parameters and the deuteron wave functions are calculated using this potential. The predictions of this potential are compared with the results of phase shift analyses and the predictions of other phenomenological potentials.

*Research supported by U.S.A.E.C. contract #AT(11-1)-3001.

CROSS SECTION OF SLOW NEUTRONS ON PARAHYDROGEN

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The coherent scattering cross section of slow neutrons on gaseous parahydrogen has been measured at several temperatures near 20 degrees Kelvin and at pressures ranging from one third of an atmosphere to one atmosphere. Previous experiments had suggested that the cross section would exhibit a significant pressure dependence. However, no pressure dependence was observed in data taken at temperatures above 19.5 degrees Kelvin. The data gives a scattering length of $-3.746 \pm .005 \times 10^{-13}$ cm., which is in excellent agreement with the latest liquid mirror measurements.

SECTION EFFICACE DES NEUTRONS LENTS SUR LE PARAHYDROGEN

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On a mesuré la section efficace de diffusion cohèrente des neutrons lents dans le parahydrogene gazeux, a plusieurs tempèratures aux environs de 20° Kelvin et pour des pressions variant d'une tiers d'atmosphère à une atmosphère. Des expèriences préalables avaient suggèré que la section efficace montrerait une forte dependance en fonction de la pression. Cependant, aucune dépendance en pression n'a été observée a des tempèratures au dessus de 19.5° Kelvin. Nous obtenons une longueur de diffusion de $-3.746 \pm .005 \times 10^{-13}$ cm, en excellent accord avec les plus recentes mesures utilisant la methode du miroir liquide.

SECTION III

RELATIONS DE BASSE ENERGIE SUR LA BRISURE DE LA SYMETRIE CHIRALE ET L'ALGEBRE DES COURANTS.

Jean-Yves Harnois
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Toronto, Ontario, Canada M5S 1A7.

Des théorèmes de basse énergie du système kaon nucléon sont obtenus en restreignant le champ du kaon à l'hyperboloide physique. Parmi ces relations, l'amplitude $A^{(+)}$, paire sous la symétrie le croisement, est contrainte par le terme sigma σ_{NN}^{KK} . Evaluée au seuil, elle dépend fortement de la constante de couplage $g_{KN\Sigma}$, permettant une évaluation sûre de σ_{NN}^{KK} . De plus, les amplitudes impaires sont contraintes par l'algèbre des courants. En particulier, nous obtenons les relations d'Adler-Weisberger généralisées mais sans que les constantes de couplage faible g_A^{Λ} et $g_A^{\Sigma^0}$ n'apparaissent, ceci étant dû au fait que le kaon n'est pas extrapolé hors de l'hyperboloïde physique.

LOW ENERGY RELATIONS ON CHIRAL SYMMETRY BREAKING AND CURRENT ALGEBRA.

Jean-Yves Harnois
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By keeping the kaon on the mass shell, we derive low-energy theorems for the kaon-nucleon system. Among these relations, a threshold calculation of the symmetric amplitude $A^{(+)}$ under crossing, constrained by the sigma term σ_{NN}^{KK} shows that it depends strongly on the coupling constant $g_{KN\Sigma}$, thus allowing a reliable estimate of σ_{NN}^{KK} . On the other hand, the odd amplitudes are constrained by current algebra. In particular, we obtain the generalized Adler-Weisberger relations which do not involve the weak coupling constants g_A^{Λ} and $g_A^{\Sigma^0}$ owing to the fact that the kaon is always kept on the mass shell.

SECTION IV

CONTRIBUTION SANS RESUME

CONTRIBUTED PAPER WITHOUT ABSTRACT

OFF-SHELL OPTICAL POTENTIAL AMBIGUITIES: A THREE-BODY MODEL*

E. F. Redish, University of Surrey and U. of Md., and S. K. Young, U.C.L.A.

Grassberger and Sandhas (Z f.Ph. 220 29 (69)) have shown how the AGS three-body equations may be separated into an L-S equation and an AGS - type equation for the effective interaction (optical potential) by separation of the pole part from the 2-particle T matrices. The AGS equations and the optical potential separation may be generalized to the N-body problem (Gy. Bereze, Nucl. Phys. A210 569 (1973) and E. F. Redish, Saclay preprints D Ph T. 74/3 and 74/34) This separation is ambiguous corresponding to the fact that one may perform phase equivalent transformations of the optical potential without affecting the elastic scattering amplitudes. Explicitly, in either the 3- or the N-body case, the equations for the scattering operators may be written symbolically as matrices (on the 2-cluster channel indices) of operators on the Hilbert space as

$$U = B + KU. \qquad (1)$$

The kernel of these equations, has a cut corresponding to the 2-cluster states of the available subsystems. (This cut is usually referred to as the "pole' part.) The kernel may be written in general

$$K = BO\Gamma\Omega + K' \qquad (2)$$

where O and Ω are energy-dependent matrix-diagonal operators equal to the identity on the energy shell and Γ is the propagator for 2 bound non-interacting clusters. This leads to the equations

$$u = u^{(1)} + u^{(1)}\Gamma u \qquad (3)$$

$$u^{(1)} = B + \Omega K'\Omega^{-1}u^{(1)} \qquad (4)$$

Eq. (3) is an L-S equation with optical potential $u^{(1)}$ and eq. (4) is a many-body equation for the optical potential. The italic operators indicate transforms by O and Ω, thus $u = \Omega U O$, etc.

Iteration of (4) leads to a multiple scattering series for the optical potential. The convergence rate of this series depends on the kernel of (4) and hence on the operators O and Ω. Otherwise said, *the convergence rate of the series for the optical potential depends on the off-shell continuation chosen.*

A particularly striking example of this can be obtained by a consideration of a 3-body model with separable forces. The model considered has 2 identical protons and an inert triton with s-wave forces chosen to fit 2-nucleon and nucleon-^{3}He data (see Young and Redish, Md. preprint 74-014 for details). We find that when the pole separation is made following Grassberger and Sandhas, an iteration of eq. (4) diverges whenever the iterated AGS eqn. does and does so more rapidly. However the full kernel of (1) has the form K = BOΓΩ for a particular choice of O and Ω so an off-shell transformation can be made which makes the kernel of (4) identically zero. The exact optical potential is therefore obtained after one iteration (elimination of the pickup channel).

A study of the trajectories of the eigenvalues of the kernel of (4) for the diverging case suggests a physical explanation of the divergence. There is a single eigenvalue outside the unit circle which appears to be the analytic continuation of the bound state pole to the complex coupling constant plane (Padé variable). We know that (1) must diverge at the 3-body bound state pole. When the equation is separated into (3) and (4) the pole may either arise from iteration of (3) (the bound state is a bound state in the optical potential) or from an iteration of (4) (the bound state is not a bound state of the optical potential but the optical potential itself has a pole at the bound state energy). In order to get convergence of the series for the optical potential this warns us that it is necessary to calculate that optical potential whose analytic continuation to negative energy binds the bound state. This will be particularly true at low energies when the bound state trajectory will not have had time to return to inside the unit circle.

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SECTION VI

LES NIVEAUX "CLUSTER" COMME LES ÉTATS EXCITÉS DE TRITON

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Par la continuation analytique du déphasage n-d, nous avons trouvé un état de ^2S antilié à $E_{CM} = -0.49$ Mev, et une résonance de ^4P à $E_{CM} = -0.336-0.2770i$ Mev sur le deuxième énergie-plan. Parce que ces pôles de la amplitude de la diffusion sont produit par la singularité de l'échange de une particule, ces états doit être appeler les niveaux "cluster", qui sont composé de un deuteron et un neutron.

CLUSTER LEVELS APPEARED AS EXCITED STATES OF TRITON

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By the analytic continuation of the experimental n-d phase shift, we found the anti-bound state for the ^2S-state at $E_{CM} = -0.49$ Mev and a resonance for ^4P-state at $E_{CM} = -0.336 - 0.277i$ Mev on the second energy sheet. (The energy is measured from the n-d elastic threshold.) Since these poles of the scattering amplitude are caused by the exchange singularity, these states should be called the cluster states, which is composed of deuteron and neutron.

SECTION X

SUPPRESSION OF ISOBAR EXCITATION IN LIGHT NUCLEI*

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Isobar excitation is a prominent s-channel effect in deuteron photodisintegration. In the two-body photo disintegration of He^3, He^4, no such structure is observed. From a recent series of experiments on the reactions $\gamma He^3 \rightarrow pd$, and $pd \rightarrow \gamma He^3$, we conclude that the M1-photoexcitation of nucleons appears to be suppressed in these channels to a remarkable extent, while some E-2 excitation may persist. We compare with other evidence and discuss implications.

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