Asymptotic Normalization Coefficients for $^{14}N \leftrightarrow {}^{13}C + p$ from $^{13}C(^3He,d)^{14}N$

P. Bém, V. Burjan, V.Kroha, J. Novák, Š. Piskoř, E. Šimečková, J. Vincour, C.A. Gagliardi, A.M. Mukhamedzhanov, R.E. Tribble

Phys. Rev. C (Submitted March 2000)

The $^{13}C(^3He,d)^{14}N$ proton transfer reaction has been measured at an incident energy of 26.3 MeV. Angular distributions for proton transfer to the ground state and excited states at 2.313 and 3.948 MeV in ^{14}N are analyzed within the framework of the modified DWBA. Asymptotic normalization coefficients (ANC's) defining the amplitude of the tails of the ^{14}N bound-state wave functions in the $^{13}C + p$ channel are extracted that are in excellent agreement with values found previously with the $^{13}C(^{14}N,^{13}C)^{14}N$ reaction. We conclude that $C^2_{p_{1/2}} = 18.2(9)$ fm^{-1} and $C^2_{p_{3/2}} = 0.91(14)$ fm^{-1} for the virtual decay $^{14}N(g.s.) \rightarrow {}^{13}C + p$. These are necessary for the analysis of the $^{14}N(^7Be,^8B)^{13}C$ and $^{14}N(^{11}C,^{12}N)^{13}C$ reactions to extract the ANC's for $^7Be + p \rightarrow {}^8B$ and $^{11}C + p \rightarrow {}^{12}N$, which determine the direct radiative capture cross sections $^7Be(p,\gamma)^8B$ and $^{11}C(p,\gamma)^{12}N$ at astrophysical energies.

Nuclear Astrophysics with Radioactive Beams

L. Trache, A. Azhari, H.L. Clark, C.A. Gagliardi, Y.-W. Lui, A.M. Mukhamedzhanov, X. Tang, R.E. Tribble, V. Burjan, J. Cejpek, V. Kroha, S. Piskor, J. Vincour and F. Carstoiu

Proceedings of the International Symposium "Advances in Nuclear Physics,"
Bucharest, Romania, December 1999, ed. D. Poenaru,
World Scientific, Singapore 2000 (In Press)

A major contribution in nuclear astrophysics is expected now and in the near future from the use of radioactive beams. This paper presents an indirect method to determine the astrophysical S-factor at the very low energies relevant in stellar processes (tens and hundreds of keV) from measurements at energies more common to the nuclear physics laboratories (5-30 MeV/nucleon, e.g.). The Asymptotic Normalization Coefficient method consists in the determination from peripheral transfer reactions of the single particle wave function of the outermost charged particle (proton or alpha particle) around a core in its asymptotic region only, as this is the part contributing to nuclear reactions at very low energies. It can be applied to the study of radiative proton or alpha capture reactions, a very important class of stellar reactions. The method is briefly presented along with our recent results in the determination of the astrophysical factor S_{17} for the proton capture reaction $^7Be(p,\gamma)^8B$. The reaction is crucial for the understanding of the solar neutrino production. Our study was done at the superconducting cyclotron K500 of Texas A&M University, using the ^7Be beam produced with MARS. Two proton transfer reactions with radioactive beams were measured $^{10}B(^7Be,^8B)^9Be$ and $^{14}N(^7Be,^8B)^{13}C$, as well as proton transfer reactions involving stable partners. We present the experiments, discuss the results and the uncertainties arising from the use of calculated optical potentials between loosely bound radioactive nuclei. A test case for our method is included.

Proton-Hydrogen Charge Exchange and Elastic Scattering in Faddeev Approach

E.O. Alt, A.S. Kadyrov and A.M. Mukhamedzhanov

Few-Body Systems Suppl. (In Press)

The impact-parameter Faddeev approach to atomic three-body collisions which has been developed for, and successfully applied to, ion-atom scattering processes, has now been developed further by including, instead of the Coulomb potentials, the full two-particle off-shell Coulomb T matrices in all "triangle" contributions to the effective potentials. Results of calculations of proton-hydrogen collisions with only the ground states of the hydrogen retained in both the direct and the rearrangement channels are presented. Total and differential electron transfer, as well as differential elastic scattering cross sections, are obtained simultaneously in very good agreement with experiment, over a wide range of (nonrelativistic) incident energies.

Momentum Space Integral Equations for Three Charged Particles: Non Diagonal Kernels

A.M. Mukhamedzhanov, E.O. Alt and G.V. Avakov

Phys. Rev. C (Accepted)

Standard solution methods are known to be applicable to Fadeev-type momentum space integral equations for three-body transition amplitudes, not only for purely short-range interactions but also, after suitable modifications, for potentials possessing Coulomb tails provided the total energy is below the three-body threshold. For energies above that threshold, however, long-range Coulomb forces have been suspected to give rise to such severe singularities in the kernels, even of the modified equations, that their compactness properties are lost. Using the rigorously equivalent formulation terms of an effective-two-body theory we prove that, for all energies, the nondiagonal kernels occurring in the integral equations which determine the transition amplitudes for all binary collision processes, posses on and off the energy shell only integrable singularities, provided all three particles have charges of the same sign, ie., all Coulomb interactions are purely repulsive. Hence, after a few iterations these kernels become compact. The case of the diagonal kernels is dealt with in the subsequent paper.

A 2^- level of ^{8}B and the ^{7}Be(p,γ)^{8}B *S*-factor

F.C. Barker and A.M. Mukhamedzhanov

Nucl. Phys. A (Accepted)

A 2^- level at 3.0 MeV in ^{8}B has been suggested from ^{7}Be+p elastic scattering measurements. The effect of such a level on the low-energy ^{7}Be(p,γ)^{8}B *S* factor is discussed, using R-matrix formulae with parameter values chosen to fit ^{7}Li+n data. It is concluded that the level must be broad ($\Gamma^0 \geq 4$ MeV).

Asymptotic Normalization Coefficients from Direct Transfer Reactions with Applications to Nuclear Astrophysics

R.E. Tribble, A. Azhari, H.L. Clark, C.A. Gagliardi, Y.-W. Lui, A.M. Mukhamedzhanov, A. Sattarov, X. Tang, L. Trache, V. Burjan, J. Cejpek, V. Kroha, S. Piskor, J. Vincour and F. Carstoiu

International Symposium on Spins in Nuclear and Hadronic Interactions, Tokyo

World Scientific (October 1999) (In Press)

Peripheral transfer reactions can be used to determine asymptotic normalization coefficients (ANC). These coefficients, which provide the normalization of the tail of the overlap function, determine S-factors for direct capture reactions at astrophysical energies. For example the overlap for ^{8}B→^{7}Be+p defines the S-factor for ^{7}Be(p,γ)^{8}B. A variety of proton transfer reactions have been used to measure ANC's. As a test of the technique, the ^{16}O(^{3}He,d)^{17}F reaction has been used to determine ANC's for transitions to the ground and first excited states of ^{17}F. The S-factors for ^{16}O(p,γ)^{17}F calculated from these ^{17}F→^{16}O+p ANC's are found to be in very good agreement with recent measurements. Following the same technique, the ^{10}B(^{7}Be,^{8}B)^{9}Be and ^{14}N(^{7}Be,^{8}B)^{13}C reactions have been used, along with optical model parameters for the radioactive beams that were obtained from a study of elastic scattering of loosely bound *p*-shell nuclei, to measure the ANC appropriate for determining ^{7}Be(p,γ)^{8}B. The reults from the two transfer reactions provide an indirect determination $S_{17}(0)$.

Asymptotic Normalization Coefficients and Astrophysical Factors

A. Mukhamedzhanov, A. Azhari, V. Burjan, F. Carstoiu, H.L. Clark, C.A. Gagliardi, V. Kroha, Y.-W. Lui, A. Sattarov, L. Trache, and R.E. Tribble

Few-Body Systems Suppl. (In Press)

We present the results for the astrophysical *S* factors determined in our group by measuring ANC's from proton transfer reactions. 1. Determining the *S* factors for the ^{16}O(p,γ)^{17}F reaction from its ANC's has been recognized as an important test for our indirect method. Furthermore, the reaction ^{16}O(p,γ)^{17}F has substantial similarities to the ^{7}Be(p,γ)^{8}B reaction. The reaction ^{16}O(3He,d)^{17}F has been used to determine ANC's for transitions to the ground and first excited states of ^{17}F. These coefficients allowed us to calculate *S* factors for ^{16}O(p,γ)^{17}F at astrophysical energies which are found to be in excellent agreement with the experimental ones. 2. The reactions ^{10}B(^{7}Be,^{8}B)^{9}Be and ^{14}N(^{7}Be,^{8}B)^{13}C have been studied with an 84 MeV ^{7}Be radioactive beam to determine the ANC's for ^{8}B→^{7}Be+p. These coefficients have been used

to calculate the S factor for the direct capture reaction $^{7}Be(p,\gamma)^{8}B$, $S_{17}(O)$. Using the ANC's determined from the reactions $^{10}B(^{7}Be,^{8}B)^{9}Be$ and $^{14}N(^{7}Be,^{8}B)^{13}C$ we find $S_{17}(0) = 17.8\pm2.8 eVb$ and $S_{17}(0)=16.6\pm2.2 eVb$, correspondingly.

Vector Meson Production and Nuclear Effects in FNAL E866

M.J. Leitch, T.C. Awes, M.L. Brooks, C.N. Brown, J.D. Bush, T.A. Carey, T.H. Chang, W.E. Cooper, C.A. Gagliardi, G.T. Garvey, D.F. Geesaman, E.A. Hawker, X.C. He, L.D. Isenhower, S.B. Kaufman, D.M. Kaplan, D.D. Koetke, D.M. Lee, W.M. Lee, N. Makins, P.L. MeGaughey, J.M. Moss, B.A. Mueller, P.M. Nord, B.K. Park, V. Papavassiliou, J.C. Peng, G. Petitt, P.E. Reimer, M.E. Sadler, P.W. Stankus, W.E. Sondheim, R.S. Towell, R.E. Tribble, M.A. Vasiliev, J.C. Webb, J.L. Willis, D.K. Wise, G.R. Young (FNALE866/NuSea Collaboration)

Proc. of the Intl. Seminar on Relativistic Nucl. Physics and Quantum Chromodynamics, Dubna Russia (In Press)

Fermilab E866/NUSEA is a fixed-target experiment which has made a number of measurements of the production of vector mesons by 800 GeV protons. These include the nuclear dependence of J/ψ, ψ' and ϕ over very broad ranges in x_F and p_T, and the J/ψ decay angular distribution at very large x_F. Preliminary results from measurements on Be, Fe and W targets are presented and discussed in the context of nuclear effects such as energy loss and multiple scattering of the partons, absorption of the produced $c\bar{c}$ pairs, and shadowing. Production mechanisms involving color-singlet or color-octet states for the $c\bar{c}$ pair which eventually forms a J/ψ or ψ' have implications on the strength of absorption in the nucleus and on the angular distribution of the decay muons. Preliminary results on the angular distributions versus x_F and p_T indicate some transverse polarization of the J/ψ as predicted by models of production through the color octet state. Measurements of dimuons in the 1 to 3 GeV region explore the nuclear dependence of the ϕ meson and also the composition of the continuum between the ϕ and the J/ψ. These studies of vector meson production and it's nuclear dependence are critical in furthering our understanding of these processes towards future measurements at RHIC and new results from NA50 at CERN, where J/ψ suppression is predicted to be an important signature of the creation of quark-gluon plasma in heavy-ion collisions.

$\bar{d}/\bar{u}$ Asymmetry in the Nucleon Sea

C.A. Gagliardi, T.C. Awes, M.E. Beddo, M.L. Brooks, C.N. Brown, J.D. Bush, T.A. Carey, T.H. Chang, W.E. Cooper, G.T. Garvey, D.F. Geesaman, E.A. Hawker, X.C. He, L.D. Isenhower, S.B. Kaufman, D.M. Kaplan, P.N. Kirk, D.D. Koetke, G. Kyle, D.M. Lee, W.M. Lee, M.J. Leitch, N. Makins, P.L. McGaughey, J.M. Moss, B.A. Mueller, P.M. Nord, B.K. Park, V. Papavassiliou, J.C. Peng, G. Petitt, P.E. Reimer, M.E. Sadler, J. Selden, P.W. Stankus, W.E. Sondheim, T.N. Thompson, R.S. Towell, R.E. Tribble, M.A. Vasiliev, Y.C. Wang, Z.F. Wang, J.C. Webb, J.L. Willis, D.K. Wise, G.R. Young (FNAL E866/NuSea Collaboration)

Proc. of the Intl. Seminar on Relativistic Nucl. Physics and Quantum Chromodynamics (In Press)

Fermilab E866 has performed a precise measurement of the ratio of Drell-Yan yields from an 800 GeV/c proton beam incident on hydrogen and deuterium targets, leading to the first determinations of $\bar{d}/\bar{u}$ and $\bar{d}-\bar{u}$ in the proton as functions of x, as well as the integral of $\bar{d}-\bar{u}$ over the range $0.02 \le x \le 0.345$. The data show that $\bar{d} > \bar{u}$ over a broad range of x. For $x < 0.15$, the results are in reasonable agreement with pre-existing parton distribution functions, but $\bar{d}/\bar{u}$ falls toward unity for $x > 0.2$ much faster than expected. The results provide valuable information regarding the relative importance of non-perturbative *vs.* perturbative QCD origins of the antiquark sea in the nucleon and are in reasonable agreement with models in which virtual mesons play an important role in the $\bar{d}/\bar{u}$ asymmetry.

Proton Induced Drell-Yan Dimuon Production at 800 GeV

M.A. Vasiliev, T.C. Awes, M.E. Beddo, C.N. Brown, J.D. Bush, T.A. Carey, T.H. Chang, W.E. Cooper, C.A. Gagliardi, G.T. Garvey, D.F. Geesaman, E.A. Hawker, X.C. He, L.D. Isenhower, D.M. Kaplan, S.B. Kaufman, P.N. Kirk, D.D. Koetke, G. Kyle, D.M. Lee, W.M. Lee, M.J. Leitch, N. Makins, P.L. McGaughey, J.M. Moss, B.A. Mueller, P.M. Nord, V. Papavassiliou, B.K. Park, J.C. Peng, G. Petitt, P.E. Reimer, M.E. Sadler, J. Selden, W.E. Sondheim, P.W. Stankus,

T.N. Thompson, R.S. Towell, R.E. Tribble, Y.C. Wang, Z.F. Wang, J.C. Webb, J.L. Willis, D.K. Wise, G.R. Young (FNAL E866/NuSea Collaboration)
Proceedings of the International Conference on Elastic and Diffractive Processes, July, 1999, Protvino, Russia (In Press)

Fermilab E866 has performed a precise measurement of the ratio of Drell-Yan yields in 800 GeV/*c* *pp* and *pd* collisions, leading to determinations of $\bar{d}/\bar{u}$ and $\bar{d}-\bar{u}$ in the proton as functions of x. The results provide valuable information regarding the origins of the $\bar{d}/\bar{u}$ asymmetry and the antiquark sea in the nucleon. The target-mass dependence of Drell-Yan dimuon production induced by an 800 GeV proton beam on targets of Be, Fe and W was also measured. Clear evidence of nuclear shadowing is observed in the Drell-Yan cross section ratios per nucleon at small x_2. The x_1 dependence of the cross section ratios provides a determination of the energy loss of ultra-relativistic quarks as they pass through cold nuclei.

Experiment E614 at TRIUMF: A Close Look at Muon Decay

N.L. Rodning, P. Amaudruz, W. Andersson, M. Comyn, Yu. Davydov, P. Depommier, J. Doornbos, W. Faszer, C.A. Gagliardi, D.R. Gill, P. Green, P. Gumplinger, J.C. Hardy, M. Hasinoff, R. Helmer, R. Henderson, A. Khruchinsky, P. Kitching, D.D. Koetke, E. Korkmaz, Y. Lachin, D. Maas, J.A. Macdonald, R. Manweiler, T. Mathie, J.R. Musser, P. Nord, A. Olin, D. Ottewell, R. Openshaw, L. Piilonen, T. Porcelli, J.-M. Poutissou, R. Poutissou, M.A. Quraan, J. Schaapman, V. Selivanov, G. Sheffer, B. Shin, F. Sobratee, J. Soukup, T.D.S. Stanislaus, G. Stinson, R. Tacik, V. Torokhov, R.E. Tribble, M.A. Vasiliev, H-C. Walter, D. Wright
Lake Louise Winter Institute, Lake Louise, Canada, Feb. 1999
(In Press)

Muon decay, a process which involves only the weak interaction, is precisely described within the Standard Model. Therefore, a precision measurement of the decay distribution will provide an unambiguous test of physics beyond the Standard Model. Experiment E614, an experiment under preparation at TRIUMF, will determine the energy and angular distributions of positrons from μ^+ decay to a precision of one part in 10^4. After discussing the general framework for muon decay, the experiment and its sensitivity to new physics are described.

Measurement of the Light Quark Flavor Asymmetry in the Nucleon Sea

B.A. Mueller, T.C. Awes, M.E. Beddo, C.N. Brown, J.D. Bush, T.A. Carey, T.H. Chang, W.E. Cooper, C.A. Gagliardi, G.T. Garvey, D.F. Geesaman, E.A. Hawker, X.C. He, L.D. Isenhower, S.B. Kaufman, D.M. Kaplan, P.N. Kirk, D.D. Koetke, G. Kyle, D.M. Lee, W.M.Lee, M.J. Leitch, N. Makins, P.L. MeGaughey, J.M. Moss, P.M. Nord, B.K. Park, V. Papavassiliou, J.C. Peng, G. Petitt, P.E. Reimer, M.E. Sadler, J. Selden, P.W. Stankus, W.E. Sondheim, T.N. Thompson, R.S. Towell, R.E. Tribble, M.A. Vasiliev, Y.C. Wang, Z.F. Wang, J.C. Webb, J.L. Willis, D.K. Wise, G.R. Young (FNAL E866/NuSea Collaboration)
EPICs Conference Proc., (April 1999) Bloomington, Indiana
(In Press)

Fermilab experiment E866 has performed a precision measurement of the ratio of Drell-Yan yields from 800 GeV/c protons incident on deuterium and hydrogen targets. The measurement is used to determine the ratio of down antiquarks ($\bar{d}$) to up antiquarks ($\bar{u}$) in the proton over a broad range in the fraction of the proton momentum carried by the antiquark, $0.02<x<0.345$. For $x<0.15$, the data is in reasonable agreement with pre-existing parton distributions while for $x>0.20$ the data is much closer to unity than these parton functions had indicated. The light quark asymmetry provides valuable information on the relative role perturbative and non-perturbative mechanisms play in generating the nucleon sea. A proposal to extend the Drell-Yan measurement to higher values of x using 120 GeV protons from the Fermilab main injector will be discussed.

Nuclear Dependence of J/ψ and ψ' Production

W.M. Lee, M.E. Beddo, C.N. Brown, T.A. Carey, T.H. Chang, W.E. Cooper, C.A. Gagliardi, G.T. Garvey, D.F. Geesaman, E.A. Hawker, X.C. He, L.D. Isenhower, S.B. Kaufman, D.M. Kaplan,

D.D. Koetke, M.J. Leitch, P.L. McGaughey, J.M. Moss, B.A. Mueller, V. Papavassiliou, J.C. Peng, G. Petitt, P.E. Reimer, M.E. Sadler, W.E. Sondheim, P.W. Stankus, R.S. Towell, R.E. Tribble, M.A. Vasiliev, J.C. Webb, J.L. Willis, G.R. Young (FNAL E866/NuSea Collaboration)
Proc. of the Centennial Meeting APS, Atlanta 1999, World Scientific
(In Press)

Fermilab E866/NuSea has made a number of measurements of J/ψ and ψ' production by 800 GeV protons on fixed targets of Be, Fe and W. Preliminary results are presented and discussed in the context of nuclear effects such as energy loss and multiple scattering of the partons, absorption of the produced $c\bar{c}$ pairs, and shadowing. Production mechanisms involving color-singlet or color-octet states for the $c\bar{c}$ pair which eventually forms a J/ψ or ψ' have implications on the strength of absorption in the nucleus. These nuclear dependence studies are critical in furthering our understanding of these processes towards future measurements at RHIC and the LHC, where J/ψ suppression is predicted to be an important signature of the creation of quark-gluon plasma in heavy-ion collisions.

Effect of Nucleon Exchange on Projectile Multifragmentation in the Reactions of ^{28}Si + ^{112}Sn and ^{124}Sn at 30 and 50 MeV/nucleon
M. Veselsky, R.W. Ibbotson, R. Laforest, E. Ramakrishnan, D.J. Rowland, A. Ruangma, E.M. Winchester, E. Martin, and S.J. Yennello
Phys. Rev. C (Submitted March 2000)

Multifragmentation of quasiprojectiles was studied in reactions of ^{28}Si beam with ^{112}Sn and ^{124}Sn targets at projectile energies 30 and 50 MeV/nucleon. The quasiprojectile observables were reconstructed using isotopically identified charged particles with $Z_f \leq 5$ detected at forward angles. The nucleon exchange between projectile and target was investigated using isospin and excitation energy of reconstructed quasiprojectile. For events with total reconstructed charge equal to the charge of the beam ($Z_{tot} = 14$) the influence of beam energy and target isospin on neutron transfer was studied in detail. Simulations employing subsequently model of deep inelastic transfer, statistical model of multifragmentation and software replica of FAUST detector array were carried out. A concept of deep inelastic transfer provides good description of production of highly excited quasiprojectiles. The isospin and excitation energy of quasiprojectile were described with good overall agreement. The fragment multiplicity, charge and isospin were reproduced satisfactorily. The range of contributing impact parameters was determined using backtracing procedure.

Distribution of Isospin During Fragmentation of Excited Quasiprojectiles from the Reactions of ^{28}Si + ^{112}Sn and ^{124}Sn at 30 and 50 MeV/nucleon
M. Veselsky, R.W. Ibbotson, R. Laforest, E. Ramakrishnan, D.J. Rowland, A. Ruangma, E.M. Winchester, E. Martin, and S.J. Yennello
Phys. Rev. Lett. (Submitted March 2000)

We have reconstructed quasiprojectiles from completely isotopically identified fragments produced in the reactions of ^{28}Si + ^{112}Sn and ^{124}Sn at 30 and 50 MeV/nucleon. The difference in N/Z of the reconstructed quasiprojectiles allows the investigation of the disassembly as a function of the isospin of the fragmenting system. The isobaric yield ratio ^{3}H/^{3}He depends strongly on N/Z ratio of quasiprojectiles. The dependences of mean fragment multiplicity and mean N/Z ratio of the fragments on N/Z ratio of the quasiprojectile are different for LCPs and IMFs. Observation of a different N/Z ratio of LCPs and IMFs is consistent with the inhomogeneous distribution of isospin in the fragmenting system.

Target N/Z Effects on Projectile Fragmentation
S.J. Yennello, R. Laforest, E. Ramakrishnan, D.J. Rowland, A. Ruangma, E.M. Winchester, and E. Martin
Proc. of the 15th Winter Workshop on Nuclear Dynamics, Park City, Utah
(To Be Published)

Peripheral reactions of ^{28}Si with ^{112}Sn and ^{124} Sn at 30, 40 and 550 MeV/nucleon were used to elucidate the effect of the neutron content of the target on the process of projectile fragmentation. It is demonstrated that the fragments that

result from these projectile fragmentation reactions can be divided into those which are the result of statistical emission of the quasi-projectile and those that are part of a direct component. The statistical part is independent of the target whereas the isotopic composition of fragments from the direct component are dependent on the neutron content of the target.

Heating the Nuclear Liquid With GeV Hadrons

V.E. Viola, K. Kwiatkowski, W.-c. Hsi, G. Wang, D.S. Bracken, H. Breuer, E. Cornell, E. Renshaw Foxford, F. Gimeno-Nogues, D.S. Ginger, S. Gushue, R.G. Korteling, R. Legrain, W.G. Lynch, K.B. Morley, E.C. Pollacco, E. Ramakrishnan, M.B. Tsang, C. Volant, S.J. Yennello, H. Xi, and N.R. Yoder

Proc. of the 8th International Conference on Nuclear Reaction Mechanisms, Cagliari, Italy
(To Be Published)

(No Abstract Available)

Heating of Nuclear Matter and Multifragmentation: Antiprotons vs. Pions

L. Beaulieu, T. Lefort, W.-c. His, K. Kwiatkowski, V.E. Viola, L. Pienkowski, R.G. Korteling, R. Laforest, E. Martin, E. Ramakrishnan, D. Rowland, A. Ruangma, E. Winchester, S.J. Yennello, H. Breuer, S. Gushue, L.P. Remsberg and B. Back

Proc. of the 15th Winter Workshop on Nuclear Dynamics, Park City, UT
(To Be Published)

Heating of nuclear matter with 8 GeV/c$\bar{p}$ and π^- beams has been investigated in an experiment conducted at BNL AGS accelerator. All charged particles from protons to Z~16 were detected using the Indiana Silicon Sphere 4π array. Significant enhancement of energy deposition in high multiplicity events is observed for antiprotons compared to other hadron beams. The experimental trends are qualitatively consistent with predictions from an intranuclear cascade code.

Isolating the Thermal Degree of Freedom in Nuclear Multifragmentation

V.E. Viola, T. Lefort, K. Kwiatowski, W.-c. His, L. Beaulieu, L. Pienkowski, R.G. Korteling, R. Laforest, E. Martin, E. Ramakrishnan, D. Rowland, A. Ruangma, E. Winchester, S.J. Yennello S. Gushue, L.P. Remsberg, H. Breuer and B. Back

Proc. of the Multifragmentation, Intl. Workshop XXVII on Gross Properties of Nuclei and Nuclear Excitations, Hirschegg, Kleinwalsertal, Austria
(To Be Published)

Multifragmentation studies induced by GeV light-ion beams permit investigation of the influence of intrinsic thermal properties of hot nuclear matter, with minimal interference from the compression/decompression cycle and rotational instabilities. We summarize recent results obtained with ^{3}He, proton and pion beams up to 15 GeV/c and present the initial results from a recent experiment with 8 GeV/c antiproton and pion beams. The results are compared with INC simulations coupled to EES and SMM models and the caloric curve for the ^{3}He data will also be discussed.

Heating ^{197}Au Nuclei with 8 GeV Antiproton and π^- Beams

T. Lefort, K. Kwiatkowski, V.E. Viola, W.-c. His, L. Beaulieu, L. Pienkowski, R.G. Korteling, R. Laforest, E. Martin, E. Ramakrishnan, D. Rowland, A. Ruangma, E. Winchester, S.J. Yennello, S. Gushue, L.P. Remsberg, H. Breuer and B. Back,

Proc. of the XXXVII International Winter Meeting on Nuclear Physics, Bormio, Italy
(To Be Published)

This contribution stresses results recently obtained from experiment E900 performed at the Brookhaven AGS accelerator with 8 GeV/c antiproton and negative pion beams using the Indiana Silicon Sphere detector array. An investigation of the reaction mechanism is presented, along with source characteristics deduced from a two-component fit to the spectra. An enhancement of deposition energy with the antiproton beam

with respect to the pion beam is observed. The results are qualitatively consistent with predictions of an intranuclear cascade code.

Transition in Isospin Behavior Between Light and Heavy Fragments Emitted from Excited Nuclear Systems

E. Martin, R. Laforest, E. Ramakrishnan, D.J. Rowland, A. Ruangma, E.M. Winchester, and S.J. Yennello
(Accepted as Brief Report to Phys Rev C)

The isospin dependence of light and heavy fragments emitted from excited nuclear systems and the change in isospin behavior between light and heavy fragments are studied in this report. The *N/Z* is calculated using data reported in the literature and from the results of the simulation code, SMM. A transition in isospin behavior between light and heavy fragments may support the recently reported two-phase bifurcation of excited nuclear matter into a neutron rich gas phase and a more symmetric liquid phase.

Probing Dynamic Evolution in Intermediate Energy Collisions

J.B. Natowitz, J. Cibor, A. Bonasera, K. Hagel, R. Wada, M. Murray, T. Keutgen, M. Lunardon, N. Marie, R. Alfaro, W. Shen, Z. Majka and P. Staszel
Acta. Phys. Pol. (Submitted March 2000)

Molecular dynamics calculations which are employed to model light particle emission in nuclear collisions at intermediate energies suggest that coalescence model analyses may be used to probe the time evolution of these systems and to provide information on the degree of thermal, chemical and isospin equilibrium achieved at particular stages of this evolution. This talk discusses the application of coalescence model analyses to explore light particle emission in reactions between 47A MeV projectiles and medium mass targets. The results provide evidence for increasing expansion of the hot composite nuclei as the projectile mass increases. Densities and temperatures of the freeze-out configurations in multi-fragmenting systems are derived.

The Use of Coalescence Models to Probe Dynamic Evolution in Nuclear Collisions

J. Cibor, A. Bonasera, J.B. Natowitz, K. Hagel, R. Wada, M. Murray, T. Keutgen, M. Lunardon, N. Marie, R. Alfaro, W. Shen, Z. Majka and P. Staszel
"Isospin Physics in Heavy-Ion Collisions at Intermediate Energies," Nova Science Publishers, Bao-An Li and W.U. Schröeder, editors (To be published)

Light particle emission occurs at essentially every stage of the evolution of composite systems produced in nuclear collisions at intermediate energies. Molecular dynamics calculations which are employed to model such collisions suggest that coalescence model analyses of the light particle emission may be used to probe both the time evolution of these systems and provide information on the degree of thermal, chemical and isospin equilibrium achieved at particular stages of this evolution. In this article the application of coalescence models for this purpose is explored within the framework of a classical molecular dynamics model. The application of techniques suggested by this study is then demonstrated in analyses of light particle emission observed in reactions between 47A MeV projectiles and medium mass targets. For those reactions densities and temperatures of the freeze-out configuration in multi-fragmenting systems are derived.

Light Particle Probes of Expansion and Temperature Evolution: Coalescence Model Analyses of Heavy Ion Collisions at 47A MeV

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Phys. Rev. C (Submitted March 2000)

The reactions $^{12}C+^{116}Sn$, $^{22}Ne+Ag$, $^{40}Ar+^{100}Mo$ and $^{64}Zn+^{89}Y$ have been studied at 47A MeV projectile energy. For these reactions the most violent collisions lead to increasing amounts of fragment and light particle emission as the projectile mass increases. This is consistent with QMD model simulations of the collisions. Moving source fits to the light

charged particle data have been used to gain a global view of the evolution of the particle emission. Comparisons of the multiplicities and spectra of light charged particles emitted in the reactions with the four different projectiles indicate a common emission mechanism for early emitted ejectiles even though the deposited excitation energies differ greatly. The spectra for such ejectiles can be characterized as emission in the nucleon-nucleon frame. Evidence that the ^{3}He yield is dominated by this type of emission and the role of the collision dynamics in determining the t/^{3}He yield ratio are discussed. Self-consistent coalescence model analyses are applied to the light cluster yields, in an attempt to probe emitter source sizes and to follow the evolution of the temperatures and densities from the time of first particle emission to equilibration. These analyses exploit correlations between ejectile energy and emission time, suggested by the QMD calculations. In this analysis the degree of expansion of the emitting system is found to increase with increasing projectile mass. The double isotope yield ratio temperature drops as the system expands. Average densities as low as $0.36\rho_0$ are reached at a time near 100 fm/c after contact. Calorimetric methods were used to derive the mass and excitation energy of the excited nuclei which are present after pre-equilibrium emission. The derived masses range from 102 to 116 amu and the derived excitation energies increase from 2.6 to 6.9 MeV/u with increasing projectile mass. A caloric curve is derived for these expanded A~110 nuclei. This caloric curve exhibits a plateau at temperatures near 7 MeV. The plateau extends from ~3.5 to 6.9 MeV/u excitation energy.

Time Scales for the Fission Process Induced in ^{20}Ne+^{169}Tm Reactions at Bombarding Energies Between E/A=8 and 16 MeV

Th. Keutgen, J. Cabrera, Y. El Masri, C. Ghisalberti, L. Tilquin, L. Legreton, A. Ninane, J. Lehmann, V. Roberfroid, R. Regimbart, J.B. Natowitz, K. Hagel, R. Wada, R.J. Charity

Phys. Rev. Lett. (Submitted July 1999)

The neutron clock method is applied to pre-scission neutron multiplicities measured in the ^{20}Ne+^{169}Tm fusion-fission reaction with the DEMON neutron array. This method is shown in simulations to give, not the mean time, but a time closer to the median time for fission. The mean and the median time can differ by orders of magnitude as the predicted time distribution has an extremely long tail. The time scale for fission was found to decrease as the excitation energy is increased from 100 to 250 MeV.

Fragment Excitation Energies at Freeze-out in ^{84}Kr+^{93}Nb Collisions at 45 MeV/nucleon

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Phys. Rev. C (Submitted 1999)

The emission of light charged particles (LCPs) and intermediate mass fragments (IMFs) from central collisions at 45 MeV/nucleon ^{84}Kr with ^{93}Nb has been studied. Violent collisions have been selected using the total collected charge condition. The analysis of the primary IMF excitation energies has been performed for four bins of the detected IMF charge (between $2<Z_{IMF}<20$). The mean excitation energy per nucleon for these fragments is independent of fragment charge and approximately equal to 2.5 MeV. In addition we find evidence that a) the primary fragments at freeze-out preserve the entrance channel (combined system) *N/Z* ratio, b) the derived fragment temperatures depend on the level density parameter applied in the analysis and c) that the freeze-out volume itself is far from spherical.

Reaction Mechanisms and Multifragmentation Processes in ^{64}Zn + ^{58}Ni at 35A-79A MeV

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Phys. Rev. C (To be submitted)

Reaction mechanisms and multifragmentation processes have been studied for ^{64}Zn + ^{58}Ni collisions at intermediate energies with a help of antisymmetrized molecular dynamics model (AMD-V) calculations. Experimental energy spectra, angular distributions, charge distributions and isotope distributions, classified by their associated charged particle multiplicities, are compared with the results of the AMD-V calculations. In general the experimental results

are reasonably well reproduced by the calculations. The multifragmentation observed experimentally at all incident energies is also predicted by the AMD-V models. A detailed study of AMD-V events reveals that a semi transparency and subsequent expansion processes play important roles in the multifragmentation process. In the semi transparency process, even for central collisions, most of the projectile nucleons appear in the forward direction, but with a significant energy dissipation. For the expansion processes, two different expansion processes are predicted at the incident energies below 57A MeV and above 69A MeV. At the lower incident energies, a thermal expansion occurs at the end of the energy dissipation process. At the higher incident energies, a nuclear density compression is predicted and the expansion is ignited by the compression just before the maximum overlap of the two nuclei is achieved. At t~300 fm/c the system is fragmented into small pieces and the average excitation energy of the maximum fragment is around 3A MeV regardless of the incident energies. This scenario predicted by AMD-V is consistent with explaining all the essential features of the experimental results.

Anti-Deuteron Production in 158 GeV/c Pb+Pb Collisions

I.G. Bearden, H. Bøggild, J. Boissevain, P. Christiansen, J. Dodd, B. Erazmus, S. Esumi, C.W. Fabjan, D. Ferenc, A. Franz, J.J. Gaardhøje, A.G. Hansen, O. Hansen, D. Hardtke, H. van Hecke, E.B. Holzer, T.J. Humanic, P. Hummel, B.V. Jacak, K. Kaimi, M. Kaneta, T. Kohana, M. Kopytine, T. Ljubicic, B. Lörstad, R. Malina, L. Martin, M. Murray, H. Onishi, G. Paic, F. Piuz, J. Pluta, V. Polychronakos, G. Poulard, A. Sakaguchi, J. Simon-Gillo, J. Schmidt-Sørensen, W. Sondheim, T. Sugitate, J.P. Sullivan, Y. Sumi, W.J. Willis, K. Wolf, N. Xu, and D. Zachary
Phys. Rev. Lett. (Submitted November 1999)

The invariant cross section of anti-deuterons produced in 158 GeV/c per nucleon Pb+Pb central collisions has been measured by the NA44 experiment at CERN. This measurement together with a measurement of anti-protons allows for the determination of the antideuteron coalescence parameter. The extracted coalescence radius is found to agree with the deuteron coalescence radius and HBT radii assuming a sharp sphere density profile of the source at freeze-out.

Low Energy Fission of the Neutron-Deficient Compound Nuclei ^{220}Th, ^{224}Th, and ^{226}Th Formed in Reactions with ^{16}O and ^{18}O

M.G. Itkis, N.A. Kondratiev, E.M. Kozulin, Yu. Ts. Oganessian, V.V. Pashkevich, I.V. Pokrovsky, V.S. Salamatin, A.Ya. Rusanov, L. Calabretta, C. Maiolino, K. Lukashin, C. Agodi, G. Bellia, G.G. Chubarian, B.J. Hurst, D. O'Kelly, R.P. Schmitt, F. Hanappe, E. Liatard, A. Huck, L. Stuttgé
European Journal of Physics A (Submitted)

The fission of the systems ^{220,224,226}Th was investigated by measuring the mass-energy distributions of the fission fragments using a time-of-flight spectrometer. The corresponding excitation energies at the saddle point, E^*_{sp}, ranged from 16 to 40 MeV. As E^*_{sp} decreases, an asymmetric mass component becomes visible on the predominately symmetric mass distribution. The contribution of the asymmetric mode is characterized by the total yield ratio Y_s/Y_a, which decreases rapidly for the heavier isotopes of thorium. This behavior of Y_s/Y_a is in qualitative agreement with theoretical calculations, which predict that at low E^*_{sp} a transition should occur from predominately symmetric to asymmetric fission as the mass number of the thorium nucleus increases. For all isotopes studied, the subtracted asymmetric fission component, $Y_a = Y_t - Y_s$, exhibits a complex structure, actually showing two components, $Y_a = Y_{a1} + Y_{a0}$, which have average masses $M_{a1} = 132$ and $M_{a0} = 140$. Evidence for multimodal fission is also visible in the properties of the kinetic energies of the fragments. At the lowest E^*_{sp}, both the kinetic energy, TKE, and its dispersion σ^2_{TKE}, show irregularities in the regions where the asymmetric modes have their largest relative yield.

Fission modes in the reaction ^{208}Pb(^{18}O, f)

I. V. Pokrovsky, M. G. Itkis, J. M. Itkis, N. A. Kondratiev, E. M. Kozulin, E. V. Prokhorova, V. S. Salamatin, V. V. Pashkevich, S. I. Mulgin, A. Ya. Rusanov, S. V. Zhdanov, G. C. Chubarian, B. J. Hurst, R. P. Schmitt, C. Agodi, G. Bellia, L. Calabretta, K. Lukashin, C. Maiolino, A. Kelic, G. Rudolf, L. Stuttge, and F. Hanappe. Phys. Rev. **C61,** 2000 (in press).

Results of fission fragment mass-energy distributions of the compound ^{226}Th nucleus formed in the sub-barrier fusion reaction ^{18}O+^{208}Pb at an energy of ^{18}O ions E_{lab}=78 MeV are reported. The reaction has been studied twice using two

different accelerators, and both sets of experimental data agree quite well. Performed analysis of the experimental data with the use of a new multicomponent method has shown that alongside the well known modes, i.e., the symmetric (S) and two asymmetric modes standard-one and standard-two, a high-energy mode standard-three has manifested itself. The last named mode appears due to the influence of the close-to-sphere neutron shell with N≈50 in the light fission fragment group. Theoretical calculations of the prescission shapes of the fissioning nuclei ^{224,226}Th confirm this conclusion.

Probing Hadron Properties in Heavy Ion Collisions
C.M. Ko, V. Koch, and G.Q. Li
Proc. of APCTP Workshop on Astro-Hadron Physics (In Press)

This talk is devoted to the discussion of hadron properties in the nuclear medium and its relation to the partial restoration of chiral symmetry. In particular, we discuss medium effects on the Goldstone bosons (pion, kaon and eta), the vector mesons (rho, omega and phi), and the nucleon. Also, for each proposed in-medium effect the experimental consequence and results are surveyed.

Excitation Function of Collective Flow in Relativistic Heavy Ion Collisions
B.A. Li, C.M. Ko, A.T. Sustich, and B. Zhang
Proc. of the Relativistic Heavy Ion Mini-Symposium (World Scientific, Singapore)
(In Press)

Using the relativistic transport model ART, we study the excitation function of total, differential and elliptical transverse flow of nucleons, pions, and kaons in Au+Au reactions from 1 to 15 GeV/nucleon. For nucleons, we shall report the dependence of the collective flow on the equation of state of hadronic matter. In particular, the effect due to the existence of a soft region in the equation of state, as suggested by lattice QCD calculations of baryon free matter at finite temperature, will be discussed. For kaons, medium effects due to the change of their mass on the collective flow will be presented.

A Transport Model for Heavy Ion Collisions at RHIC
B. Zhang, C.M. Ko, B.A. Li and Z. Lin
Proc. of the Relativistic Heavy Ion Mini-Symposium, World Scientific, Singapore
(In Press)

To study heavy ion collisions at energies to be available from the Relativistic Heavy Ion Collider (RHIC), we have developed a transport model that includes both initial partonic and final hadronic interactions. Specifically, the parton cascade model ZPC, which uses as input the parton distribution from the HIJING model, is extended to include the quark-gluon to hadronic matter transition and also final-state hadronic interactions based on the ART model. Comparisons with SPS data and predictions for RHIC are report.

Hadronic Scatterings of Charm Mesons and Enhancement of Intermediate-Mass Dileptons
Z. Lin, C.M. Ko and B. Zhang
Proc. of the Relativistic Heavy Ion Mini-Symposium, World Scientific, Singapore
(In Press)

The scattering effects of charm mesons by hadrons such as the pion, rho meson andnucleon are studied in an effective Lagrangian, and are found to be important in heavy ion collisions. At the CERN-SPS energies, hadronic rescatterings are shown to harden the charm meson m_T spectra, leading to a significant enhancement of the yield of intermediate-mass dimuons from charm meson decays.

Role of Gluons in Thermal Dilepton Production from the Quark Gluon Plasma
Z. Lin and C.M. Ko
Nucl. Phys. A (In Press)

We study dilepton production from gluon-induced processes, in a thermally equilibrated but chemically undersaturated partonic matter that is expected to be created in the initial stage of ultra-relativistic heavy ion collisions. Regulating the divergence in these processes by the thermal quark mass, we find that gluon-induced processes are more important than the leading-order $q\bar{q}$ annihilation process as a result of the larger number of gluons than quarks in the partonic matter. The dependence of the thermal dilepton yield from the partonic stage of heavy ion collisions on the initial conditions for the partonic matter is also studied. We further discuss the feasibility of observing thermal dileptons from the quark-gluon plasma in heavy ion experiments.

Open Charm and Drell-Yan at RHIC
Z. Lin, et al.
Nucl. Phys. A (To Be Published)

In this talk we discuss various sources of dilepton productions at high invariant mass. Calculation from the parton cascade code ZPC indicates that thermal dileptons are very difficult to be observed at RHIC. Effects of energy loss and hadronic scatterings of charmed mesons on dilepton yields from open charm decays are also discussed.

Effect of Nuclear Deformation on J/ψ Suppression in the Relativistic Nucleus-Nucleus Collisions
B.-H. Sa and A. Tai
(To be Submitted)

Using a hadron-string cascade model, JPCIAE, we study the effect of nuclear deformation on J/ψ suppression in the collision of uranium nuclei at 200A GeV/c. We find that the J/ψ survival probability is much smaller if the major axes of both deformed nuclei are along the beam direction than if they are perpendicular to the beam direction.

Directed Flow of Neutral Strange Particles at AGS
B. Zhang, C.M. Ko, B.-A. Li and A.T. Sustich
Phys Rev. C (Submitted)

Directed flow of neutral strange particles in heavy ion collisions at AGS is studied in the ART transport model. Using a lambda mean-field potential which is 2/3 of that for a nucleon as predicted by the constituent quark model, lambdas are found to flow with protons but with a smaller flow parameter as observed in experiments. For kaons, their repulsive potential, which is calculated from the impulse approximation using the measured kaon-nucleon scattering length, leads to a smaller anti-flow than that shown in the preliminary E895 data. Implications of this discrepancy are discussed.

A Multiphase Transport Model for Nuclear Ion Collisions at RHIC
B. Zhang, C.M. Ko, B.-A. Li and Z. Lin
Phys. Rev. C (In Press)

To study heavy ion collisions at energies available from the Relativistic Heavy Ion Collider, we have developed a multi-phase transport model that includes both initial partonic and final hadronic interactions. Specifically, the parton cascade model ZPC, which uses as input the parton distribution from the HIJING model, is extended to include the quark-gluon to hadronic matter transition and also final-state hadronic interactions based on the ART model. Predictions of the model for central Au on Au collisions at RHIC are reported.

Isoscalar Compression Modes Within Fluid Dynamic Approach
V.M. Kolomietz and S. Shlomo
Phys. Rev. C (In Press)

We study the nuclear isoscalar monopole and dipole compression modes in nuclei within the fluid dynamic approach (FDA) with and without the effect of relaxation. For a wide region of the medium and heavy nuclei, the FDA predicts that the isoscalar giant monopole resonance (ISGMR) and the isoscalar giant dipole resonance (ISGDR) exhausts about 90% of the corresponding model independent sum rules. In the case of neglecting the effect of relaxation, the FDA,

when adjusted to reproduce the centroid energy $E0$ of the ISGMR, results with centroid energy $E1$ of the ISGDR which is in agreement with the predictions of the self consistent Hartree Fock (HF) random phase approximation (RPA) calculations and the scaling model but significantly larger than the experimental value. We also show that the FDA leads to the correct hydrodynamic limit for the ratio $(E1/E0)_{FDA}$. We find that the ratio $(E1/E0)_{FDA}$ depends on the relaxation time and approaches the preliminary experimental value $(E1/E0)_{exp} = 1.5 \pm 0.1$ in a short relaxation time limit.

Surface Instability of a Nuclear Fermi Liquid Drop
V.M. Kolomietz and S. Shlomo
Phys. Rev. C (Submitted)

The instability of the incompressible Fermi-liquid drop with respect to surface distortions is considered. It is shown that the Fermi-surface distortion (FSD) effect reduces the instability growth rate for the surface fluctuations due to its effects on both the viscosity and the increase in the stiffness coefficient. The dependence of the limiting temperature T_{lim} on the mass number and the multipolarity of the surface distortion is calculated. It is shown that T_{lim} is not influenced by the FSD effect.

Giant Resonance Splitting in Asymmetric Nuclei
V.M. Kolomietz, A.G. Magner and S. Shlomo
Phys. Rev. C (Submitted)

We suggest an explanation of the splitting of both the isoscalar and the isovector modes in spherical neutron-rich nuclei within the Fermi-liquid-drop model (FLDM) based on the collisional Landau kinetic theory and extended to two-component asymmetric nuclei. Our approach can be used for the description of the giant multipole resonance (GMR) splitting phenomenon in a wide region of nuclear masses $A \sim 40 \div 240$. For the isovector dipole modes the splitting energy, the relative strength of the resonance peaks and the contribution to the energy weighted sum rule (EWSR) are in agreement with experimental data for the integral cross sections of the photonuclear (γ,n) and (γ,p) reactions.

Microscopic Description of Excitation of Nuclear Isoscalar Giant Monopole Resonance by Inelastic Scattering of 240 MeV α-Particles
A. Kolomiets, O. Pochivalov, and S. Shlomo
Book in memory of Prof. E.A. Eramzhyan, JINR (Dubna, Russia
(In Press)

A microscopic description of the isoscalar monopole resonance (ISGMR) excitations in ^{28}Si, ^{40}Ca. ^{58}Ni, and ^{116}Sn is provided based on self-consistent Skyrme-Hartree-Fock (HF) Random-Phase-Approximation calculations. A description of 240 MeV α-particle scattering by these nuclei is given within the Distorted-Wave-Bom-Approxiniafion (DWBA). The folding model is used to obtain optical potentials from the HF ground state density and a density dependent Gaussian nucleon α interaction ($V_{\alpha n}$). Parameters of ($V_{\alpha n}$) are found by fitting experimentally measured angular distributions for the case of elastic scattering. Angular distributions of inelastically scattered α-particles for ISGMR excitations of the target nucleus are obtained using the folding model DWBA and both microscopic (RPA) and hydrodynamical (collective model) transition densities (found from HF ground state densities). Possible overestimation of the energy weighted sum rules and shifts of centroid energies due to collective-model-based DWBA reaction description is reported.

Structure and Decay Properties of the Isoscalar Giant Monopole and Dipole Resonances Within the Continuum-RPA Approach
M.L. Gorelik, S. Shlomo and M.H. Urin
"Nuclear Shells - 50 Years," Editors Yu. Ts. Oganessian and Ts. Vylov,
Dubna publication (In Press)

Strength function and partial widths for the direct nucleon decay of the isoscalar giant monopole and dipole resonances are analyzed within a continuum-RPA approach. Calculations are performed for several medium and heavy mass nuclei

with the use of the phenomenological nuclear mean field, Landau-Migdal particle-hole interaction and some partial self-consistency conditions. Calculation results are compared with available experimental data.

Structure and Nucleon Decay Properties of the Isoscalar Giant Monopole and Dipole Resonances in Nuclei

M.L. Gorelik, M.H. Urin and S. Shlomo

Phys. Rev. C (Submitted)

Strength function and partial widths for the direct nucleon decay of the isoscalar giant monopole and dipole resonances are analyzed within a continuum-RPA approach. Calculations are performed for several medium and heavy mass nuclei with the use of the phenomenological nuclear mean field, Landau-Migdal particle-hole interaction and some partial self-consistency conditions. Calculation results are compared with available experimental data.

Target-atom Inner-shell Vacancy Distributions Created in Collisions with Heavy ion Projectiles

V. Horvat, R.L. Watson, and J.M. Blackadar

Nucl. Instrum. Methods Phys. Res. B (In Press)

A model of the evolution of Cu atom inner-shell electron configurations was developed in order to establish the relationship between the original populations created in K-vacancy producing collisions with fast heavy-ion projectiles and those that exist at the time of Cu Kα and Kβ x-ray emission. The model takes into account multi-step vacancy rearrangement processes that may occur prior to K x-ray emission. An iterative procedure is employed in which a set of trial parameters that define the original inner-shell population distributions are varied to obtain satisfactory agreement of the calculated Kα satellite relative intensities and energies, as well as the overall intensity ratio of Kβ satellites to Kα satellites, with the experimental data. In addition to deducing the properties of the original L- and M-shell population distribution, this procedure also provides the average value of the fluorescence yield for conversion between x-ray and K-vacancy production cross sections.

Target-atom K-shell Ionization by Binary Encounter Electrons

V. Horvat and R.L. Watson

Phys. Rev. A (Submitted)

Spectra of Kα x rays emitted from Cu atoms bombarded with 10-MeV/u beams of Kr, Xe, and Bi ions were measured with a curved crystal spectrometer. Large enhancements of the Kα diagram lines were observed and attributed to secondary ionization by photons and electrons. To explain these results quantitatively, contributions from binary encounter electrons have been calculated by considering their production and transport as well as the effective cross section for target K-shell ionization by electron impact. The results are in good agreement with the measurements.