Giant Resonances in ^{24}Mg

D.H. Youngblood, Y.-W. Lui and H.L. Clark

Phys. Rev. C (In press)

The giant resonance region in ^{24}Mg was studied with inelastic scattering of 240 MeV α particles at small angles including 0°. The giant resonance peak was found to extend up to E_x = 41 MeV. Isoscalar E0, E1 and E2 strength corresponding to 72±10%, 81^{+26}_{-14}%, and 72±10% of the respective energy weighted sum rules was identified in the peak with centroids of 21.0±0.6 MeV, 18.8±1.7 MeV and 16.9±0.6 MeV and RMS widths of 7.3±1.2, 6.7±1.0 and 3.4±0.5 MeV respectively. Elastic scattering was measured from θ_{cm}=3° to 33° and density dependent folding model parameters obtained. Inelastic scattering to states at 1.369, 4.122, 4.238, 6.010, 6.432, 7.349, 7.555, 7.616 and 8.358 MeV was measured and B(EL) values obtained.

Astrophysical S-factors from Asymptotic Normalization Coefficients

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, Š. Piskoř, J. Vincour, F. Cârstoiu

Pramana J. of Phys. (In Press)

S-factors for direct capture reactions can be found at astrophysical energies from asymptotic normalization coefficients which provide the normalization of the tail of the overlap function. For example the overlap for ^{8}B→^{7}Be + p defines the S-factor for ^{7}Be(p,γ)^{8}B. Peripheral transfer reactions offer a technique to determine these asymptotic normalization coefficients. As a test of the technique, the ^{16}O(^{3}He,d)^{17}F reaction has been used to determine asymptotic normalization coefficients for transitions to the ground and first excited states of ^{17}F. The S-factors for ^{16}0(p,γ)^{17}F calculated from these ^{17}F→^{16}O + p asymptotic normalization coefficients 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 to measure the asymptotic normalization coefficient for ^{7}Be(p,γ)^{8}B. This result provides an indirect determination of S_{17}(0).

The Connection Between Asymptotic Normalization Coefficients, Subthreshold Bound States and Resonances

A.M. Mukhamedzhanov and R.E. Tribble

Phys. Rev. C (In press)

We present here useful relations showing the connection between the asymptotic normalization coefficient (ANC) and the fitting parameters in K- and R-matrix theory methods which are often used when analyzing low energy experimental data. It is shown that the ANC of a subthreshold bound state defines the normalization of both direct radiative capture leading to this state and resonance capture in which the state behaves like a subthreshold resonance. A determination of the appropriate ANC(s) thus offers an alternative method for finding the strength of these types of capture reactions, both of which are important in nuclear astrophysics.

The ^{10}B(^{7}Be,^{8}B)^{9}Be Reaction and the ^{7}Be(p,γ)^{8}B S Factor

A. Azhari, V. Burjan, F. Carstoiu, H. Dejbakhsh, C.A. Gagliardi, V. Kroha, A.M. Mukhamedzhanov, L. Trache, R.E. Tribble

Phys. Rev. Lett. (In press)

The ^{10}B(^{7}Be,^{8}B)^{9}Be reaction has been studied with an 84 MeV ^{7}Be radioactive beam. The measured cross section determines the asymptotic normalization coefficients for the virtual transitions ^{7}Be + p↔^{8}B. These coefficients specify the amplitude of the tail of the ^{8}B wave function in the two-body channel ^{7}Be + p, and may be used to calculate the S factor for the direct capture reaction ^{7}Be(p,γ)^{8}B at solar energies, S_{17}(0). We find that S_{17}(0)=17.8 ± 2.8 eVb.

S-factor for $^{9}Be(p,\gamma)^{10}B$

A. Sattarov, A. M. Mukhamedzhanov, A. Azhari, C. A. Gagliardi, L. Trache, R. E. Tribble

Phys. Rev. C. (Submitted)

The $^{9}Be(p,\gamma)^{10}B$ reaction plays an important role in primordial and stellar nucleosynthesis of light elements in the *p*-shell, but the energy-dependence of *S(E)* has not been well-understood. We re-analyze the existing $^{9}Be(p,\gamma)^{10}B$ experimental data within the framework of the *R*-matrix method. The direct capture part of the *S*-factor is calculated using the experimentally measured asymptotic normalization coefficients for $^{10}B \rightarrow ^{9}Be + p$. The fitted parameters of the low-lying ^{10}B resonances are also required to be consistent with previous measurements of $^{6}Li(\alpha,\gamma)^{10}B$. A good simultaneous fit to both radiative capture reactions is found, in contrast to previous analyses. These results demonstrate that experimentally measured asymptotic normalization coefficients, coupled to the *R*-matrix method, can provide a reasonable determination of direct radiative capture rates, even when the captured proton is tightly bound in the final nucleus.

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. Nordi, 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 International Nuclear Physics Conference '98 (INPC98) Paris, France (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. The results show that $\bar{d} > \bar{u}$ over a broad range of x and provide valuable information regarding the origins of the $\bar{d}/\bar{u}$ asymmetry and the antiquark sea in the nucleon.

$\bar{d}/\bar{u}$ 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 $0.02 \leq x \leq 0.345$. 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.

Measurements of the Light Quark Flavor Asymmetry in the Nucleon Sea

J.C. Peng, T.C. Awes, M.E. Beddo, 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, 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, B.A. Mueller, P.M. Nord, B.K. Park, V. Papavassiliou, G. Petitt, P.E. Reimer, M.E. Sadler, 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. Conference on High Energy Physics (ICHEP'98), Vancouver, BC (In press)

The Drell-Yan cross section ratios, $\sigma(p + d)/\sigma(p + p)$, measured in Fermilab E866, have led to the first determination of $\bar{d}(x)/\bar{u}(x)$, $\bar{d}(x)$ - $\bar{u}(x)$, and the integral of $\bar{d}(x)$ - $\bar{u}(x)$ for the proton over the range $0.02 \leq x \leq 0.345$. The E866 results are compared with predictions based on parton distribution functions and various theoretical models. The relationship between the E866 results and the NMC measurement of the Gottfried integral is discussed. The agreement between the E866 results and models employing virtual mesons indicates these non-perturbative processes play an important role in the origin of the $\bar{d}$, $\bar{u}$ asymmetry in the nucleon sea.

Nuclear Dependence of J/ψ and ψ' Production

W.M. Lee, 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, M.J. Leitch, N. Makins, P.L. McGaughey, J.M. Moss, B.A. Mueller, P.M. Nordi, B.K. Park, V. Papavassiliou, 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, M.A. Vasiliev, J.C. Webb, J.L. Willis, D.K. Wise, G.R. Young (FNAL E866/NuSea Collaboration)

Proc. of the International Nuclear Physics Conference '98 (INPC98) Paris, France (In press)

FNAL 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.

The Current Status of V_{ud}

I.S. Towner and J.C. Hardy

Proc. of Intl. Symposium on Weak and Electromagnetic Interactions in Nuclei (To be published)

The value of the V_{ud} matrix element of the Cabibbo-Kobayashi-Maskawa (CKM) matrix can be derived from nuclear superallowed beta decays, neutron decay, and pion beta decay. We survey current world data for all three. Today, the most precise value of V_{ud} comes from the nuclear decays; however, the precision is limited not by experimental error but by the estimated uncertainty in theoretical corrections. The neutron data are approximately a factor of four poorer in precision but this could change dramatically in the near future as planned experiments come to fruition. The nuclear result (and the most recent of the neutron decay results) differ at the 98% confidence level from the unitarity condition for the CKM matrix. We examine the reliability of the small calculated corrections that have been applied to the data, and assess the likelihood of even higher quality nuclear data becoming available to confirm or deny the discrepancy. Some of the required experiments depend upon the availability of intense radioactive beams. Others are possible today.

Superallowed Fermi Beta Decay and Coulomb Mixing in Nuclei

J.C. Hardy and I.S. Towner

Proc. of Nuclear Structure '98, Gatlinburg, Tennessee (To be published)

Superallowed $0^+ \rightarrow 0^+$ nuclear beta decay provides a direct measure of the weak vector coupling constant, G_V. We survey current world data on the nine accurately determined transitions of this type, which range from the decay of ^{10}C to that of ^{54}Co, and demonstrate that the results confirm conservation of the weak vector current (CVC) but differ at the 98% confidence level from the unitarity condition for the Cabibbo-Kobayashi-Maskawa (CKM) matrix. We examine the reliability of the small calculated corrections that have been applied to the data, and conclude that there are no evident defects although the Coulomb correction, δ_C, depends sensitively on nuclear structure and thus needs to be constrained independently. The potential importance of a result in disagreement with unitarity, clearly indicates the need for further work to confirm or deny the discrepancy. We examine the options and recommend priorities for new experiments and improved calculations. Some of the required experiments depend upon the availability of intense radioactive beams. Others are possible with existing facilities.

Weak Interaction Studies With an On-line Penning Trap Mass Spectrometer

G. Savard, R.C. Barber, F. Buchinger, J.E. Crawford, X. Feng, S. Gulick, G. Hackman, J.C. Hardy, J.K.P. Lee, R.B. Moore, K.S. Sharma and J. Uusitalo

Proc. of the International Nuclear Physics Conference, Paris, France (To be published)

Superallowed β decays are a sensitive probe of the fundamental aspects of the weak interaction. Such decays are used to stringently test the CVC hypothesis, deduce a precise value of the weak vector coupling constant, test the unitarity of the CKM matrix and looks for deviation from the V-A structure for the weak interaction. The ability to efficiently capture and store short-lived superallowed beta emitters in ion traps will help to elucidate discrepancies in the most precise unitarity test of the CKM matrix and tighten the present limits on interactions outside the standard V-A form.

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.

Energy Deposition and GDR Emission in the Reaction $^{209}Bi(\alpha,\alpha')$ at 240 MeV

G. Viesti, M. Lunardon, D. Fabris, G. Nebbia, M. Cinausero, E. Fioretto, D.R. Napoli, G. Prete, K. Hagel, J.B. Natowitz, R. Wada, P. Gonthier, Z. Majka, R. Alfarro, Y. Zhao, N. Mdeiwayeh, T. Ho
Nucl. Phys. A. (Accepted)

Neutron fold distributions measured for the reaction $^{209}Bi(\alpha,\alpha')$ at 240 MeV have been analyzed with the help of Statistical Model calculations to determine the distribution of excitation energy, E_x, in the primary target fragments as a function of the projectile energy loss, EL. The reconstructed distributions in excitation energy feature a plateau which extends from the kinematical limit E_x=EL to very small excitations, indicating a variety of interactions of the beam particles with the target nucleus. The requirement of an additional coincidence with a light charged particle leads to the selection of a significant higher average excitation energy. Those results are extrapolated to explore the effects of including the excitation energy distributions in the analysis of previous measurements of GDR in ^{208}Pb. Corrections of the derived GDR parameter due to the partial transfer of excitation energy are suggested.

Dynamic Evolution and the Caloric Curve for Medium Mass Nuclei

J. Cibor, R. Wada, K. Hagel, M. Lunardon, N. Marie, R. Alfaro, W. Shen, B. Xiao, Y. Zhao, J. Li, B.-A. Li, M. Murray, J.B. Natowitz, Z. Majka, P. Staszel
Phys. Rev. Lett. (Submitted)

Self-consistent coalescence model analyses of light particle emission have been used to follow the evolution of the temperatures and densities of A~120 nuclei produced in violent collisions induced by four different 47 A MeV projectiles. The degree of expansion of the emitting system increases with increasing projectile mass. The caloric curve derived for these expanding A~120 nuclei plateaus near T=7 MeV. The plateau extends from 3 to 7.4 MeV/u excitation energy.

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
Nucl. Phys. A (In press)

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.

Elliptical Flow From a Parton Cascade

B. Zhang, M. Gyulassy, and C.M. Ko
Phys. Lett. B (In press)

The dependence of elliptic flow at RHIC energies on the effective parton scattering cross section is calculated using the ZPC parton cascade model. We show that the v_2 measure of elliptic flow saturates early in the evolution before the hadronization transition to a rather large value of about 0.05-0.15 as the cross section varies from 2-10 mb and thus is a sensitive probe of the dynamics in the plasma phase.

Isospin Dependence of Nuclear Collective Flow

B.A. Li and C.M. Ko

Nucl. Phys. A (In press)

Nuclear collective flow in heavy-ion collisions at intermediate energies has been studied in an isospin-dependent transport model. It is found that both the sign and strength of collective flow are significantly affected by the isospin asymmetry of the colliding system. The predicted dependence of the balance energy, defined bythe incident energy at which the collective flow disappears, on the isospin asymmetry is compared with recent experiments at NSCL/MSU.

Kaon Differential Flow in Relativistic Heavy Ion Collisions

B.A. Li, B. Zhang, A.T. Sustich, and C.M. Ko

Phys. Rev. C (In press)

Using a relativistic transport model, we study the azimuthal momentum asymmetry of kaons with fixed transverse momentum, i.e., the differential flow, in heavy-ion collisions at beam momentum of 6 GeV/c per nucleon, available from the Alternating Gradient Synchrotron (AGS) at the Brookhaven National Laboratory (BNL). We find that in the absence of kaon potential the kaon differential flow is positive and increases with transverse momentum as that of nucleons. The repulsive kaon potential as predicted by theoretical models, however, reduces the kaon differential flow, changing it to negative for kaons with low transverse momenta. Cancellation between the negative differential flow at low momenta and the positive one at high momenta is then responsible for the experimentally observed nearly vanishing in-plane transverse flow of kaons in heavy ion experiments.

Hadronic Scatterings of Charm Mesons

Z. Lin and C. M. Ko

Phys. Rev. C (Submitted)

Hadronic scatterings of charm mesons by hadrons such as the pion, rho meson and nucleon are studied in an effective Lagrangian. In heavy ion collisions, hadronic rescatterings of charm mesons are shown to harden their m_T spectra, leading to a significant enhancement of the yield of intermediate-mass dimuons from open charm decays. Effects on the D meson m_T spectrum and dileptons from charm decays in heavy ion collisions at SPS energies are estimated. We also discuss possible effects at RHIC energies.

Excitation Function of Nucleon and Pion Elliptical Flow in Relativistic Heavy Ion Collisions

B.A. Li, C.M. Ko, A.T. Sustich, and B. Zhang

Phys. Rev. C (Submitted)

Within a relativistic transport (ART) model for heavy-ion collisions, we show that the recently observed characteristic change from out-of-plane to in-plane elliptic flow of protons in mid-central Au+Au collisions as the incident energy increases is consistent with the calculated results using a stiff nuclear equation of state (K= 380 MeV). We have also studied the elliptical flow of pions and the transverse momentum dependence of both the nucleon and pion elliptic flow in order to gain further insight about the collision dynamics.

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.

Description of Heavy Ion Collisions

C. M. Ko

Proc. of International School on Nuclear Physics (In press)

Heavy ion collisions are best described by transport models that include both mean-field potentials and two-body collisions. In particular, the relativistic transport model, which treats consistently the change of hadron masses and energies in hot dense matter, allows one to study these medium effects in heavy ion collisions. In this talk, we review the present understanding of hadron in-medium properties and the progress made in extracting such information from available experimental data using the relativistic transport model.

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, and B.A. Li

Proc. of the Relativistic Heavy Ion Mini-Symposium (World Scientific, Singapore) (In press)

The dilepton yield from open charm decays in relativistic heavy ion collisions is studied in a transport model. Because of their scattering with other hadrons, charmed mesons develop a transverse flow and thus have a harder transverse mass spectrum than that in proton-proton scattering. As a result, in heavy ion collisions at CERN-SPS energies, charm meson decays can lead to a large enhancement of dileptons with intermediate mass (1.5-2.5 GeV), as shown in a previous study based on a schematic model. The dependence of the enhancement on the centrality or total transverse energy in the collision is also studied. For heavy ion collisions at RHIC energies, effects due to initial partonic rescattering need to be considered and are included using the parton cascade model ZPC.

Enhancement of Intermediate-Mass dileptons from Charm Flow

Z. Lin and C.M. Ko

Proc. of the Relativistic Heavy Ion Mini-Symposium (World Scientific, Singapore) (In press)

To study heavy ion collisions at energies 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. Results on various hadronic observables, such as the rapidity and transverse mass distributions of protons, pions and kaons as well as their collective flow parameters will be reported.

Microscopic Calculation of the Nuclear Level Density Parameter at Finite Temperature

B.K. Agrawal, S.K. Samadar, J.N. De and S. Shlomo

Rapid Communication Section of Phys. Rev. C (Submitted)

We calculate the nuclear level density parameter a for a broad range of temperatures ($0.6 \leq T \leq 6$ MeV) using a microscopic model which includes important ingredients like the thermal and quantal fluctuations of nuclear shapes, continuum corrections and Coulomb interaction. Numerical calculations have been performed for ^{40}Ca and ^{56}Fe in a large model space comprising of all the single-particle states with energies up to around 35 MeV above the Fermi

energy. We find that at low temperatures, shell effects are larger for ^{40}Ca and effects of quantal fluctuations are larger for ^{56}Fe. As temperature increases, these effects tend to disappear and continuum corrections become important for T > 3 MeV.

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) (Submitted)

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.

Giant Monopole Resonance and Nuclear Incompressibility Within the Fermi-liquid Drop Model

A. Kolomiets, V.M. Kolomietz, and S. Shlomo

Phys. Rev. C (In press)

We study the important effects of Fermi surface distortion on the isoscalar giant monopole resonance (ISGMR), within a Fermi-liquid drop model, by considering consistently the effects on nuclear incompressibility coefficients and the boundary conditions needed to determine the energy of the ISGMR. There is a significant difference between the static nuclear incompressibility K, derived as a stiffness coefficient with respect to an adiabatic change in the bulk density, and the dynamic one K' associated with the zero sound velocity. We show that the enhancement in the energy of the ISGMR, the lowest breathing mode, which is due to the renormalisation of K into K' is strongly suppressed by the effects of the Fermi surface distortion on the boundary condition. This is not the case for higher breathing modes such as the overtone. We also discuss, in particular, the effects of the Fermi surface distortion on energy weighted sums for the monopole mode and on the constrained and the scaling incompressibility coefficients and their relation to the liquid drop one.

Excitation of Isoscalar Giant Monopole Resonance by Inelastic Scattering of 240 MeV α-Particles

A. Kolomiets, O. Pochivalov and S. Shlomo

NUCLOEX99, RIKEN Publication (In press)

We consider the excitation of the isosealar giant monopole resonances (ISGMR) in ^{28}Si, ^{40}Ca, ^{58}Ni, and ^{116}Sn. We carry out self-consistent Skyrme Hartree-Fock (HP) Random Phase Approximation (RPA) calculations of the strength distributions $S(E)$ and the transition densities $\rho_{tr}(r)$ as functions of the excitation energy E. Recent experimental data of 240 MeV α-particle scattering by these nuclei is analyzed within the Distorted Wave Born Approximation (DWBA) using the folding model (FM) with a density dependent Gaussian nucleon-α interaction $V(\rho,r)$. The parameters of $V(\rho,r)$ are found by fitting the experimentally measured angular cross sections $\sigma(\theta)$ for the case of elastic scattering, using the HF ground state density ρ_{HF}. The inelastic cross sections $\sigma(\theta)$ for the ISGMR are then obtained using the FM- DWBA and both microscopic (RPA) and hydrodynamical (collective model) $\rho_{tr}(r)$ (found from $\rho_{HF}(r)$). Possible overestimation of the energy weighted sum rules and shifts of the centroid energies due to the couective-model-based DWBA reaction description are obtained.

Low Density Instability in an Nuclear Fermi Liquid Drop

V.M. Kolomietz and S. Shlomo

Phys. Rev. C (Submitted)

The instability of a Fermi-liquid drop with respect to bulk density distortions is considered. It is shown that the presence of the surface strongly reduces the growth rate of the bulk instability of the finite Fermi-liquid drop because of the anomalous dispersion term in the dispersion relation. The instability growth rate is reduced due to the Fermi surface distortions and the relaxation processes. The dependence of the bulk instability on the multipolarity of the particle density fluctuations is demonstrated for two nuclei ^{40}Ca and ^{208}Pb.

Projectile Z-Dependence of Cu K-Shell Vacancy Production on 10 MeV/amu Ion-Solid Collisions

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

Phys. Rev. A (In press)

The dependence of Cu (target atom) K-shell vacancy production cross sections on projectile atomic number was investigated in collision systems for which the ratio of projectile-to-target atomic numbers (Z_1/Z_2) ranged from 0.34 to 2.86. A combination of energy and wavelength dispersive x-ray spectrometry was used to measure Cu K x-ray production cross sections and to determine the appropriate fluorescence yields for converting them to K-vacancy production cross sections. The high resolution spectra also revealed the presence of sizable contributions from predominately single-ionization mechanisms not directly associated with ion-atom interactions. The role of electron capture to the projectile was examined by observing the dependence of the cross sections on target thickness. The Cu K-vacancy production cross-sections determined for equilibrated projectiles display a plateau centered in the region of symmetric collisions ($Z_1/Z_2 \sim 1$) and they become essentially constant beyond $Z_1 = 54$. The cross sections for $Z_1 > 24$ fall far below a Z_1^2 scaling law and are greatly overestimated by the ECPSSR theory.

ECR Ion Sources for Accelerators

D.P. May

Proc. of the 15th International Conference on Cyclotrons and their Applications, Caen, France (In press)

ECR ion sources have proven to be ideal providers of multi-charge-state beams for many cyclotrons in the world, as well as for some accelerators besides cyclotrons. The ECR ion source injecting the Super Proton Synchrotron (SPS) at CERN is a notable example of the latter case. Some ECR sources are capable of fully stripping species as heavy as argon and providing ion beams of some of the heaviest species with charge-to-mass ratios up to 1/4, while other ECR sources are designed to produce 100 mA proton beams for accelerator injection. The properties of ECR ion sources, the methods used to produce both intense and high-charge-state ion beams of many stable and radioactive species, and the methods and problems associated with optimizing these sources to match with widely varying requirements will be discussed.

Striving for Intense Beams from the Texas A&M K500 Cyclotron

G.J. Kim and D.P. May

Proc. of the 15th International Conference on Cyclotrons and their Applications, Caen, France (In press)

Recently, our efforts on increasing the extracted beam intensity from our K500 superconducting cyclotron at Texas A&M University have increased in the interest of supporting secondary radioactive beam experiments. We are pursuing plans to upgrade our ECR ion source, such as employing two frequency microwaves for plasma heating, and to clean up our injection line optics to get more beam into the cyclotron. However, the bottleneck will be the performance of the deflectors. In this report, we will describe our general beam tuning procedures and our current cyclotron performance. We will then focus on the properties of three recent beams, two with large beam currents and one with an exceptional extraction efficiency, in order to learn and to extend the performance of our cyclotron.