3. THEORY

3.1 Nuclear Reactions

3.1.1 Relativistic description of Coulomb dissociation: a one-dimensional model

H. Berghammer, D. Vretenar, and P. Ring

Time-dependent relativistic mean field theory is used to describe the dynamics of a one-dimensional nuclear slab after an electromagnetic excitation. Depending on the strength of the excitation we observe harmonic oscillations, evaporation of parts of the slab and full Coulomb dissociation [1].

[1] Phys. Lett. **296B** (1992) 290

3.1.2 The decay of hot nuclei

J.L. Egido and P. Ring

We review the decay modes of nuclear compound states formed after heavy ion fusion reactions. Temperature dependent mean field theory is used as a basis for a statistical description of the hot nuclear system. After a short reminder on traditional cascade calculations for the emission of light particles, statistical γ-rays and the fission process, much emphasis is put on the discussion of recent work on the giant resonance decay. It allows a detailed investigation of these collective excitations and their damping mechanisms both as a function of temperature and angular momentum. Temperature dependent linear response theory in connection with a classical treatment of thermal fluctuations provide a relatively simple framework for a microscopic description not only of these collective transitions but also for the first microscopic calculations of the statistical γ-decay properties [1].

[1] J.Phys. **G19** (1993) 1

3.1.3 Coulomb excitations of a nuclear slab in relativistic mean field theory

H. Berghammer, D. Vretenar, and P. Ring

Time-dependent relativistic mean field theory is used to describe the dynamic behaviour of a nuclear slab excited at time zero by a rapid Coulomb push. At small incident energies of the projectile, we observe oscillations of small amplitude with isovector character. With increasing excitation energy, the motion becomes increasingly anharmonic, and parts of the nuclear material are ejected. At the highest energies, we find a rapid dissociation between the proton and neutron part of the slab. It turns out that the character of the oscillations is strongly influenced by the strenght of the ρ-meson coupling. For vanishing coupling, we observe two modes corresponding in nature to the Goldhaber-Teller mode and the Steinwedel-Jensen mode of the giant dipole resonance in realistic nuclei. At larger ρ-meson coupling, the Goldhaber-Teller mode is more and more suppressed, and one is left with one strongly damped mode of the Steinwedel-Jensen type.

3.1.4 Dynamical aspects of thermal nuclear properties

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We study the collective motion of a certain shape degree of freedom Q, close to local thermal equilibrium parametrized by the thermal entropy S. The extent to which S may be substituted by the more convenient choice of temperature T is discussed. The dynamics in Q and S are treated consistently within a locally harmonic approximation. The collective frequencies are determined by a secular equation, the structure of which is well known in nuclear physics. The effective coupling constant k, however, depends sensibly on thermal, quasi-static properties of the system. Its form differs from the one of previous approaches where dT/dt had been assumed zero. This difference, as well as the dependence of k on T (or S), is numerically estimated. Consequences for the dynamics in Q are demonstrated. Finally, for the case of strict harmonic motion, we compare our results to the one obtained if the concept of "diabatic" motion were plainly combined with that of equilibrium.

3.1.5 Strength distribution of isoscalar vibrations around thermal equilibrium

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We study the collective response as function of excitation for a typical isoscalar mode. We apply a quasi-static picture in which the effective coupling constant changes with temperature T [1]. Around $T = 2$ MeV we find a marked transition in the behaviour of the strength function. Whereas at small T there appear several moderately broad peaks, the strength becomes concentrated in one low frequency mode at large T. The latter is strongly overdamped and its inertia is the one of irrotational flow. We thus interprete this phenomenon as a demonstration of the transition from the coherent collective motion of the shell model, and its modern variants like TDHF, to the one of the compound nucleus, in which all states are strongly mixed.
For more details see [2].

[1] D. Kiderlen, H. Hofmann and F.A. Ivanyuk, "Dynamical aspects of thermal nuclear properties", Nucl.Phys. A550 (1992) 473; see also note in this report.
[2] H. Hofmann, S. Yamaji and A.S. Jensen, Phys.Lett. B 286 (1992) 1

3.1.6 From microscopic to macroscopic nuclear collective dynamics

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The findings of [1] strongly asks for an interpretation of the transition discussed there in terms the Strutinsky method—if extended properly to dynamical situations. To study such a possibility, we apply smoothing procedures to response functions (for isoscalar vibrations). For collective motion, we again find the transition from a structured strength distribution to one corresponding to one incoherent, strongly overdamped mode, seen in [1] within a microscopic computation. It is argued that the latter may be interpreted as "macroscopic" motion—very much in the spirit of the Strutinsky procedure, as applied previously to static properties. To some extent this motion exhibits features of the hydrodynamical model. In [2] the physical origin of this behaviour is discussed, in particular its relation to the disappearance of shell structure.

[1] H. Hofmann, S. Yamaji and A.S. Jensen, Phys.Lett. **B286** (1992) 1, see also note in this report.
[2] H. Hofmann and F.A. Ivanyuk, Z.Phys. **A344** (1993) 285

3.1.7 Decay rate determined from a quantal transport equation

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The decay of a metastable system is parametrized as a damped process along a given collective variable. The decay rate across the barrier (with height B) is obtained by extending Kramers' result [1]

$$R_K = \frac{\varpi_a}{2\pi}\sqrt{\frac{M_a}{M_b}}\left(\sqrt{1+\eta_b^2}-\eta_b\right) e^{-\beta B}$$

to the quantal regime, using an appropriate transport equation. The latter involves a delicate analytical continuation of the fluctuation dissipation theorem to unstable modes. For temperatures above twice the so called crossover value $T_0 = \frac{\varpi_b}{2\pi}\left(\sqrt{1+\eta_b^2}-\eta_b\right)$ we recover the result

$$R = \frac{|\mathcal{Z}_b|}{\mathcal{Z}_a}\frac{\varpi_b}{2\pi}\left(\sqrt{1+\eta_b^2}-\eta_b\right) e^{-\beta B} \equiv f_Q R_K$$

known from applying path integrals to solvable models. Here, the $\mathcal{Z}$'s represent the effective partition functions, calculated for damped collective motion at the minimum a and at the barrier b; the ϖ's stand for the undamped frequencies and the η's measure the effective (dimensionless) damping rates.

In the models mentioned the derivation is restricted to a linear coupling of the "macroscopic" variable to a heat bath of oscillators (see e.g.[2]). This prohibits a direct application to the nuclear case, for which the necessary requirement of self-consistency leads to inherent non-linearities. Moreover, in all cases but one [3], the derivations were even performed within Euclidean metric. Such deficiencies are overcome in the present approach which may thus allow for interesting practical applications. Indeed, as we look at real time propagation, the transport equation can easily be used for Monte Carlo simulations. The latter have proven successfully in many fields of physics. Let us only allude to the following

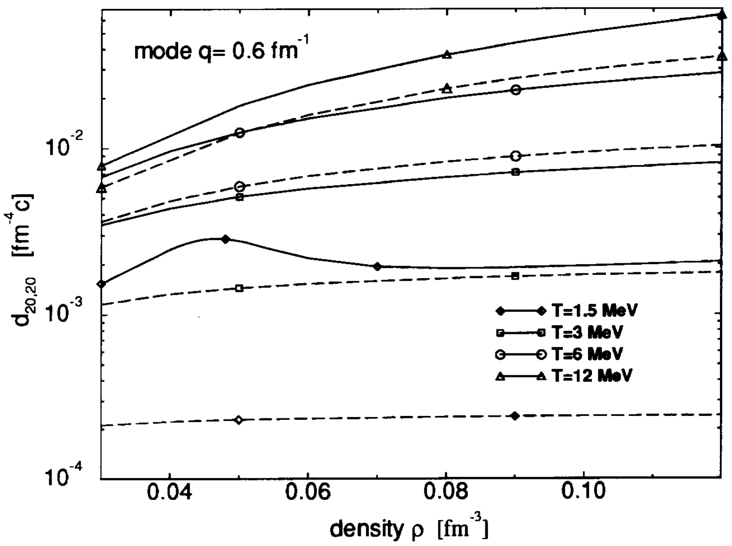
examples where instabilities play a dominant role: a) at low energies: fusion reactions and fission in general; b) at intermediate energies: nucleation and spinodal decompositions in the expansion phase (multifragmentation); c) at high energies: hadronization out of an eventual quark gluon plasma.
For more details see [4].

[1] H. A. Kramers, Physica **7** (1940) 284
[2] P. Hänggi, P. Talkner and M. Borkovec, Rev. Mod. Phys. **62**, (1990) 251
[3] G.-L. Ingold, Thesis, Univ. Stuttgart 1988
[4] H. Hofmann, G.-L. Ingold and M. H. Thoma, submitted for publication in Phys.Rev.Lett.

3.1.8 Dynamics of fluctuations in hot and unstable nuclear matter

D. Kiderlen and H. Hofmann

We follow the suggestion of [1] and picture the onset of multifragmemtation as a dynamical process in the space of a fluctuating one-body density. Whereas in [2] time evolution is treated within the mean field approach of Landau-theory (including a collision term), our approach does take into account a genuine fluctuating force. As compared to [1] our new version contains the following improvements: 1) We explicitly extend our treatment into the regime of spinodal instabilities, following the method described in [3]. 2) The strict limit of the wavenumber $q \rightarrow 0$ is given up. In this way one is able to simulate density oscillations which may be associated to typical break ups into small fragments (c.f. [2]).



Within this formulation local response functions were analyzed numerically and diffusion coefficients $d_{\mathrm{lm,km}}$ were calculated by means of the quantal fluctuation dissipation theorem (FDT). For the case of a quadrupole deformation in momentum space, $\mathrm{l} = \mathrm{k} = 2, \mathrm{m} = 0$, we present numerical results in the figure. For the wave number a value of $q = 0.6\mathrm{fm}^{-1}$ has been chosen to allow for a direct comparison with the results of [4]. For different temperatures we compare the exact results (fully drawn lines) with the ones obtained when quantum effects in the FDT are neglected (dashed curves). We observe strong deviations which decrease with increasing T, of course. It is interesting to note that quantum effects seem to prevail at as high T's as $6MeV$. Furthermore, for smaller T's they lead to intriguing structures in the regime where instabilities occur at smaller densities. At this stage a full comparison with the results of [4] is premature. However, we may note that the change of the diffusion coefficient of [4] with T is almost identical to the one we obtain if we neglect quantum effects in the FDT.

The computations have been performed in the relaxation time approximation. For the mean free path values have been adjusted to the appropriate densities and temperatures, following [5] (see also [2]). The Landau parameters have been fitted to the equation of state of Friedman-Pandharipande, similar to [2].

[1] H. Hofmann, D. Kiderlen and I. Tsekhmistrenko, Z.Phys. **A341** (1992) 181
[2] H. Heiselberg, C.J. Pethick and D.G. Ravenhall, Phys. Rev. Lett. **61** (1988) 818
[3] H. Hofmann, G.-L. Ingold and M.H. Thoma, preprint and this report
[4] M. Colonna, Ph. Chomaz and J. Randrup, preprint (1993) LBL-33402, see also J. Randrup and B. Remaud, Nucl. Phys. **A514** (1990) 339
[5] P. Danielewicz, Phys.Lett. **B146** (1984) 168

3.1.9 Relativistic kinetic calculations of heavy ion collisions with phase space dependent fields

C. Fuchs, L. Sehn, H.H. Wolter

The investigation of heavy ion collisions of about 1 to 2 GeV/A bombarding energy is largely motivated by the search for the equation of state (eos) at high densities and temperatures. A well established framework for the description of such reactions are relativistic transport theories of a Boltzmann-Vlasov type, where mean fields and NN cross section should be determined consistently with the phase space configuration.

Nevertheless in most approaches the mean field is calculated in the so called local density approximation (LDA) which refers to ground state nuclear matter and therefore does not take into account non-equilibrium features of the phase space. To go beyond this description we use self energies which are constructed for the limiting case of colliding nuclear matter by parametrizing ground state Dirac-Brückner results and extrapolating them in a consistent way to colliding nuclear matter [1, 2]. These self energies are then used in relativistic transport calculations in a local phase space configuration approximation (LCA) [3, 4].

For the solution of the transport equation we use a relativistic extension of the Landau-Vlasov method (RLV) with relativistic Gaussian testparticles [4], which reduces the numerical effort as compared to the widely used point testparticle method. In fig. 1 a comparison of the RLV method with results determined with a point particle ansatz [5] are shown for the reaction $^{40}Ca + ^{40}Ca$ at 1 GeV/A. The rapidity distribution is shown for a full BUU-calculation including the collision integral whereas the transverse flow is calculated in a run without collision term (Vlasov). As numerical parameters 50 testparticles with width $\sigma = 1.4$ fm have been chosen in contrast to about 1000 testparticles taken in ref.[5]. In both calculations a good agreement between the different methods can be seen.

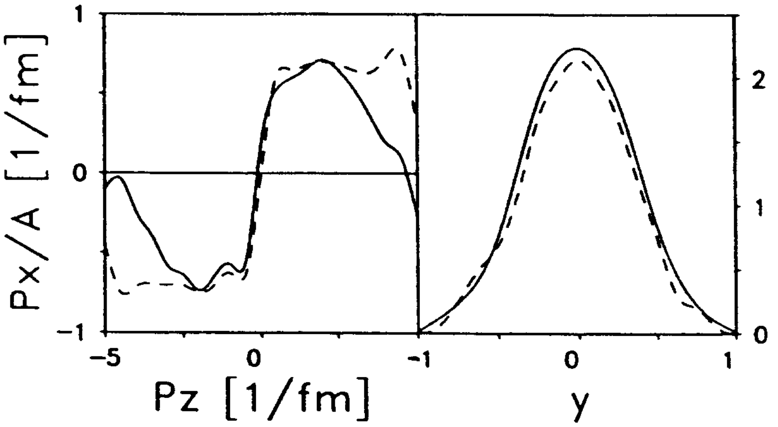


Fig. 1: Rapidity distribution (left) for $^{40}Ca + ^{40}Ca$ at 1 GeV/A, b = 0 fm, RBUU, and transverse momentum distribution (right) $b = 2$ fm, Vlasov. Full line: RLV, dashed line: point test particles.

First results of simulations of heavy ion collisions in the local configuration approximation are shown in fig. 2 and compared to the local density approximation. Transverse flow and rapidity distribution are displayed for the reaction $^{40}Ca + ^{40}Ca$ at 0.8 GeV/A bombarding energy and input parameter b = 1.62 fm. It can be seen that the non-equilibrium effects contained in the LCA approach may influence kinetic observables as flow and stopping power in the same order of magnitude as the use of different eos does and are therefore not negligible.
A more detailed investigation of these effects as well as the investigation of other observables, in particular particle production, and comparison to experiment is in progress.

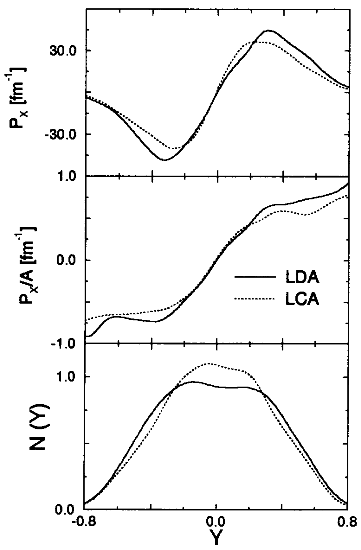


Fig. 2: Final total transverse flow (top), transverse flow per nucleon (midth) and rapidity distribution (bottom) for $^{40}Ca + ^{40}Ca$, B = 0.8 GeV/A, b = 1.62 fm.

Supported by BMFT-grant 06LM352

[1] L. Sehn, H.H. Wolter, Nucl. Phys. **A519** (1990) 289c
[2] H. Elsenhans, L. Sehn et al., Nucl. Phys. **A 536** (1992) 750
[3] C. Fuchs et al., Nucl. Phys. **A 545** (1992) 191c
[4] C. Fuchs et al., Progr. Part. Nucl. Phys., Vol.30, in press
[5] K. Weber et al., Nucl. Phys. **A 515** (1990) 747

3.1.10 Quantum transport theories

R. Fauser, H.H. Wolter

Quantum Transport Theories are used today to describe many-particle systems with strong correlations, like heavy ion collisions or plasmas. They are kinetic equations for large systems which are derived from the basic principles of quantum field theory [1, 2] using as the basic ingredients self consistent summations of perturbation diagrams, Wick's theorem, the linked-cluster-theorem, the Wigner transformation and the quasi-particle approximation. In our investigations we extend the usual Quantum Transport Theories to a general non-equilibirum situation. The main difference is that in the Wick theorem for products of field operators the expectation value of the normal ordered products does not vanish in general [3]. We therefore substitute these normal ordered products by correlation functions and formulate a Wick theorem in non-equilibrium in terms not only of 1-particle Green's functions but also higher-order correlation functions. A linked-cluster-theorem for such a perturbation theory can be derived by using the Schwinger-Keldysh formalism and the analytic properties in the time coordinate for all Green's funcitons. We obtain also for this situation the well-known result that disconnected vacuum-to-vacuum diagrams do not contribute. In analogy to the definition of the self-energy on the level of Hartree-, Hartree-Fock- or T-matrix-approximation, we can also define self-energies in the non-equilibrium case in a self-consistent way. Thus all the ingredients of a QFT are established and the derivation of a transport theory can be performed with the usual steps: Wigner transform, semiclassical and quasi-particle approximations.

To obtain explicit results, we study at the moment the numerical implementation of a Quantum Transport Theory containing the first nontrivial order in the correlations for a non-relativistic Fermi-field with a 2-particle interaction, where we explicitly construct non-equilibrium statistical matrices.

Supported by GSI, Darmstadt

[1] P. Danielewicz, Ann. Phys. **152** (1984) 239
[2] W. Botermans, R. Malfliet, Phys. Rep. **198** (1990) 115
[3] P.A. Henning, Nucl. Phys. **B 337** (1990) 547

3.1.11 Simultaneous and sequential transfer of proton and alpha-particle in elastic ^{11}Be + ^{16}O scattering

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We have developed a method to treat multi-nucleon transfer as the transfer of two - possibly different - subclusters, as e.g. with "^5Li" = (αp). As a consequence we take into account two reaction mechanisms, the one-step simultaneous and the two-step sequential transfer of the two clusters. We formulate the method of calculation of the simultaneous transfer form factor for two non-identical particles and also of the two-cluster spectroscopic amplitudes from shell model wave functions. We apply the method to the elastic transfer reaction $^{11}B(^{16}O,^{11}B)^{11}O$ together with the single α and p transfer reaction $^{11}B(^{16}O,^{15}N)^{12}C$ for E_{lab} between 30 and 60 MeV. We obtain a consistently good description of all the data by reasonable adjustment of the spectroscopic amplitude. In particular we find that the simultaneous (αp) transfer is considerably more important than the sequential transfer indicating strong five-nucleon correlations in these light nuclei.

published in Zeitschr. f. Physik **A342** (1992) 149

3.1.12 Microscopic description of nucleon induced pre-equilibrium reactions

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In nucleon induced processes one usually distinguishes different reaction types, as quasi-elastic, pre-equilibrium, or compound processes. In this work we try to give a unified picture and and a largely unified theoretical calculation of the complete spectrum of a nucleon induced reaction. This is achieved by introducing statistical multistep theories, where statistical assumptions are introduced on the nature of the states and on the reaction mechanism. The approaches discussed here are microscopic in the sense that the nuclear structure information is based on known methods of the nuclear many body problem.

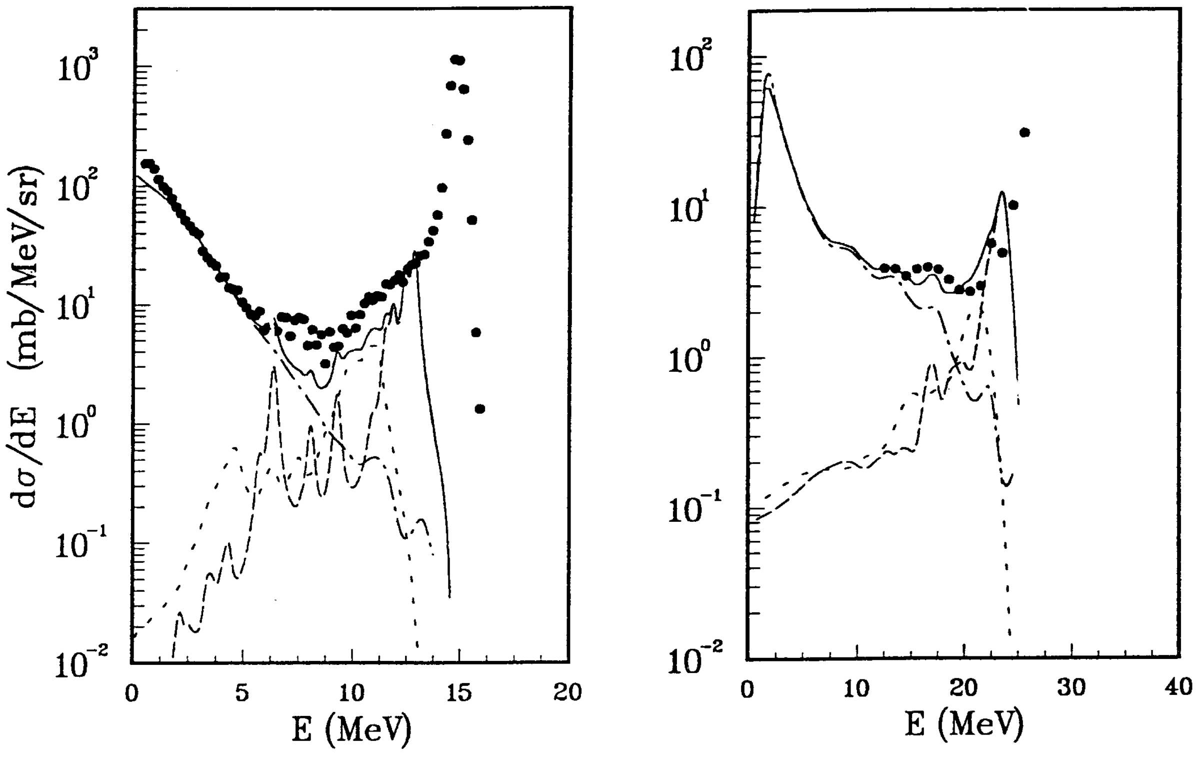

Fig. 1: Neutron spectra from the $^{93}Nb(n,xn)$ reaction at $E_n = 14.8$ (left) at $\Theta = 23^0$ and $25.7 MeV$ (right) at $\Theta = 45^0$. The calculated curves are the MSC contribution (dash-dot), and the one-step (dash) and the two-step (dot) MSD contributions, and their total sum (solid).

The methods considered are the multistep compound method (MSC) which was originally introduced by Nishioka, et al. [1], and the multistep direct reaction theory (MSD), originally proposed by Tamura, et al.[2]. Both approaches describe the reaction as proceeding in steps to more complicated states, where in each step an additional particle-hole pair is created due to the residual interaction. The complicated states reached in this way are assumed to have random phases leading to an incoherent superposition of multistep processes.

In the MSC method all states reached are bound and the transitions between them are described in terms of microscopic shell model level densities and average transition matrix elements [3]. In the MSD method at least one particle is in the continuum. The transitions occur through average transition form factors and the dynamical properties of the process are described by higher order DWBA transition amplitudes. The transistion strength functions are calculated in a quasiparticle-RPA approach, which includes collective effects in the low-lying strength[4].

A result of a calculation is shown in figure 1 for the reaction $^{93}Nb(n, xn)$, as an example. It is seen that the sum of the pre-equilibrium cross section of MSC and MSD (treated up to two steps in this case), plus a compound contribution (HF) for low energies, describes the experimental spectra quite satisfactorily. The biggest discrepancies arise in the overlap reagion of MSC and MSD processes. In this region they are, in fact, not strictly separated, since it is to be expected that flux from the MSD chain enters the MSC chain at higher classes. This effect has been treated heuristically in the present work, but will be investigated in a more systematic way in the future.

[1] H. Nishioka, J. Verbaarschot, H.A. Weidenmüller, S. Yoshida, Ann. Phys. **172** (1986) 67
[2] T. Tamura, T. Udagawa, H. Lenske, Phys. Rev. **C26** (1982) 379
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3.1.13 Continuum spectra of heavy ion induced processes

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In this work we describe the continuum spectra of heavy ion induced reactions in terms of a statistical multistep direct reaction theory, i.e. in an analogous way as in the preceeding contribution. However, here there is no multistep compound contribution. We include elastic scattering and one- and two-step inelastic statistical processes. In addition, we include a pickup-breakup contribution, where in a first step a nucleon is transfered into any state above the particle threshold and is emitted isotropically in a second step, giving a contribution to the inelastic channel. The theoretical treatment is given in more detail in ref.[1].

We have applied the method to ^{12}C induced spectra on ^{12}C,^{58}Ni and ^{90}Zr at about 30 MeV/A [2]. The strength functions in the continuum were calculated in the QRPA approach and reproduce known spectroscopic properties of the nuclei involved. The one-step transfer, i.e. the first step of the pickup-breakup contribution, is consistent with the spectra in the ^{11}B and ^{11}C channels. A representative result for the ^{12}C spectra form the $^{12}C+^{12}C$ reaction at several angles is given in figure 1. It is seen that inelastic processes up to second order account for the data up to about 20 MeV excitation energy, while the pickup-breakup gives a dominant contribution for higher energy losses. The discrepancy at intermediate energy loss is probably due to 3-step inelastic processes.

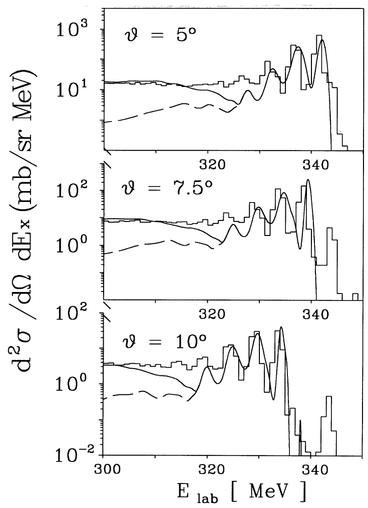

Fig. 1: Double differential cross section of ^{12}C ejectiles in the $^{12}C+^{12}C$ scattering at $E_{lab} = 344.5$ MeV at several angles. The dashed curve is the result of the statistical multistep direct calculation with one- and two-step inelastic excitation. The solid curve includes, in addition, the pickup-breakup contribution.

Supported by BMFT, grant 06LM352, and Internat. Büro, KfK Karlsruhe

[1] H. Lenske, H.H. Wolter, Nucl.Phys. Rev. **A538** (1992) 483c
[2] L. Jarczyk et al., Nucl. Phys. **A518** (1990) 583

3.1.14 Relativistic impulse approximation for heavy ion scattering

M. Haft, H. Lenske, H.H. Wolter

Direct reactions at relativistic energies are of growing interest because of the investigation with radioactive beam experiments of unstable nuclei for astrophysical or nuclear structure reasons. We have started a program to develop a relativistic formulation of scattering and transfer reactions to describe such processes.

In this work we treated the elastic scattering of heavy ions in the impulse approximation in the single folding approximation. The scattering amplitudes of the projectile nucleons in the scalar and vector optical potentials of the target are summed coherently to obtain a first order T-matrix. This is, however, not yet realistic since it contains no distortions of the relative wave function. Therefore higher orders in the nucleus-nucleus interaction have to be included. We have done this in a rough model by treating the T-matrix as a non-relativistic potential, similar as in ref. [1]. A result of such a calculation is given in fig. 1. It is now seen the general shape of the cross section is reasonable, but in detail the diffraction structure is too strong. A more consistent treatment of the higher order effects as well as an extension to inelastic and charge exchange processes is in progress.

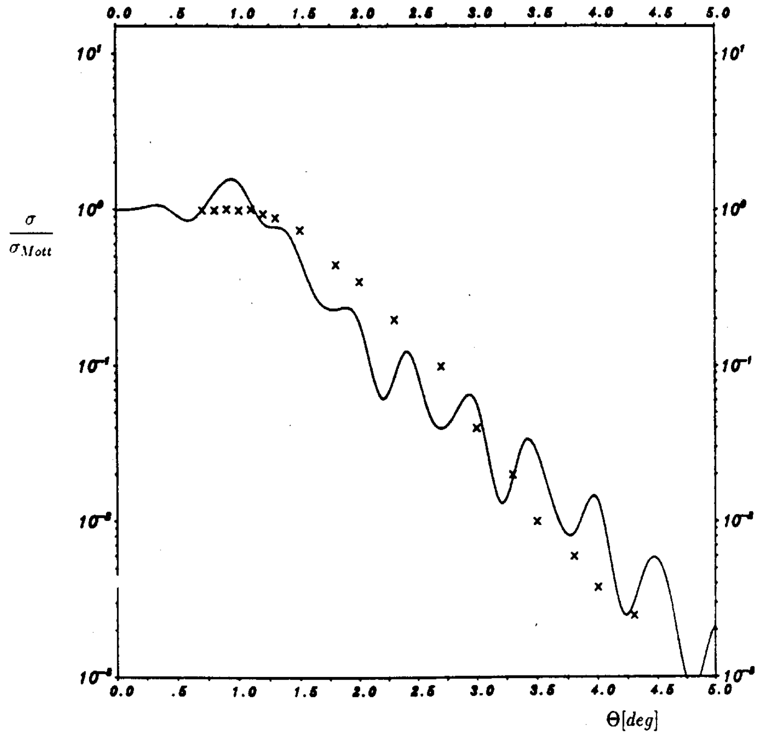

Fig. 1: Elastic scattering of ^{12}C on ^{208}Pb at $E_{lab}/A = 200$ MeV. The solid line is calculated with the relativistic impulse approximation T-matrix used as a potential. The crosses are data from ref. [2].

[1] F.D. Santos, A. Amorim, Phys. Rev. **C37** (1988) 1183.
[2] J.Y. Hostachy, et al., Nucl. Phys. **A490** (1988) 441.

3.1.15 Electromagnetic and mesonic Cherenkov effects in nuclear media

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In this lecture we analyzed the nuclear γ- and π- Cherenkov radiations. All these results can be extended to (η, K etc.)-pseudoscalar mesons or (ρ, ω, K^* etc.)-vector mesons or even to weak boson emission via Cherenkov effects provided the coupling constant $G^2_{MN\bar{N}}$ and in addition the elementary meson-nucleon forward scattering amplitudes are known from experiment.

According to their importance the predicted Cherenkov effects can be considered to be of two types. (i) The Cherenkov effects for the emission of the pseudoscalar mesons. These effects are predicted to be important in the range of 2 - 4 GeV/nucleon (e.g. COSY (Jülich) energies) since the maximum of the integrated cross section is found to be in this range of projectile energies. (ii) Production of γ, vector mesons or even vector weak bosons via Cherenkov processes. Such effects will be important at energies higher than 1 TeV (e.g. at SSC energies) where these effects are exprected to be dominant for the production of vector mesons. We should like to note that at SSC energies both Cherenkov bands are predicted to be experimentally detectable.

Before discussion of whether the band CB-I and B-II can be observed by existing or planned accelerators it is suited to look for their astrophysical implication. We proposed nuclear gamma Cherenkov radiation (NGCR) as a possible mechanism (competitive with bremsstrahlung, π^0 production, synchrotron radiation etc.) contributing to the explanation of the origin of high-energy gamma radiation from galactic sources. We argued that protons or other light ions, accelerated by an internal mechanism of the source star should be able to produce both nuclear gamma bands. By using our values for the cross sections in these two bands and the integrated experimental flux $\phi_1(\omega_1)$ for $\omega \geq \omega_1$ of the CB-I band we are able to predict the integrated flux $\phi_2(\omega_2)$ for $\omega \geq \omega_2$ of the CB-II energy region. For the Crab-pulsar we obtain in this way the predictions displayed in Fig.6 of these proceedings. From these results it can be seen that a correlation between the observed fluxes $\phi_1(\omega_1)$ and $\phi_2(\omega_2)$ can be explained by the NGCR mechanism. More elaborate investigations will be necessary to take into account the contributions to galactic gamma radiation from decaying π^0, ρ^0 and ω^0 mesons. Some of these mesons might also be produced by a nuclear mesonic Cherenkov process by the same incident beam of charged particles (p, α etc.).

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3.1.16 Coherent photon and meson production via Cherenkov-like effects in heavy-ion interactions

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Numerical results on the refractive indices of photons and mesons inside a nuclear medium are calculated. These values are obtained via a multi-particle scattering approach by using the experimental data on spin-averaged gamma-nucleon and pion-nucleon forward scattering amplitudes. Our special interest concerns the possibility of gamma as well as of pion radiation through Cherenkov mechanisms in relativistic heavy-ion collisions. A nuclear gamma-Cherenkov band is predicted for photon energies between 140 MeV and 300 MeV, and projectile energies higher than 16 GeV per nucleon. A pionic Cherenkov band is found to be observed in the energy range 200 MeV$\leq \omega \leq$ 300 MeV for projectile energies higher than 750 MeV/nucleon. Differential and integrated cross sections are calculated taking density and absorption effects into consideration.

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Abstract of Contributed Paper No. 230, XXVI Int. Conf. on High-Energy Physics, Dallas, 1992

3.1.17 High-energy nuclear γ-Cherenkov radiation and astrophysical implications

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Using γN forward scattering amplitude data and the Foldy-Lax multiple scattering formalism, the refractive index for photons inside a nucleus is calculated. The existence of two nuclear γ-Cherenkov bands, localized in the energy regions of $140 \div 300$ MeV and $50 \div 500$ GeV, is established. The corresponding threshold energies are 15 GeV/A and 1.5 TeV/A. The intensities of the nuclear γ-Cherenkov radiation are predicted taking also absorption effects into acount. On this basis, the nuclear γ-Cherenkov radiation is proposed as one of the possible mechanisms for a unified description of cosmic γ-ray emission at photon energies higher than 100 MeV.

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3.1.18 Quantum theoretical approach to meson production in nuclear media via Cherenkov mechanisms

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A quantum theoretical approach to single scalar and pseudoscalar meson production via mesonic Cherenkov mechanisms in homogeneous nuclear media is worked out. The expressions for the quantum Cherenkov coherence condition as well as for the quantum rate of emission for Cherenkov mesons are derived. Some numerical estimates of these expressions as well as their semi-classical limits are discussed.

Supported in part by COSY (Jülich)