Nuclear Disassembly in Relativistic Heavy Ion Reactions

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In relativistic heavy ion collisions nuclear matter will be fast and strongly compressed. The decompression, expansion and disassembly of such an excited system is discussed by a *selfconsistent Hartree-Fock model* . The time dependence of the nuclear disassembly shows *bubbles-cluster behaviour* which arise from strong fluctuations of the one-body density. *Mass spectra* are shown and discussed.

Consider a relativistic heavy ion collision forming a highly excited and compressed nuclear system. How does such a system finally disassemble after its expansion to the limits of dynamical stability? How small or big are the stable nuclear fragments? Up to now this problem has been discussed by quasi-static concepts, envoking a freeze-out at the 'end' of the expansion[1,2]. Even chemical dynamics in terms of rate equations[3] may not make too much sense as the range of nuclear 'bonds' still exceed the spacing among nucleons before break-up.

Thus, there is a need for an entirely dynamical description of the decompression and expanison phase as it was suggested in ref. 4. Let us consider a field theoretical model. It comprises three ingredients: a) the definition of the initial compressed nuclear system with temperature, b) the dynamics that cranks this configuration through the instability region, and c) a counting procedure of the final stable fragments.
a: We assume a macrodynamical model which provides the information upon the one-body density matrix $f^0(r,p)$ at time t=0 the starting time of the decompression and expansion phase. At this time the system is represented by an ensemble of pure states (Slater determinants), such that the ensemble average reproduces f^0.
b: Each of these pure states is propagated selfconsistently in its proper one-body field (like in TDHF) until stable fragments are built up.
c: Fragments are defined and counted if the density exceeds 0.1 ρ^0.

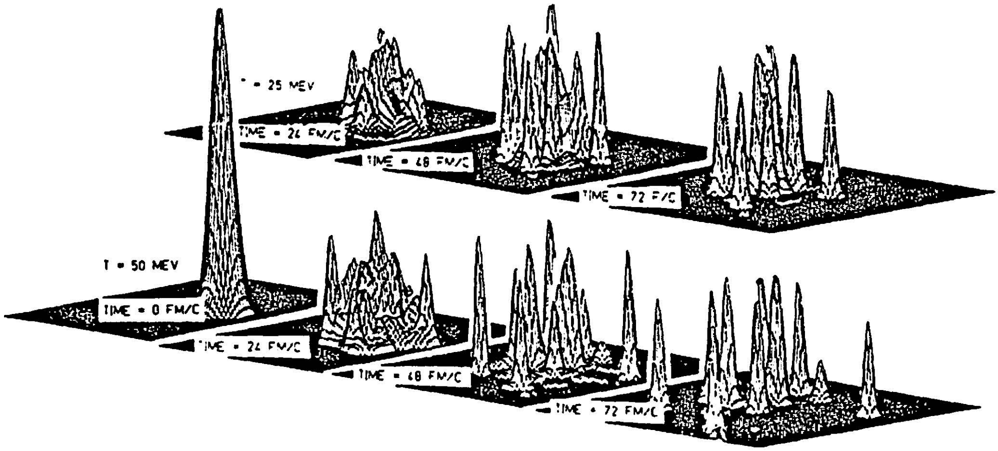

Fig. 1: Sequence of density plots in a 2+1 dimensional calculation; T= 50 MeV and T= 25 MeV are representing the two different momentum distributions. The initial compression is always equal 3 ρ^0.

As compared to ordinary mean field theories at finite temperature which treat the whole statistical ensemble in a single common mean field, here each individual state evolves in its proper one-body field. Thus fluctuations in the one-body field are calculated, which in turn generate the various forms the system can granulate. The fluctuations are caused by the high entropy (S=2 to 4) of the ensemble of pure states.

The time evolution of one compressed configuration is displaced in figure 1.. Two different momentum distributions representing a T= 50 MeV and a T= 25 MeV pure state of a spin-isospin symmetric (40 particle) system are shown. Clearly one sees that fragments are not produced during a surface evaporation process. A fluid-bubbles-cluster behaviour 'is the more precise definition.

The number of final fragments and especially the mass spectra are a sensitive function of the excitation energy (see fig. 2). The binding effect included in the calculation are not only seen in the dynamics displayed in fig. 1 but also in the characteristic differences in the resulting mass spectra. Fig. 2 is discussed in ref. 5.

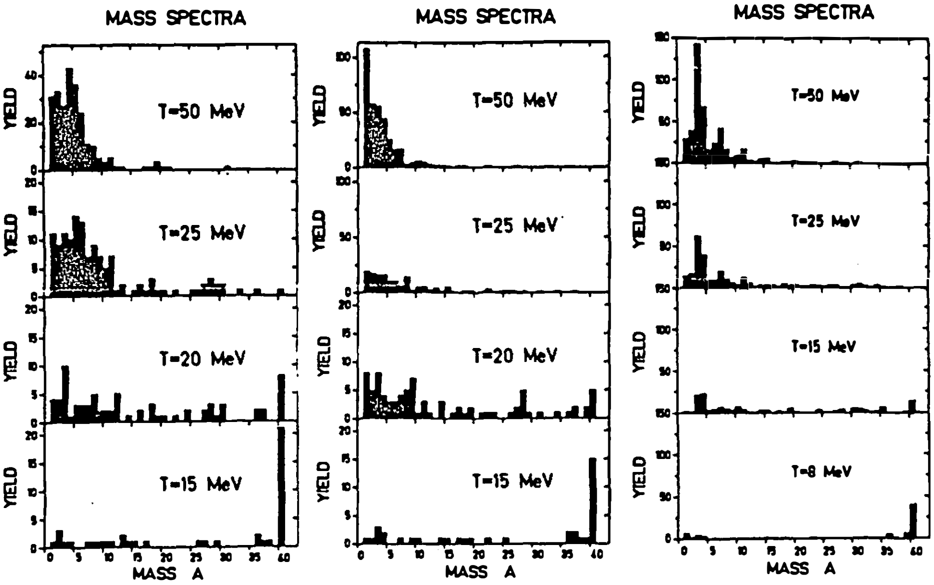

Fig. 2: Mass spectra at four values of T and initial compression of $3\rho^0$ resulting from the ensemble average of thirty runs for each T. The spectra on the r.h.s. is extracted from 60 runs for each T. The figure contains from left to right:

a: Spectra with spin-isospin dependent dependent force calculated with 40 wave functions.

b: Spectra with no spin-isospin dependent force calculated with 40 wavefunctions.

c: Spectra based on spin-isospin symmetric force calculated with 10 wavefunctions.

References

1) A.Z. Mekjian, Phys. Rev. Lett. 38(1977)640,
Phys. Rev. C17(1978) 1051.
2) H. Gutbrod et al., Phys. Rev. Lett. 37(1976)667.
H. Sato, K. Yazaki, Phys. Lett. 98B(1981)153.
3) I. Montvay, J. Zimanyi, Nucl.Phys. A316(1979)490.
4) B. Strack,J. Knoll, GSI Scientific Report 1982,119.
B. Strack,J. Knoll, Z. Phys. A315(1984)249.
5) J. Knoll, B. Strack, Proc. Hirschegg 1984, p.45, Austria.