Thermodynamic Variables from Spectator Decay

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The experimental study of the nuclear liquid-gas phase transition has made considerable progress in recent years. In particular, the first reports of a caloric curve and of values for critical point exponents have received wide interest and stimulated further work. These results suggest that signals of the nuclear liquid-gas phase transition may be revealed by studying reactions of finite nuclei.

A program to measure thermodynamic variables in spectator decays is being pursued by the ALADIN collaboration. The reaction ^{197}Au + ^{197}Au at energies from 600 to 1000 AMeV was studied in several experiments covering the projectile and the target spectator regime. The excitation energies and masses at breakup are determined by calorimetry, i.e. by reconstituting the decaying system from the observed fragmentation products. The masses are in very good agreement with the predictions of the geometrical participant-spectator model. The excitation energies, however, were found to depend considerably on the bombarding energy. This is in contrast to the universality observed for the products with $Z \geq 2$ and may indicate contributions from pre-breakup emissions.

Evidence for spatial expansion is obtained from particle interferometry. Proton-proton correlations and correlations of light complex particles (p-α, d-α, t-α) yield similar breakup densities of the order of one third to one fifth of normal nuclear density.

Temperatures deduced from double ratios of isotopic yields and from populations of excited states in light fragments do not agree and seem to be sensitive to different stages of the fragment production. The saturation of the excited-state temperatures at values of about 5 MeV is in marked contrast to the isotope temperatures which rise to values of more than 10 MeV with increasing spectator excitation.