Clustering effects in the nearby of N=Z excited nuclei produced in heavy-ion collisions

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There is much recent interest in studying clustering effects well above the separation energy for light autoconjugate atomic nuclei [1–4]. The idea is that the underlying α structure of these systems can survive at relatively high excitation energies thus producing, for instance, detectable effects in the evaporative chains occurring after nuclear reactions or, at higher excitation, in the many fragment disassembling. At bombarding energies below 15-20 MeV/u the investigated nuclei can be excited through fusion or strongly damped collisions and one can observe their decay and detect possible deviations from 'standard' statistical models basing only on the average phase-space, where details of the structure are not included. This kind of study is quite interesting not only in regards to the most abundant α cluster nature but opens a broader panorama on nuclear correlations and in-medium effects. In the same sense it could be interesting to extend correlation studies (e.g. α clustering and in medium effects) at higher energies where the role of the dynamics coupled to the underlying cluster nature can give specific fragment configurations and manifest during the break up of the neck developing during the interaction.

NUCL-EX group [6] is active in this field both at the Tandem energies (at Legnaro) and at the Fermi regime at the facilities like LNS and, in the next future, at GANIL. The experiments are conducted with different arrays for charge particle detection where, thanks to the long expertise of the participants, quite excellent performances have been achieved. At Legnaro, experiments are based on the GARFIELD + RCO multidetector [7], which is under continuous upgrading also in view of the next coming SPES radioactive beams. At the Fermi energies, our group is carrying on experiments with the FAZIA blocks [8], made of Si-Si-CsI telescopes with advanced fragment identification capabilities allowing to access isotopic distributions up about Z=24 for enough energetic ions. Together with performing detectors, our group has proficuous contacts with theorists expert in the field of nuclear reactions and, in some cases, also developed by itself some specific code to interpret the experimental results. For example, for the experiments with light systems the group has implemented a version of the Hauser-Feshbach model for nuclear decay, purposely devoted for light nuclei $A \leq 25$, including all known single-level information inferable from databases.

My thesis will concentrate on this kind of subject, following the evolution of the group experiments. Thus, I'll work on the investigation of cluster effects and correlations in nuclear reactions. At lower energies, the idea is to propose a first experiment at Legnaro using the local GARFIELD + RCO array dedicated to the investigation of the system ^{24}Mg and ^{25}Mg formed by fusion reactions of ^{12}C and ^{13}C on ^{12}C at beam energies around 12 MeV/u. The aim is to completely reconstruct all the decay channels for both systems, in order to underline if there are some residual clustering effects even at these high excitation energies (around 90 MeV), at the limit of the fragmentation regime. Moreover, with the proposed experiment we would like to extend our analysis to the fission channel where an heavier fragments is associated to an intermediate mass fragment instead of some light charged particle (as tipically happens): this study can be used as another way to investigate the presence of cluster effects in the fused systems, like already did in Ref. [4], but with complete data and exclusive analysis. The data obtained will be also compared with the same system but formed at lower energies (around 60 MeV), from which we have already seen some clustering effects in the decay channels branching ratios. These data are already in possession of the NUCL-EX group.

As for the cyclotron energies, this year the group will perform two experiments at LNS on the systems ^{40}Ca, ^{48}Ca+^{12}C at 25, 45 MeV/u and ^{32}S+^{12}C at 25, 45 MeV/u. The objectives of these measurements go from the pre-equilibrium effects as a function of the neutron content of the system to the decay of excited light fragments produced in the medium. It's my intention to profit

of this hopefully rich variety of data to investigate in detail the presence of α cluster effects both in central and in peripheral events where during the formation and/or the decay of excited subsystems the role of strong clusterized structure of the reacting ions can still be sizeable. Comparison with refined (MonteCarlo) dynamical and decay models will be used, in contacts with theorists, for a deeper understanding of the processes.

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