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Investigating cluster structures in the A=10 mass region via ^{10}B + ^{10}B nuclear reactions

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Reveling the details of different states in light nuclei and gaining a complete spectroscopic picture of nuclei close to the A=10 is important for many reasons. In this mass region states of dominantly shell model character are mixed with molecular and cluster states, including rather exotic ones, like Borromean (e.g. 9Be) and halo (e.g. 11Be) states, or even Bose-Einstein condensates (11,12C, 11B).
The nuclei of interest have been accessible by ab initio calculations for some time, so they can serve as a testing ground for improving the corresponding models. Furthermore, many of the states close to the A=10 region are important inputs to astrophysical and cosmological models, since light nuclei occur in early nucleosynthesis and every phase of stellar evolution.

The high-energy region of these nuclei exhibits a dense concentration of states with significant overlap, posing a particular challenge for investigation. Well-defined states preferentially populated in specific experimental channels within this high-energy region not only offer insights into structural characteristics but also serve as compelling evidence thereof. While reaching high-spin states is not always feasible, the unique conditions of the experiment presented here, allow for the population of such states in the exit channels.

Results of nuclear reactions 10B + 10B, measured at 72 MeV, will be presented, the most important being new and rarely seen states in the 12C and 13C [1, 2], which motivate targeted future experiments. In particular, a new state of 12C at Ex = 24.4 MeV is strongly populated in the triple α-particle coincidences, while the rarely seen state at Ex = 30.3 MeV is found to be strong in the d+10B decay channel, reinforcing the previous suggestions that it has the exotic 2α+2d molecular structure [3]. Regarding the 13C nucleus, a potentially novel state at Ex = 19.0 MeV is prominently observed in α+9Be coincidences and demonstrates a well-defined cluster structure. Furthermore, so far unobserved alpha decay of two high-energy 13C states at 21.9 and 23.6 MeV is discussed.

In four nucleons transfer reaction channel, excited states of the 14N at Ex = 13.2 and 15.39 MeV were measured. Both of them fit nicely to a recent AMD calculations [4] as the head and the 5+ state of the 10B(3+) + α rotational band (Kπ = 3+).

Lastly, the unique opportunity presented by 10B + 10B reactions to study high-energy, high-spin states in mirror nuclei pairs such as 9Be-9B, 10Be-10C and 11B-11C is explored. Mirror pairs provide information about the charge independence of the nuclear force, and, in certain cases, the Coulomb displacement energy (via so-called Thomas-Ehrman effect), that can lead to a better understanding of underlying nuclear structure. The experimental data on cluster states in light mirror nuclei are still very rare, though it is clear that they can provide very useful insights.

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[3] - Miljanić Đ. et. al., Zeitschrift für Physik A 312, No. 3 (1983) 267
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