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Continuum spectroscopy of light nuclei studied by high-order correlation experiments

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Recent technical advances have allowed for high-order correlation experiments to be done. We have primarily focused on experiments in which the final channels are composed of only alphas and protons. Five cases we have studied are:  ${}^{6}Be_{gs}, {}^{8}C_{gs}, {}^{8}B*_{AS}, {}^{10}C*, {}^{12}C*, {}^{12}O_{gs}, and {}^{12}N*_{AS}$ . While the first case  ${}^{6}Be_{gs}$  had been studied before, our work presents very high statistics in the full Jacobi coordinates (the coordinates needed to describe 3-body decay). <sup>8</sup>C decay presents the only case of sequential 3-body 2p decay steps (i.e. 2p-2p.) The intermediate in this 2-step process is the first example ({}^{6}Be) mentioned above. Unlike the well-studied second step ({}^{6}Be decay), the first step in this 2p-2p process provides another example of correlated 2p emission. The decay of  ${}^{8}B_{AS}$ , the isobaric analog of  ${}^{8}C$ , also decays overwhelmingly by 2p emission, in this case to  ${}^{6}Li_{AS}$ . This is the first case of IAS-to-IAS 2p decay, one for which decay to the potential 1p intermediates is energetically allowed but isospin forbidden. This represents an expansion, over that originally envisioned by Goldanski, of the conceivable nuclear territory for 2p decay. Our study of {}^{10}C excited states provides isolatable examples of: correlated 2p decay, from one state, and the decay of another which is unusually highly correlated, a "menage a quatre". Data for the second case of IAS  $\rightarrow$  IAS  $2^{-p}$  decay  ${}^{12}N*_{AS} \rightarrow {}^{10}B*_{AS}$  will be presented. In this case, the correlation experiment allowed for the  ${}^{12}N*_{AS}$  to be found, thus completing the A = 12 T=2 quintet. A long-standing controversy over the width of  ${}^{12}O_{gs}$  is resolved, we deduce an upper limit to the width 6 times smaller than the literature value. We have also found the double isobaric analog state (DIAS) in {}^{11}B\_{DAS}. This provides three members of the T=5/2 sextet that includes  ${}^{11}Li_{gs}$ .

The data from these high-order correlation experiments allowed for: an improved fit of the IMME equation for the A = 8 isobar, the first fitting of the A = 12 quintet, and proving the extended nature of the  ${}^{11}Li_{gs}$  wavefunction. Isospin symmetry is broken in the A = 8 system but not for the A = 12 system. Of relevance for nucleosynthesis, these correlation data allowed us to demonstrate that the alpha decays of the excited states of  ${}^{12}C$  at 7.65 MeV (Hoyle) and 9.64 are consistent with preceding 100% through  ${}^{8}Be_{gs}$  and show that the first 2<sup>-</sup> of  ${}^{12}N$ , relevant for  ${}^{11}C(p,g)$ , is almost a factor of two narrower than previously thought.

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