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Experiment Proposals

Suggestions based on recent theory

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Proposals for new experiments resulting from recent theoretical work at Oxford.

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1. Our recent interpretation of the decay of alpha chain states suggests that the spreading width is larger than the escape (or fission) width. The implication of this is that the chain state resonance is strongly mixed with other cluster resonances at the same excitation energy in ^{24}Mg. This implies that if the chain state is observed with high energy resolution it should be seen to be fragmented into a large number of narrower resonant structures.

   We propose that the excitation function and angular distributions (from 30° to 90°) should be measured with an adequately thin target and an energy step of 100-200 keV in the centre of mass. These data should show evidence of the narrower intermediate structure resonances typical of ^{12}C+^{12}C scattering. We essentially have found evidence of this effect in the Argonne data where we had to add random components at each energy to fit the data. But the energy step was too large to really determine if this was intermediate structure.

2. Following on from the above, as we know from our own work and the Strasbourg conference, because of the mixing and the coherence of the angular distributions at 90° evidence of the existence of a "shape eigenstate" can be found in reaction channels other than the fission channel. Thus the search for other alpha chain states may be easier if we were to look for 90° enhancements in mismatched 0^+–0^+ final states—but not necessarily the multi-alpha fission final state.

   Thus for ^{28}Si we maybe should use the ^{16}O+^{12}C reaction but look at the ^{16}O(12.05 MeV 0^+) + ^{12}C(7.65 MeV 0^+) channel, at 90° in the centre of mass over a wide energy range.

   It may be there are effects we do not yet understand about chain states in odd-alpha nuclei. Possibly the existence of negative parity states in the entrance channel also creates problems. Thus it may be better to look in ^{32}S via ^{16}O+^{16}O looking at the mutual 12.05 MeV 0^+ excitation.

The 12.05 MeV state is observed in ^{16}O scattering using the RPS technique (Rae et al. Phys.Rev. **C30** (1984) 158, S Allcock D.Phil Thesis 1986). It is close to the 11.47 MeV 2^+ which is strong. But with detectors placed sufficiently far from the target it should be easily resolved cleanly. It decays to $^{12}C_{gs} + \alpha$ so a hybrid-strip pair is required to detect each ^{16}O.

3. Calculations of the D1 band in ^{24}Mg (Jie Zhang) are beginning to suggest that the ground state of the D1 is below the barrier—possibly starting at around 15 MeV E_x in ^{24}Mg (c.f. ^{20}Ne. The ground state of ^{20}Ne is closely related to D1. The 0_2^+, 0_3^+ and 0_4^+ bands in ^{20}Ne are closely spaced bands in ^{20}Ne two of which are known to be vibrations of the $^{20}Ne_{gs}$. The third we believe is also closely related. These bands start at around 6 MeV E_x in ^{20}Ne and are closely spaced. These could correspond with the barrier resonances in ^{24}Mg some 6 MeV or so above the D1 ground state.) (See also next section 4.)

   To probe this we should use ^{16}O+^{12}C and sit on one of the resonances observed by S.Fox in the $^{16}O_{gs}$+$^{12}C(0_2^+)$ final channel. Such a resonance should have an α–^{16}O–α–α structure. Thus alpha decay should take it to the gs of the D1 band in ^{24}Mg and although this is below the barrier for ^{8}Be or ^{12}C decay—it can alpha decay. So study the $^{16}O(^{12}C,\alpha–\alpha)^{20}Ne$ reaction (c.f. Rae + Keeling, Nucl.Phys. **A575** (1994) 175). Data should be taken at the strong resonance energies in S.Fox's data and off resonance to compare the spectra of ^{24}Mg on and off resonance. (See also Zhang et al. Phys.Rev. **C48** (1993) 2117 and Eswaran et al. Phys.Rev. **C47** (1993) 1418.)

4. A new type of shape eigenstate in ^{32}S and negative parity D1.

   We have just modified the BB model to improve the calculations for the D1 band in ^{24}Mg. As a result of this we can now predict a stable negative parity D1 band in ^{24}Mg some 0.5–1 MeV above the positive parity band.

   The D1 is part of a family starting with ^{12}C. The family is ^{12}C, ^{12}C–α (^{16}O gs), α–^{12}C–α (^{20}Ne gs), α–^{12}C–α–α (D1), α–α–^{12}C–α–α (see above 3), α–α–α–^{12}C–α–α (^{32}S) and ...

   Alan Merchant is calculating the properties of these states using the new improved BB code. In ^{32}S the moment of inertia of the band may be close to that of the 6–α chain state—and thus may be a "Shape Eigenstate". The entrance channel is obviously ^{20}Ne+^{12}C—thus an Argonne experiment. We will keep you posted.

   (The improvement to the BB model is essentially a better parity projection algorithm which generates a better wavefunction in a variational sense.)