Octupole correlations in ^{235}U.

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In a recent paper [1], we suggested that the large attenuation of Coriolis matrix elements between members of the j15/2 multiplet in ^{235}U might be linked to the strong E3 excitations observed in our Coulomb excitation studies. To test this idea, calculations within the framework of the QPRA (quasi-particle random phase approximation) and QPVC (quasiparticle-vibration coupling) coupling to octupole phonons have been performed, and are now completed.

The calculations used standard Nilsson model parameters, and octupole coupling strengths were taken from the self-consistent values for the deformed harmonic oscillator [2]. First, the octupole phonon energy $\hbar\omega_n$ and its creation operator X_n^+ are constructed by solving the RPA equation of motion. The Hamiltonian for an odd-A nucleus is shown in the equation below,

$$H = const + \sum_{\mu} E_{\mu} a_{\mu}^{+} a_{\mu} + \sum_{n} \hbar\omega_n X_n^{+} X_n + \sum_{\mu\nu}\sum_{n} f_n(\mu\nu) a_{\mu}^{+} a_{\nu} X_n^{+} + h.c.$$

where $\alpha_\mu(E_\mu)$ is a quasiparticle operator (energy) and the coupling constant $f_n(\mu\nu)$ is determined by the RPA solutions. Dressed quasiparticle states are found by diagonalizing this Hamiltonian within the space of one-qp states, and one phonon–plus-one-qp states. The QRPA calculations produced octupole phonons K = 0, 1, and 2, which were nearly degenerate at an excitation energy of about 700 keV, the K=3 phonon was calculated to lie at about 1MeV. In neighboring even nuclei, K=0 phonons are known near 700 keV, but the known K=1, and 2 phonons lie higher than calculated near 980 keV; the positions of K=3 phonons are not known experimentally.

Results for the calculated dressed quasiparticle wave functions for important members of the j15/2 multiplet are as follows:-

|K=3/2> = 0.76 |[761] 3/2> + 0.60 |[633] 5/2> K=1-
|K=5/2> = 0.92 |[752] 5/2> + 0.32 |[633] 5/2> K=0-
|K=7/2> = 0.98 |[743] 7/2> + 0.13 |[613] 7/2> K=0-
|K=9/2> = 0.77 |[734] 9/2> + 0.51 |[622] 5/2> K=2-

These results may be compared with those of Gareev et al derived with the Woods-Saxon potential [3]: the present results indicate substantially more octupole mixing.

With the wave functions given above, we have computed the Coriolis matrix elements, < K+1 |j+| K > and find that they are attenuated by the approximate factors 0.75(K=3/2), 0.90(K=5/2), and 0.70(K=7/2). The corresponding experimental numbers [1], derived by fitting the energies of the K = 5/2, 7/2 and 9/2 bands are 0.78, 0.52, and 0.43. The octupole mixing then appears to offer only a partial explanation for the attenuated matrix elements, however the effect of pairing (not yet included) strongly reduces the K=5/2-7/2 value where the orbitals lie on opposite sides of the Fermi surface. Our present estimate for the pairing reduction is about 0.7 for this matrix element, but more detailed calculations are in progress.

A consequence of octupole mixing with the positive parity states is to generate enhanced B(E3) strengths to the ground state (7/2-). The results of the QPVC calculations are shown below, where P is the probability for zero phonon states, ie. a pure quasiparticle state has P = 1.

[631]1/2	P > 0.99	[622]5/2	P = 0.91
[633]5/2	P = 0.89	[631]3/2	P = 0.90
[624]7/2	P = 0.75	[606]13/2	P > 0.99

With the exception of the [606]13/2, rotational states built on all these quasiparticles were observed in the experiments and the measured B(E3)-values are within 20% of those calculated above with the exception of the [631]1/2 band, which is strongly excited in the experiment, but is calculated to be an almost perfectly pure quasiparticle state.

REFERENCES

[1] D. Ward et. al. " Nuclei at the Limits" ANL 2004
[2] H. Sakamoto & T. Kishimoto, Nucl. Phys. A501(1989) 205
[3] F. A. Gareev et. al. Nucl. Phys. A171 (1971) 134