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Investigation of octupole excitations in 207Tl using gamma-gamma angular correlations at the ISOLDE Decay Station

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^{208}Pb is the heaviest stable doubly-magic nucleus and has been studied in great detail. Its first excited state occurs at 2.6 MeV and corresponds to an octupole vibration, resulting from the collective behaviour of a number of E3 ($\Delta l = \Delta j = 3$) particle excitations across the closed shell. This octupole transition has been observed in several other nuclei around ^{208}Pb, including the single proton-hole ^{207}Tl[1]. This nucleus has a number of known states; however, below the core-breaking limit[2] only the four states below 2 MeV ($s^{-1}_{1/2}, d^{-1}_{3/2}, h^{-1}_{11/2}, d^{-1}_{5/2}$) are well-known from previous experiments[3]. It is expected that, given a $\frac{9}{2}^+$ ground state in ^{207}Hg and a Q-value of 4.8 MeV, β decay from ^{207}Hg should populate many of the states consisting of one of these proton-hole states coupled to the octupole 3^- vibration.

One experiment took place in 2014 and a second in 2016, both at the ISOLDE Decay Station (IDS) at CERN. Using the molten lead target on the General Purpose Separator (GPS), ^{207}Hg was produced at a rate of up to 5×10^4 pps in 2014, and 2×10^5 pps in 2016. This was deposited on the tape at IDS and observed by an array of five HPGe detectors.

A new level scheme, including 9 new levels and 73 new transitions, has been established in this analysis. Using relative transition strengths, $\gamma\gamma$ angular correlations, logft values and electron conversion coefficients, spin-parities have been deduced for the majority of observed states. Angular correlations of successive gamma rays have been performed successfully for a small number of transitions, and used where possible to guide the assignments. This study has motivated the improvement of the IDS setup for angular correlation studies in the future. The KHM3Y shell model calculation - which gives the most accurate replication of the octupole excitation in this region[4] - was performed, and a good agreement was observed between the predicted and experimental level schemes. The majority of the states correspond to three-particle excitations breaking the neutron core. Six collective octupole-coupled states have been observed: the two states corresponding to $\pi s^{-1}_{1/2} \times 3^-$, three of the four $\pi d^{-1}_{3/2} \times 3^-$ states and, tentatively, the $\frac{7}{2}^+$ $\pi h^{-1}_{11/2} \times 3^-$ state.

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