Deviations from the Statistical Model in Capture γ-ray and EC/β^+-decay Data

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In highly excited nuclei level densities, spin distributions, and photon strengths can be described by their average statistical properties. The earliest treatment of level densities and spin distributions was by Bethe[1] in 1937. Analysis of the E1 photon strength was described by Axel[2] in 1961 based on the earlier work by Brink[3] and others. M1 and E2 photon strengths can be estimated by Weisskopf[4] single particle calculations but these transitions are dominated by nuclear structure effects that are not adequately treated in the statistical model. Many recent improvements to the statistical model have been proposed yet the fundamental concept of this model leads to smoothly varying level densities with excitation energy.

M1 and E2 photon strengths are normally assumed to be weaker than E1 photon strengths and less important in statistical model calculations. However, the shell model shows that dominant parity reverses at each oscillator gap exist leading to energy regions where M1 and E2 transitions may predominate. Favored M1 "spin-flip" and scissors band transitions may dominate. The rotational model blurs the shell gaps but also leads to collectively enhanced E2 photon strengths. In even-even nuclei pairing suppresses the emergence of negative parity levels at low excitations leaving an energy region, sometimes up to 3-4 MeV, where only M1 and E2 transitions are possible. If M1 and E2 transitions become important nuclear structure models suggest this will lead to fluctuations in the statistical model.

The level density observed in neutron time-of-flight experiments is incomplete and different from that which is observed in other reactions. Deviations from the statistical model have been observed with the Oslo method[5,6] in reaction studies. Large fluctuations in continuum beta decay strength were also observed in our Total Absorption Spectrometer (TAS) experiments. Allowed beta transitions are analogous to M1 γ-ray transitions suggesting that similar fluctuations should be seen in the M1 photon strength. I will discuss experimental evidence for deviations from statistical model level densities, spin distributions, and photon strengths, observed in our LBNL TAS data, thermal neutron capture γ-ray measurements at the Budapest Reactor, and other data from the literature.

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