Spin Considerations

In principle the spin of the Θ^+ can be determined by the decay angular distributions. Consider the reaction

$$K^+n \rightarrow \Theta^+ \rightarrow K^o\, p$$

The spins of the kaons are zero and that of the nucleons (n, p) are one half. As such one can define the Z axis as the direction of the incoming K^+ in the Θ^+ center of mass. It follows that the z component of the Θ^+ spin, J_Z must have the values of ±1/2. One can then calculate the K^o angular distribution in the Θ^+ center of mass system for various values of its spin J. These are

J^P	$I(\Theta)$
$1/2^{\pm}$	1
$3/2^{\pm}$	$1+3\cos^2\Theta$
$5/2^{\pm}$	$1-2\cos^2\Theta+5\cos^4\Theta$

One notes that $I(\Theta)$ is the same for both parities of a given spin. To unravel the parity, one needs further measurements, such as the proton spin.

We know, however, that the decay angular distribution can be modified by interference with background waves. In general such effects give rise to odd powers of $\cos\Theta$. In particular we know there is a significant S wave amplitude in the mass region of the Θ^+, and the flat distribution expected for a pure $J^P = 1/2^+$ spin is converted by interference to an asymmetric $\cos\Theta$ form. It will therefore be possible to measure a Θ^+ spin of 1/2 by observing this asymmetry in the decay angular distribution and in fact this may provide the most sensitive limit on its existence. Of course a measure of any interference in the case of spin 3/2 or higher will be exhibited in the appearance of odd powers of $\cos\Theta$.

Other Considerations

The Δ(1240)

Again one can validate this technique by observing the $\Delta^{++}(1240)$ which is $J^P = 3/2^+$ state in the π^+p system. The reaction to be investigated is

$$\pi^+p \rightarrow \Delta^{++}(1240) \rightarrow \pi^+p$$

elastic π^+p scattering which becomes resonant at an incoming pi plus momentum of 310 MeV/c. It is a rather broad resonance, width of 120 MeV as is such it spans a momentum range of 220 MeV/c to 400 MeV/c. One should see a clear excess of π^+p elastic events in this energy region as well as a $(1+ 3 \cos^2\Theta + C \cos\Theta + \square \cos^3\Theta)$ angular distribution where C + D is a measure of any possible interference.

<u>Possible Θ^{++}</u>

If the Θ^+ exists it can either be a singlet or a member of a triplet, the partners being a Θ^{++} and Θ^o. As such the Θ^{++} is a very unique object, it only couples to K^+p and is completely elastic. The reaction to be studied is

$$K^+p \rightarrow \Theta^{++} \rightarrow K^+p$$

Again one looks for a peak in the K^+p elastic cross section at a mass of 1540 MeV and in addition measures the angular distribution of the K^+ in the center of mass of the K^+p system and looks for the presence of any powers of $\cos\Theta$ (even and odd) to measure the spin of the Θ^{++} as well as evidence for its existence.