Transverse Femto-Structure of the NN*(1520) Transition

The internal structure of the first negative parity excited state of the nucleon has been of great interest for the past over 3 decades. The constituent quark model predicts a dramatic change in the spin structure of this state with increasing momentum transfer. At the real photon point, $Q^2=0$, the helicity 3/2 amplitude $A_{3/2}$ dominates the resonance excitation, while the $A_{3/2}$ amplitude is predicted to become dominant at high Q^2. New data from CLAS obtained in a large range of Q^2 were able to separate this state from other resonances in the same mass range and determine the 3 transition amplitudes $A_{1/2}$, $A_{3/2}$, $S_{1/2}$ [1]. The dramatic change in the spin structure predicted by the quark model was clearly observed. The Q^2 range covered by the data is sufficiently large allowing also a further interpretation in terms of the transverse charge density for this transition [2]. In order to obtain this information the transition amplitudes $A_{1/2}$. $A_{3/2}$, and $S_{1/2}$ are expressed in terms of transition form factors $F_1(Q^2)$, $F_2(Q^2)$, and $F_3(Q^2)$ and are then subjected to Fourier transformations over the Q dependence, e.g. $\rho_0(b) = \int dQ J_0(bQ) Q F_1(Q^2)/2\pi$ where $\rho_0(b)$ represents the unpolarized transverse charge distribution for the transition from a proton to the excited state, and the transition occurs in the spin projection $+½ \rightarrow +½$.

As seen in the contour plots below, a complex structure emerges: the light (dark) regions correspond to the positive (negative) values of the quark charge inducing the N-N* transition. For the transition on the unpolarized proton, the extracted density is dominated by the negative charge, i.e. ***d***-quarks, in a central region of around 0.75 femtometer, and by the positive charge, i.e. ***u***-quarks, in an outer band that extends up to 1.2 femtometer.

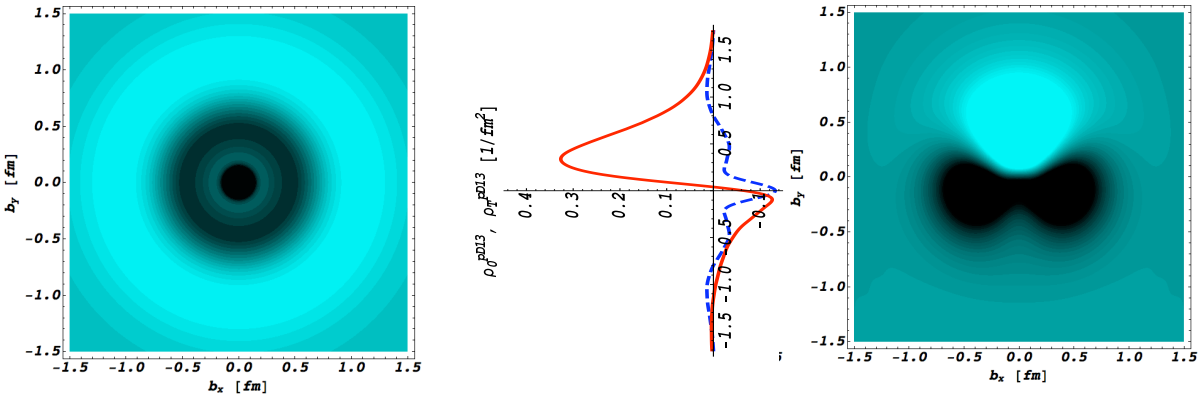

Figure. The transverse transition charge density of the proton→ N*(1520) transition is shown in the left picture. The light (dark) areas indicate the presence of dominantly positive (negative) charges. The picture to the right shows the transverse light cone transition charge density when the proton is in a spin-polarized state with the polarization axis oriented horizontally. The projection of both pictures onto the vertical axis is shown in the graph at the middle. The dashed line is the unpolarized case, the solid red line the polarized case. The unpolarized case shows an extended quadrupole distribution, while in the polarized case the transition charge density exhibits nearly complete charge separation transverse to the polarization axis.

[1] I. Aznauryan et al., Phys.Rev.C80:055203,2009.

[2] L. Tiator and M. Vanderhaeghen, Phys.Lett.B672:344-348,2009.