

1 - 7 Angular Momentum and Generalized Parton Distributions for the Proton with Basis Light-front Quantization*

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We study the properties of the proton through the light-front wave function (LFWF) obtained from a basis light-front quantization (BLFQ) approach. BLFQ is a nonperturbative approach to quantum field theory based on the Hamiltonian formalism. In order to make the numerical calculation feasible, we truncate the Fock sectors to the leading Fock sectors, that is $|P\rangle = a|qqq\rangle$. In our truncated basis the light-front Hamiltonian form,

$$\begin{aligned}
 P^- &= H_{\text{eff}}, \\
 H_{\text{eff}} &= \sum_i \frac{\vec{k}_{i\perp}^2 + m_i^2}{x_i} + \frac{1}{2} \sum_{i,j} [\kappa^4 x_i x_j (\vec{r}_{i\perp} - \vec{r}_{j\perp})^2 - \frac{\kappa^4}{(m_i + m_j)^2} \partial_{x_i} (x_i x_j \partial_{x_j})] \\
 &+ \frac{1}{2} \sum_{ij} \frac{C_F 4\pi\alpha_s(Q_{ij}^2)}{Q_{ij}^2} \bar{u}_{s'_i}(k'_i) \gamma^\mu u_{s_i}(k_i) \bar{u}_{s'_j}(k'_j) \gamma^\nu u_{s_j}(k_j) g_{\mu\nu}
 \end{aligned} \tag{1}$$

Our Hamiltonian contains the kinetic energy terms, a transverse confining potential motivated by holographic quantum chromodynamics (QCD), a complementary longitudinal confining potential, and the one-gluon exchange term based on QCD. By adopting the light quark mass $m_q = 0.3$ GeV, the confining strength $\kappa = 0.34$ GeV, and the strong coupling constant $g = 1.1 \pm 0.1$, we got the proton light-front wavefunctions and calculate the general parton distributions (GPD) of the proton in coordinate space based on the leading Fock sector LFWF, and derived the angular momentum distributions(Fig. 1).

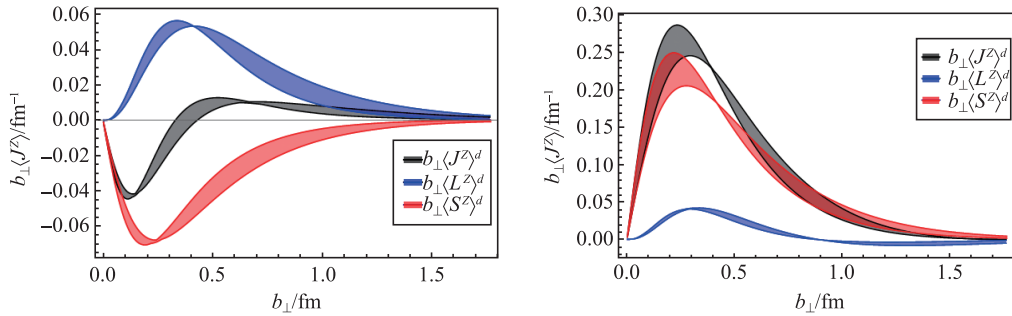


Fig. 1 (color online) Orbital angular momentum, spin, total angular momentum distribution for d (left) and u (right) quark.

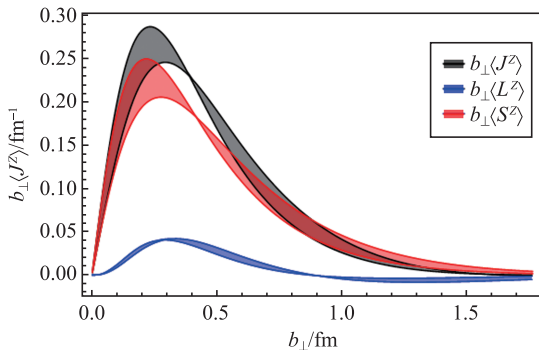


Fig. 2 (color online) Orbital angular momentum, spin, total angular momentum distribution for the proton.

We found that for d quark the orbital angular momentum is positive and the spin distribution is negative. The spin and OAM have similar absolute value, with spin concentrates at smaller b_{\perp} than OAM, which lead to the total AM for d quark negative at small b_{\perp} and positive at big b_{\perp} . For u quark spin is positive and OAM is negative. The absolute value of spin is far bigger than OAM, which lead to the total AM for u quark positive. One can also notice that the contribution of u quark is much more than d quark. We sum over the contribution of d and u quark and get the distribution for the proton(Fig.2).

The contribution for quark spin to the proton spin is about 91%, far more than the experimental data (about 25%). This is because we don't have gluon contribution, which will be our following job.

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