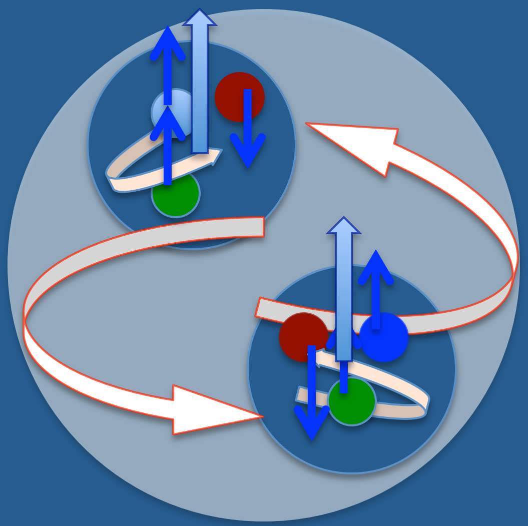
OAM and GTMDs



Simonetta Liuti
University of Virginia

APS DNP Town Meeting

Temple University

September 13th-15th, 2014

What is Orbital Angular Momentum?

THE PHENOMENOLOGIST'S TAKE

Defining observables

Measurements

Implications

What observables can be identified, what set of measurements will uniquely settle this question?

?

Defining the Observables: Two ways of getting at OAM

GTMD

$$L_q^{JM} = -\int dx\, d^2k_T \frac{k_T^2}{M^2} F_{14}(x,0,0,k_T)$$

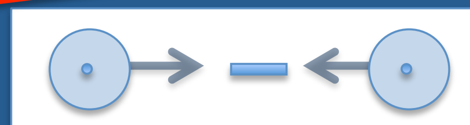
Hatta (2011)
Lorce', Pasquini (2011)
Burkardt (2012)

where the unintegrated in k_T structure is:

Meißner, Metz, Schlegel (2009)

$$W_{\Lambda'\Lambda}^{[\gamma^+]} = \frac{1}{2M}\,\overline{u}(p',\Lambda')\left[F_{11} + \frac{i\sigma^{k_\perp +}}{P^+}F_{12} + \frac{i\sigma^{\Delta_\perp +}}{P^+}F_{13} + \frac{i\sigma^{k_\perp \Delta_\perp}}{M^2}F_{14}\right]u(p,\Lambda)$$

$$\sigma_{ij} k_T^i \Delta_T^j \Rightarrow \vec{S}_L \cdot \left(\vec{k}_T \times \vec{\Delta}_T\right)$$



UL correlation

Polyakov Sum Rule

Twist 3 GPD

$$\int dx\, x G_2 = -\frac{1}{2}\int dx\, x(H+E) + \frac{1}{2}\int dx\, \tilde{H}$$

$-L_q$ $-J_q$ S_q

Polyakov et al., (2000)
Hatta, Yoshida (2012)

where the twist 3 integrated in k_T structure is:

$$W_{\Lambda'\Lambda}^{\gamma^i} = \frac{1}{2P^+}\overline{U}(p',\Lambda')\left[\frac{\Delta_T^i}{M}G_1 + \frac{i\sigma^{ji}\Delta_j}{M}G_2 + \frac{Mi\sigma^{i+}}{P^+}G_4 + \frac{\Delta_T^i}{P^+}\gamma^+ G_3\right]U(p,\Lambda),$$

UL correlation

... and the unintegrated in k_T structure is

$$-\frac{4}{P^+}\left[\frac{\mathbf{k}_T\cdot\mathbf{\Delta}_T}{\Delta_T}F_{27} + \Delta_T F_{28}\left(\frac{\mathbf{k}_T\cdot\mathbf{\Delta}_T}{\Delta_T}G_{27} + \Delta_T G_{28}\right)\right] = A^{tw3}_{++,++} + A^{tw3}_{+-,+-} - A^{tw3}_{-+,-+} - A^{tw3}_{--,-}$$

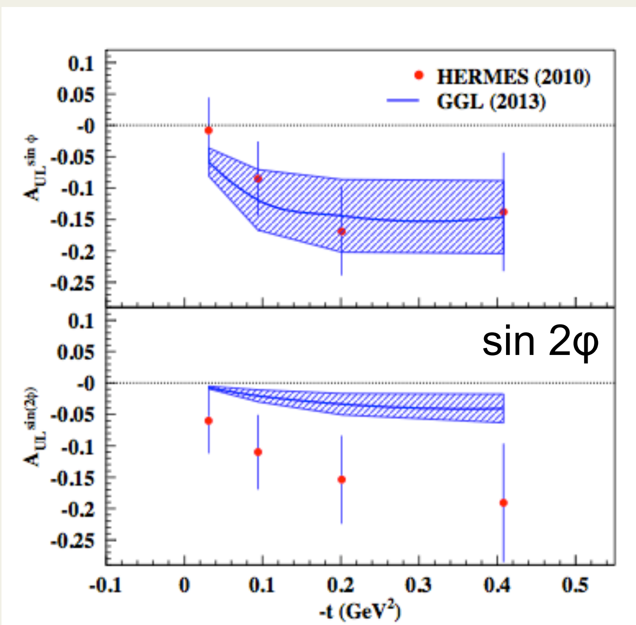
Calculable on lattice!! (M. Engelhardt)

Measurements

To measure OAM one has to be in a frame where the reaction cannot be described as a two-body quark-proton scattering (UL correlation does not exist because of Parity constraints).

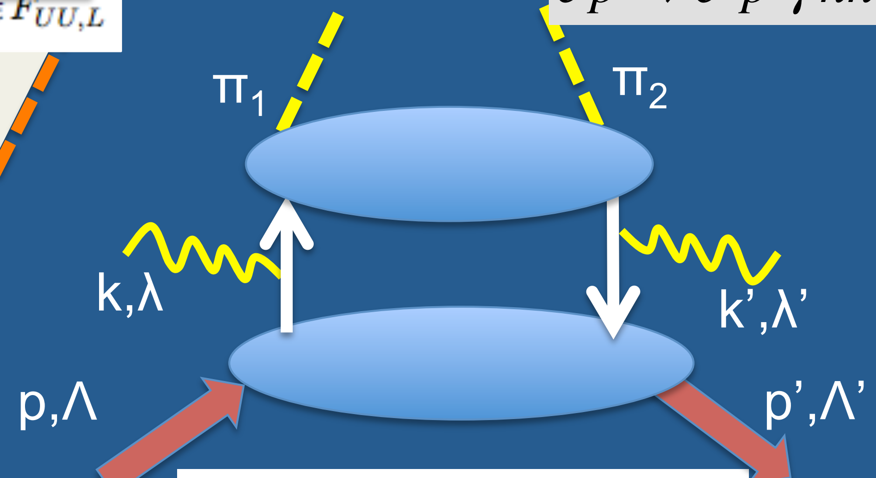
Twist three measurements

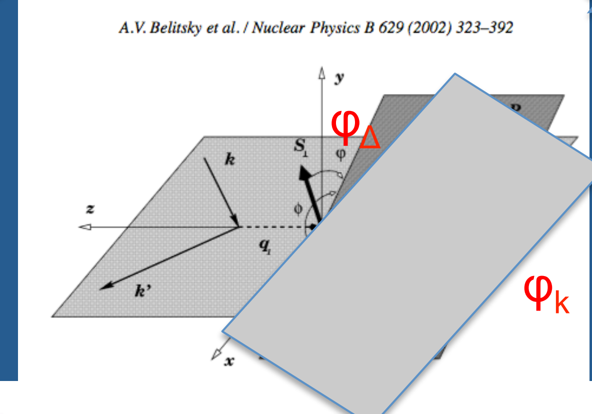
$$A_{UL,L} = \frac{N_{s_z=+} - N_{s_z=-}}{N_{s_z=+}+N_{s_z=-}} = \frac{\sqrt{2\epsilon(\epsilon+1)}\sin\phi F_{UL}^{\sin\phi}}{F_{UU,T}+\epsilon F_{UU,L}} + \frac{\epsilon \sin 2\phi F_{UL}^{\sin 2\phi}}{F_{UU,T}+\epsilon F_{UU,L}}$$



Introduce two hadronic planes: Off forward SIDIS

$$e\,p \to e'\,p'\,\gamma\,h\,\bar{h}$$



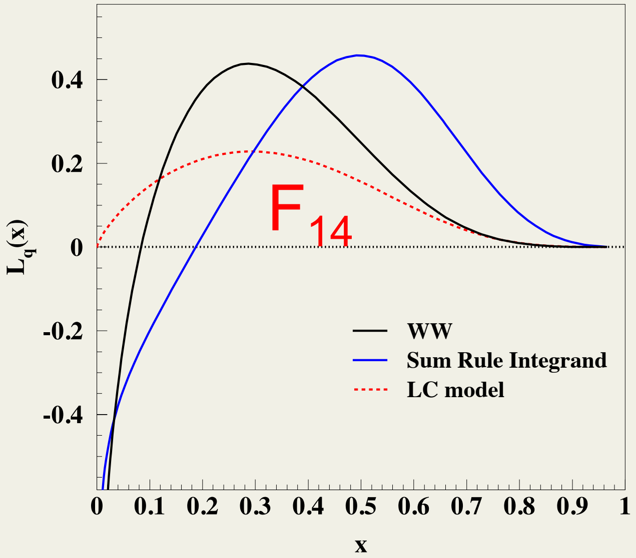


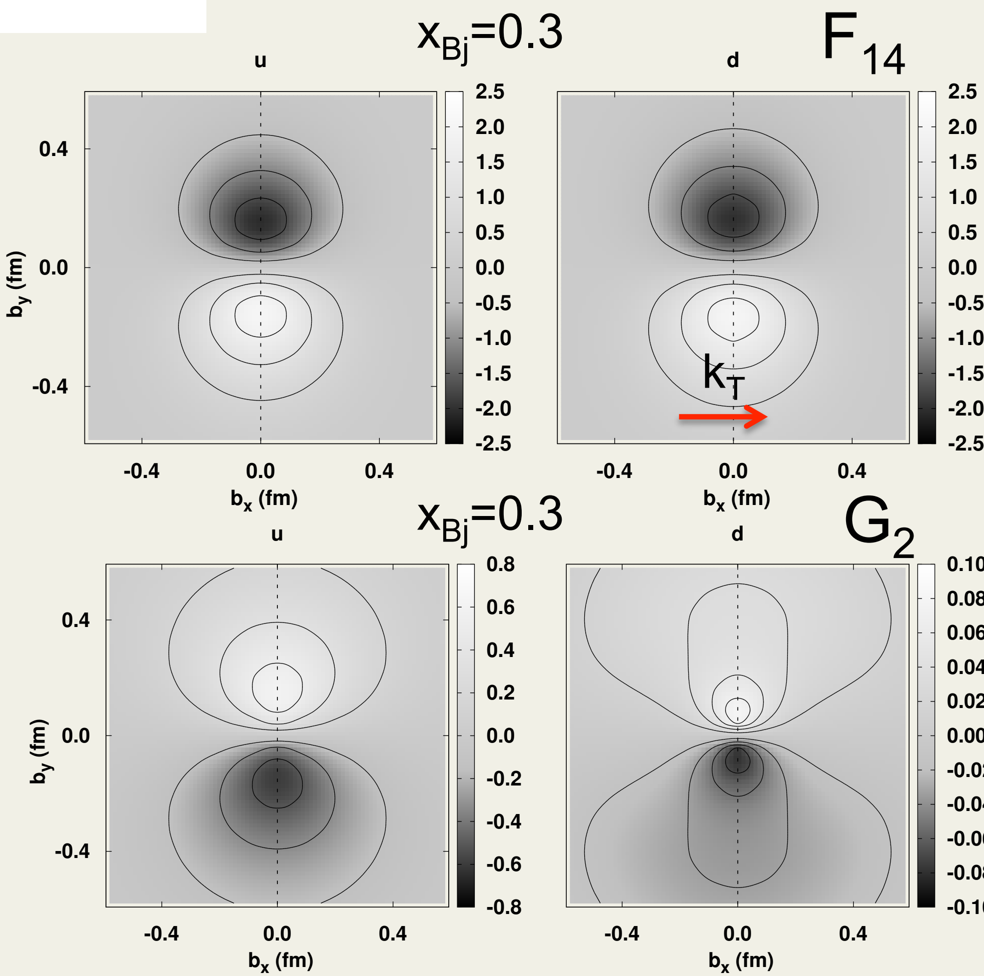
$$g_{\Lambda'_\gamma,\Lambda'_N,0;\Lambda_\gamma,\Lambda_N,0} = \sum_{\lambda,\lambda'} \tilde{g}^{\lambda'\lambda}_{\Lambda'_\gamma\Lambda_\gamma} \otimes A_{\Lambda'_N,\lambda',\Lambda_N,\lambda}(x,\xi,t) \otimes F^{\pi_1}_{\lambda 0}(z)\, F^{\pi_2}_{\lambda' 0}(v)$$

Implications: knowing the helicities configurations allows us to interpret OAM in the proton

Comparison of different OAM density distributions for Jaffe Manohar and Ji

$$L_q(x,0,0) = x\int_x^1 \frac{dy}{y}(H_q(y,0,0)+E_q(y,0,0)) - x\int_x^1 \frac{dy}{y^2}\widetilde{H}_q(y,0,0),$$





I am indebted to

Harut Avakian
Aurore Courtoy
Michael Engelhardt
Gary Goldstein
Osvaldo Gonzalez Hernandez
Silvia Pisano
Abha Rajan

Details can be found in:

- ✓ Courtoy et el., Phys. Lett.B 2014, arXiv:1310.5157
- ✓ ECT* talks by A. Courtoy, G. Goldstein, S.L.
https://indico.in2p3.fr/conferenceTimeTable.py?confId=10071#20140826