SPIN Conference 2023

A few topics that I found interesting

Kong Tu

BNL

Oct 3, 2023

Fixed target at the EIC

- 18 GeV fixed target program with an experiment similar to HERMES at the EIC, with luminosity up to 10^{35} cm^{-2} s^{-1}. See details in this slides, https://indico.jlab.org/event/663/contributions/12964/attachments/10264/15542/Heracles-BW.pdf

- Designing the 2nd IR or integrating a fixed target program is challenging.
- Tagged photon beam with external target.
- Compelling idea to compete with the Jlab 22 GeV upgrade program.

Quark spin simulations – string+$^3P_0$

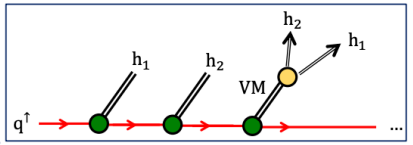
Modeling hadronization: the string+$^3P_0$ model

- We have developed a model for the simulation of the fragmentation polarized quarks
  → **string+$^3P_0$ model:** extension of the Lund string fragmentation model to include the quark spin

AK, Artru, Belghobsi, Bradamante, Martin, PRD 97, 074010 (2018)	2018	PS mesons
AK, Artru, Belghobsi, Martin, PRD 100, 014003 (2019)	2019	PS mesons
AK, Artru, Martin, PRD 104, 114038 (2021)	2021	PS mesons + VM

- Applied to the description of
  - SIDIS: polarized fragmentation quarks of struck quarks
    polarization of remnant neglected
    implemented in Pythia via StringSpinner (public)

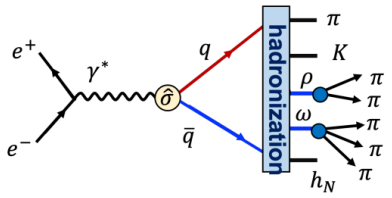
AK, L. Lönnblad, CPC **272** (2022) 108234;
CPC **292** (2023) 108886



→ promising description of transverse-spin asymmetry data
*see most recent version including PS + VM production CPC **292** (2023) 108886*

- e^+e^- annihilation to hadrons

hadronize $q\bar{q}$ using the string+$^3P_0$ model accounting for
correlated spin states of q and $\bar{q}$
quantum mechanical spin-correlations in fragmentation
in collaboration with X. Artru



https://indico.jlab.org/event/663/contributions/13018/attachments/10309/15416/Kerbizi_SPIN2023.pdf

Provides a good description to hadron production data for e+e-.

Quark spin simulations – string+$^3P_0$

Modeling hadronization: the string+$^3P_0$ model

The Monte Carlo generator: PYTHIA 8 + StringSpinner

PYTHIA 8 is used to simulate the DIS process
unpolarized beam and target, no parton showers

Spin effects enabled by **StringSpinner**
includes production of PS and VM

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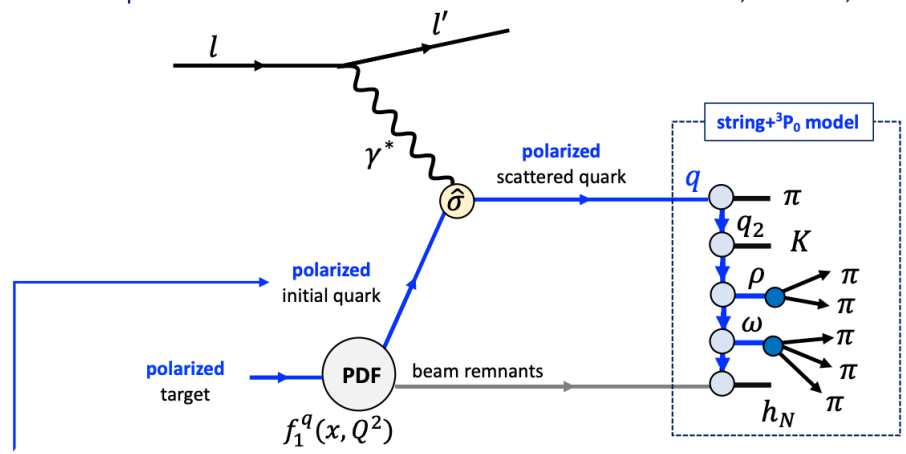


Transversity PDF $h_1^q(x)$
parametrization
valence (sea) quarks polarized (unpolarized)

string stretched between q and the beam remnants
fragmented using the string+$^3P_0$ model

*AK, Artru, Martin, **PRD 104** (2021) 11, 114038*

SPIN 2023 Albi Kerbizi (Trieste University and INFN) 7

https://indico.jlab.org/event/663/contributions/13018/attachments/10309/15416/Kerbizi_SPIN2023.pdf

Provides a good description to hadron production data for e+e-.

PYTHIA 8 is now available with this feature and can run polarized DIS. See talk here.

Would be interesting to look at some spin observables at the EIC kinematics.

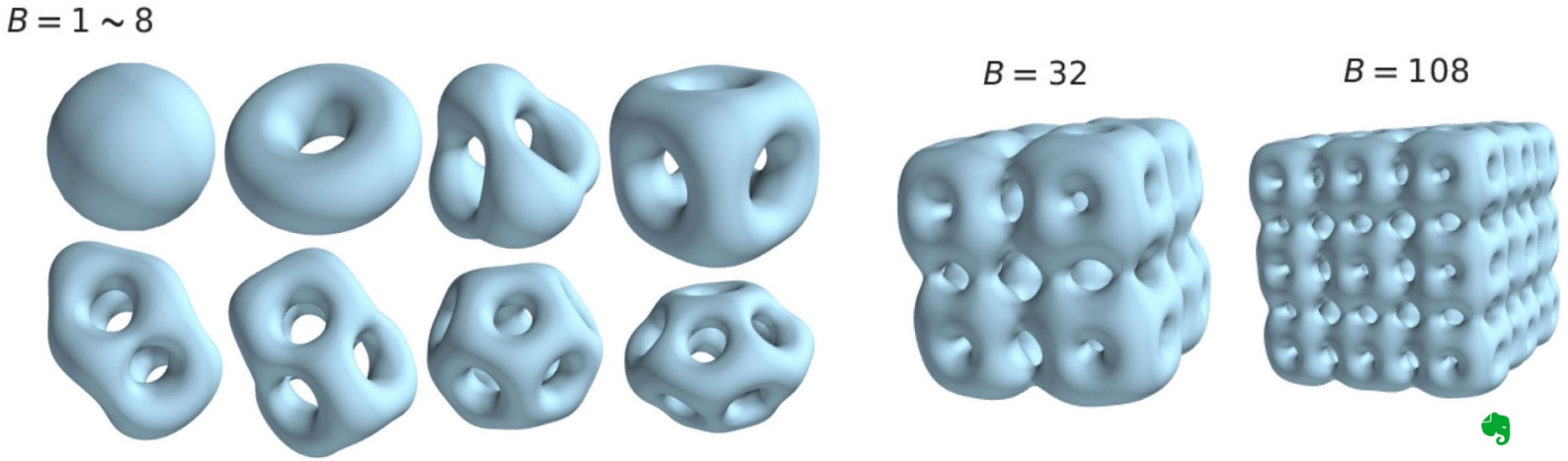
Lambda polarization

- Many talks about Lambda polarization, both Jan and Kong have given a talk on this topic. (**Jan will give a talk next week on the first look in STAR p+p collisions next week**)
- Still, the interesting observation is that for high energy collisions, it's always zero spin transfer has been measured. (STAR has released a few new results, see this session, https://indico.jlab.org/event/663/sessions/2672/#20230925)

- However, I learned that at low energy, there was positive spin transfer at CLAS 6 GeV. Also, for pp to p+Lambda+K had been measured, which was similar to my recent paper.
- **A lot of data, but no coherent picture.** (thinking about an idea of using ML/AI to ``learn" about the mechanism of Lambda polarization)

Gravitational form factor of NUCLEI!

Nuclei in the Skyrme model



For more exotic solutions, see Gudnason, Halcrow (2022)

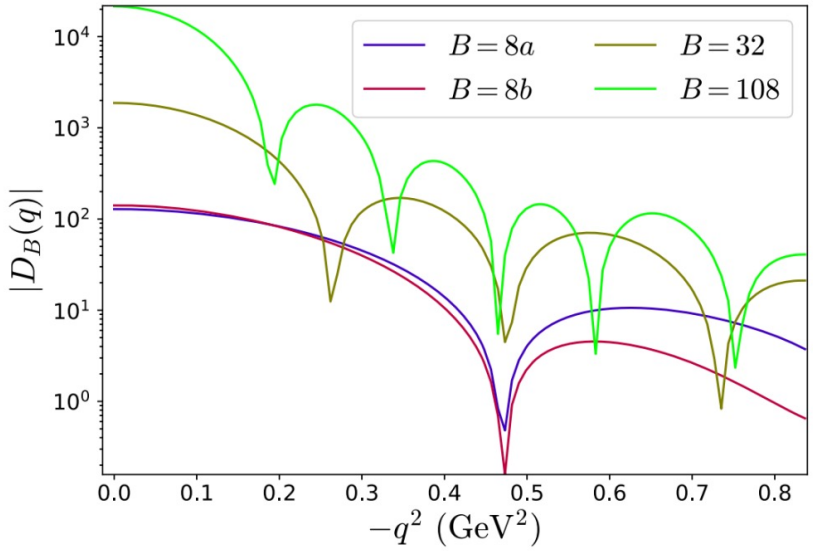
Electromagnetic form factors computed

$B = 2$	deuteron	Braaten, Carson (1989)
$B = 3$	triton, helium-3	Carson (1991)

Measurement has not been discussed. But just a direct analogy to proton, J/Psi near-threshold photoproduction off nuclei?

(Yoshitaka Hatta, https://indico.jlab.org/event/663/contributions/12958/attachments/10305/15407/SpinSkyrme.pdf)

Gravitational form factor of NUCLEI!



The form factor changes signs, oscillates around zero for large-B nuclei.

Similar to the diffractive pattern in elastic scattering off nuclei.

Measurement has not been discussed. But just a direct analogy to proton, J/Psi near-threshold photoproduction off nuclei?

B	1	2	3	4	5	6	7	$8a$	$8b$	32	108
$D(0)$	−3.701	−13.126	−26.757	−43.304	−62.72	−85.95	−106.596	−128.368	−140.816	-1.874×10^3	-2.152×10^4

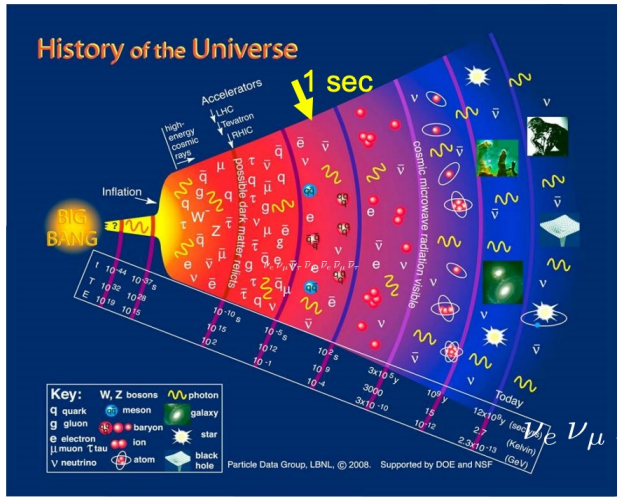
The value D(0) grows quickly with increasing B

(Yoshitaka Hatta, https://indico.jlab.org/event/663/contributions/12958/attachments/10305/15407/SpinSkyrme.pdf)

Helicity of Relic Neutrinos

- A fascinating idea!

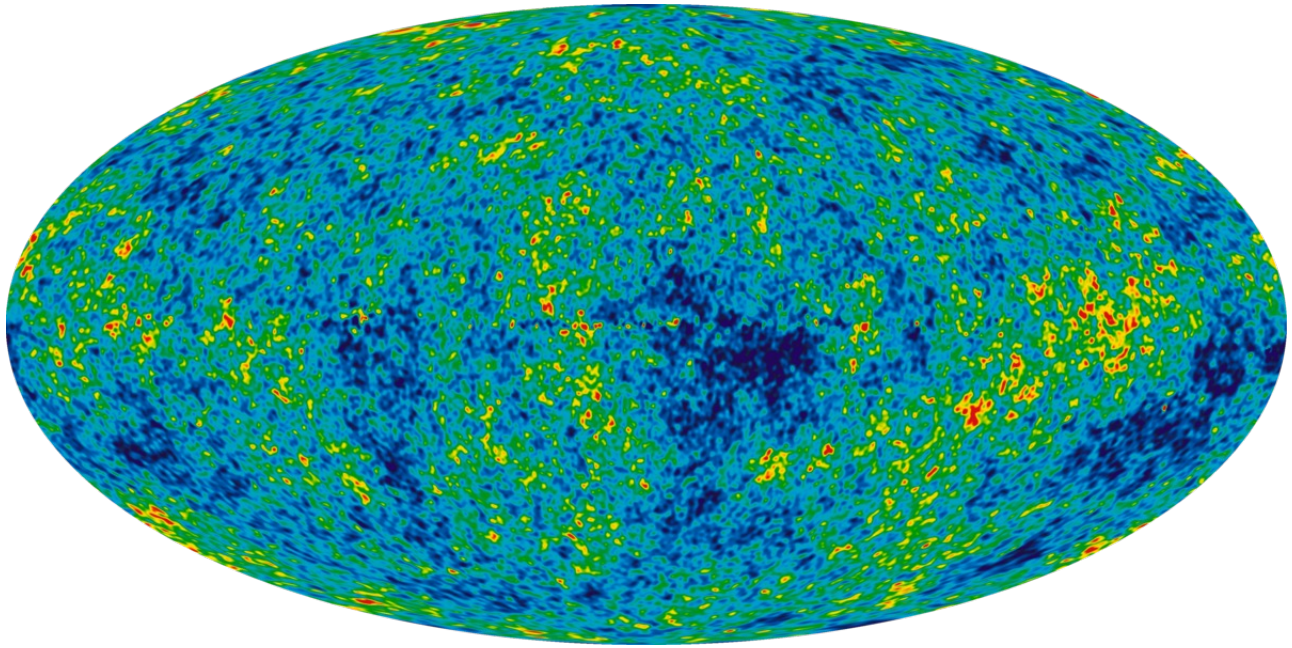
Relic neutrinos from the Big Bang forming the cosmic neutrino background (CνB)



Decoupling occurs at $t \sim 1$ sec, $T \sim 1$ MeV

CνB has never been observed !

CMB, at half million years after the big bang



https://indico.jlab.org/event/663/contributions/13200/attachments/10208/15264/SPIN2023_peng.pdf

Helicity of Relic Neutrinos

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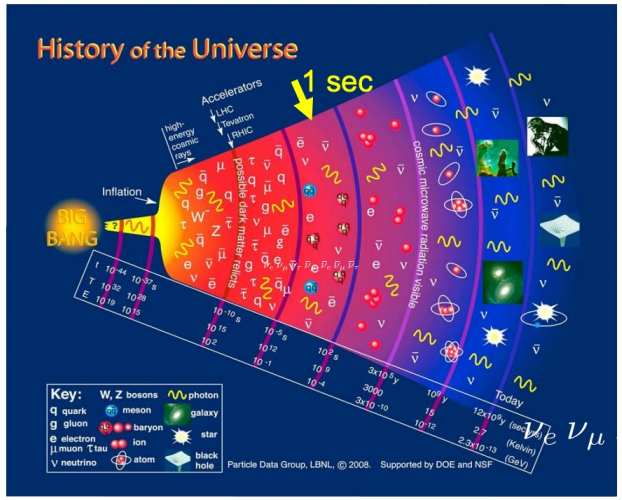
Relic neutrinos from the Big Bang forming the cosmic neutrino background (CνB)



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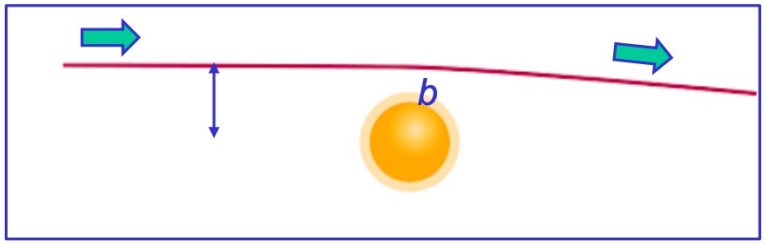
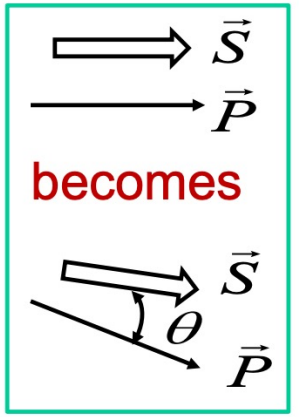
How would gravity modify the neutrino helicity?





Momentum bending: $\Delta\theta_P = \frac{2MG}{b\mathrm{v}^2}(1+\mathrm{v}^2)$

Spin bending: $\Delta\theta_S = \frac{2MG}{b}\frac{2\gamma+1}{\gamma+1}; \quad (\gamma = 1/\sqrt{1-\mathrm{v}^2})$

$\theta \equiv \Delta\theta_S - \Delta\theta_P = -\frac{2MG}{b\gamma\mathrm{v}^2}$

(spin bending lags momentum bending)

$\theta \to 0$ as $\mathrm{v} \to 1$

θ is large as $\mathrm{v} \to 0$

An angle θ between the spin and momentum directions means

$|h=+1\rangle \to \cos(\theta/2)|h=+1\rangle + \sin(\theta/2)|h=-1\rangle$

Probability for $h=-1$ is $\sin^2(\theta/2)$

https://indico.jlab.org/event/663/contributions/13200/attachments/10208/15264/SPIN2023_peng.pdf

Summary

- There are many other talks I found interesting, despite very technical and different than what I do;-). No time to cover all, but it’s a good conference.
  - Check out the plenary talks, many are great.
- Many related topics can be applied to eA physics, e.g., gravitational form factor of nuclei, spin in nuclei, etc.