Boost-invariant spin hydrodynamics with spin feedback effects

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Our approach to spin hydrodynamics

- **motivation: spin polarization measurements in RHIC**
  1. perfect spin hydrodynamics conserves the spin part of the total angular momentum,
  2. spin-orbit interaction is dissipative (not included here),
  3. two-fold expansion: in the magnitude of $\omega_{\mu\nu}$ and gradients,
  4. my talk: perfect spin hydrodynamics for Bjorken expansion with second-order corrections [1],
- **boost-invariant** and **transversely homogeneous** system with **polarization tensor** decomposed to

$$\omega_{\mu\nu} = k_\mu U_\nu - k_\nu U_\mu + t_{\mu\nu}, \qquad t_{\mu\nu} = \epsilon_{\mu\nu\alpha\beta} U^\alpha \omega^\beta, \tag{1}$$

$$k^\mu = C_{kx} X^\mu + C_{ky} Y^\mu + C_{kz} Z^\mu, \qquad \omega^\mu = C_{\omega z} X^\mu + C_{\omega y} Y^\mu + C_{\omega z} Z^\mu, \qquad t^\mu = V_x X^\mu + V_y Y^\mu + V_z Z^\mu, \tag{2}$$

- calculations with respect to **conservation laws**

$$\partial_\mu N^\mu(x) = 0, \qquad \partial_\mu T^{\mu\nu} = 0, \qquad \partial_\lambda S^{\lambda,\mu\nu} = 0, \tag{3}$$

- **result**: overdetermined system $\Rightarrow$ additional symmetry $\Rightarrow$ mathematically allowed solutions
  1. **longitudinal configuration**

$$\boldsymbol{C}_k = (0, 0, C_{kz}), \qquad \boldsymbol{C}_\omega = (0, 0, C_{\omega z}), \tag{4}$$

  2. **transverse configuration**

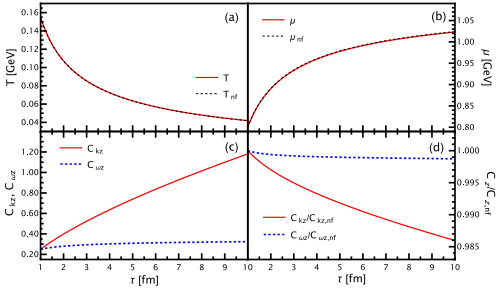
$$\boldsymbol{C}_k = \left(C_{kx}, C_{ky}, 0\right), \qquad \boldsymbol{C}_\omega = \lambda \boldsymbol{C}_k. \tag{5}$$

[1] Extension of work - W. Florkowski, A. Kumar, R. Ryblewski, R. Singh, *Spin polarization evolution in a boost invariant hydrodynamical background*, Phys. Rev. C 99, 044910 (2019), arXiv:1901.09655.

Numerical results

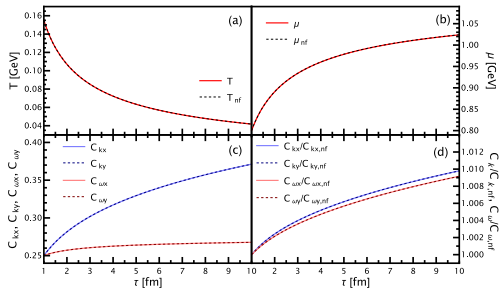
1 Longitudinal configuration

$$C^0_{kz} = C^0_{\omega z} = 0.25$$



2 Transverse configuration

$$C^0_{kx} = C^0_{ky} = C^0_{\omega x} = C^0_{\omega y} = 0.25$$



References

[1] Zbigniew Drogosz, Wojciech Florkowski, Natalia Łygan, Radoslaw Ryblewski, *Boost-invariant spin hydrodynamics with spin feedback effects* (2024), arXiv:2411.06154.

[2] J. D. Bjorken, *Highly relativistic nucleus-nucleus collisions: The central rapidity region*, Physical review D 27, 140 (1983).

[3] W. Florkowski, A. Kumar, R. Ryblewski, and R. Singh, *Spin polarization evolution in a boost invariant hydrodynamical background*, Phys. Rev. C 99, 044910 (2019), arXiv:1901.09655.

[4] W. Florkowski, *Phenomenology of Ultra-Relativistic Heavy-Ion Collisions (2010)*.

[5] W. Florkowski and M. Hontarenko, *Generalized thermodynamic relations for perfect spin hydrodynamics* (2024), arXiv:2405.03263.

[6] Z. Drogosz, W. Florkowski, and M. Hontarenko, *Hybrid approach to perfect and dissipative spin hydrodynamics* (2024), arXiv:2408.03106.