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Spin Alignment Formula for Vector Bosons at Local Equilibrium

We derive a Cooper-Frye-type spin alignment formula for spin-1 bosons at local thermal equilibrium described by a grand canonical ensemble specified by temperature, fluid velocity, and spin potential. We develop a set of Feynman rules to evaluate the matrix-valued distribution function (MVDF) order by order. And we also give the vector and tensor polarization. Due to the limitation of time-reversal symmetry, the leading order of spin alignment comes from the second-order term in MVDF. We discuss the physical meaning of different contributions to spin alignment and compare them with previous works. We also check our result at non-relativistic global equilibrium by taking zero-momentum and low-vorticity limits. The present formula provides machinery to convert the spin potential computed in, e.g., relativistic spin hydrodynamic to the spin alignment observable in, e.g., heavy-ion collisions.

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