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Higher-order thermoelectric effects in hot and dense interacting hadron gas in the presence of a magnetic field

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From low-energy semiconductor devices to strongly interacting hadronic matter, the thermoelectric coefficients encode deep information about the system's dynamics in response to non-zero gradients. What makes thermoelectricity truly beautiful is its dual nature: it is both the window into the microscopic dynamics of constituents of matter and a bridge to macroscopic energy conversion, where heat is transformed into electrical power and vice versa. The hot and dense hadronic medium produced in relativistic heavy-ion collisions at RHIC and LHC energies provides a unique platform to study thermoelectric transport phenomena because of its charged and neutral constituents, namely baryons and mesons. In the presence of temperature gradients and nonzero baryon chemical potential, the medium exhibits anisotropic thermoelectric responses under an external magnetic field[1]. Using the relativistic Boltzmann transport equation within the relaxation time approximation, we investigate the thermoelectric properties of an interacting hadron gas in different frameworks of the hadron resonance gas model. A particular focus is placed on the estimation of Thomson coefficients, which arise due to the temperature dependence of the Seebeck coefficients. For the first time, we estimate the longitudinal Thomson, magneto-Thomson, and transverse Thomson coefficients in the hot hadronic medium. The magneto-Thomson and transverse Thomson coefficients originate in the medium due to the temperature dependence of magneto-Seebeck and Nernst coefficients in the presence of a magnetic field[2]. The study of such higher-order thermoelectric coefficients enriches the broader understanding of nonequilibrium transport in strongly interacting systems, revealing complex coupling mechanisms between charge carriers and thermal gradients in the context of heavy-ion collisions.

[1] K. Singh, K. K. Pradhan, D. Sahu and R. Sahoo, Phys. Rev. D 111, 074033 (2025)
[2] K. Singh, K. K. Pradhan and R. Sahoo, [arXiv:2506.22086 [hep-ph]]

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