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Relativistic Resistive Magneto-Hydrodynamics in High-Energy Heavy-Ion Collisions: Hadron Distribution and Flow

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In high-energy heavy-ion collisions, strong and transient electromagnetic fields (~10^{14} [T]) are induced inside generated hot and dense QCD medium.
The space-time evolution of the electromagnetic field in electrically conducting nuclear matter is completely different from that of vacuum; the lifetime of it becomes much longer than that in the vacuum. Also, the electrical conductivity of the QCD matter plays an important role for space and time dependencies of an electromagnetic field [1].

Several studies of the non-resistive QCD matter have been performed in a relativistic ideal magneto-hydrodynamic framework [2]. Usually, initial electric fields produced by collision spectators are neglected because they grow $-\vec{v} \times \vec{B}$ instantaneously due to the infinite electrical conductivity.
However, for realistic analyses of the consequences of the existence of an electromagnetic field in high-energy heavy-ion collisions, electrical conductivity is important. In particular, in anisotropic collision systems such as Cu + Au collisions($\sqrt{s_{NN}} = 200$ [GeV]), the effect of electrical conductivity can be clearly found [3]. A numerical framework with the electrical conductivity of QCD matter is indispensable, for the investigation of the effect of electromagnetic fields on the final hadron distributions and flows in high-energy heavy-ion collisions.

We present a first study of the effect of the electromagnetic fields on physical observables, utilizing a newly developed relativistic resistive magneto-hydrodynamics (R2MHD) simulation code. We check our code, using several test problems; 1D shock tube test and 2D Resistive Rotor test. In addition, our numerical results of magnetized Bjorken flow and Rotor test in Milne coordinates with high electrical conductivity are consistent with the ideal relativistic magneto-hydrodynamics [4].
We show numerical results of Au +Au ($\sqrt{s_{NN}} = 200$ [GeV]) and Cu + Au ($\sqrt{s_{NN}} = 200$ [GeV]) at RHIC. We focus on the rapidity odd profile of directed flow v_1, charge-dependent splitting of elliptic flow v_2 and so on.

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