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Bayesian inference of the magnetic components in quark-gluon plasma and predictions for heavy flavor observables

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The chromo-magnetic monopoles (CMM), emergent topological excitations of non-Abelian gauge fields carrying chromo-magnetic charge, have long been postulated to play an important role in the vacuum confinement of quantum chromodynamics (QCD), the deconfinement transition at temperature $T_c \approx 160\mathrm{MeV}$, as well as the strongly coupled nature of quark-gluon plasma (QGP). While such CMMs have been found to provide solutions for challenging puzzles from heavy-ion collision measurements, they were typically introduced as model assumptions in the past. Here we show how their very existence can be determined and their abundance extracted in a data-driven way for the first time. Using the CUJET3 framework for calculations of jet energy loss and analyzing a comprehensive experimental data set for light hadrons' nuclear modification factor (R_{AA}) and elliptic flow (v_2) of high-transverse-momentum hadrons, the fraction of CMMs in the QGP is obtained by Bayesian inference and is found to be substantial in the $1 \sim 2T_c$ region. The posterior CMM fraction is further validated by excellent agreement with additional data. Such a microscopic picture of QGP is also shown to predict QGP transport properties, such as specific shear viscosity, jet transport coefficient and heavy quark diffusion constant, that are quantitatively consistent with the state-of-the-art knowledge. With the model parameters now constrained by light-flavor observables, we present Bayesian predictions for the R_{AA} and v_2 of high-p_T charm and bottom hadrons. These predictions provide a decisive, independent test for the existence and abundance of CMMs in the QGP.

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