Ohm’s Law Violated in Heavy-Ion Collisions

The magnetic field generated in a high-energy collision of heavy ions might be weaker than previously thought, hindering the experimental search for field-related effects.

By Ryan Wilkinson

At the Relativistic Heavy Ion Collider (RHIC), New York, and the Large Hadron Collider (LHC), Switzerland, heavy ions are smashed together at high speeds to study the quark-gluon plasma—the hot soup of elementary particles that existed during the Universe’s first microsecond. The strength of the magnetic field produced in these heavy-ion collisions is typically calculated using Ohm’s law of electrical conductivity. But now, Zhe Xu at Tsinghua University in China and his colleagues have shown that such a calculation can overestimate the field strength, and in turn, the magnitude of any exotic field-associated phenomena [1].

The magnetic field of the quark-gluon plasma created in a heavy-ion collision is induced by an electric current that forms at the collision site. This current is usually assumed to have a constant value that is determined by Ohm’s law. However, Xu and his colleagues realized that the current would need some time to reach this value. By considering typical heavy-ion collisions at the RHIC and the LHC, the team calculated that the delay time is longer than two key timescales of such collisions: the time taken to form a quark-gluon plasma, and the lifetime of the external magnetic field produced by protons that do not take part in the collision. They found that such a long delay time greatly reduces the predicted strength of the induced magnetic field.

The team says that this suppressed field could make field-related phenomena too small to be measured using the current RHIC and LHC detectors. Such phenomena include the chiral magnetic effect—the generation of an electric current by a difference in the number of left- and right-handed particles in a magnetic field.

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REFERENCES