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P1.4015 Transition to collisionality, magnetic fields generated by the Biermann battery and the Weibel instability

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In recent years, experiments with laser-target interactions create plasma with extremely strong magnetic fields (~ MGauss). With these conditions, and the unprecedented resolution that these experiments can now operate, we are able to probe physics that also occurs in astrophysical systems. In particular, the generation of these magnetic fields via the Biermann battery and the Weibel instability. Although intense short pulse lasers are capable of creating plasmas that are so hot that the particles are essentially collisionless, and kinetic physics is essential, the transition between such collisionless and collisional systems is not fully understood. We have investigated the generation of magnetic fields in an expanding plasma bubble with misaligned density and temperature gradients, using a Monte-Carlo collision module integrated with particle-in-cell simulations. In addition to magnetic fields generated by the Biermann battery, temperature gradients lead to temperature anisotropies that drive the Weibel instability. This mechanism is only expected in collisionless plasmas, as the temperature anisotropies are washed away by collisions. We show how collisional the plasma must be to suppress the Weibel instability. The growth rate of the Weibel instability is itself modified by the collision rate for a constant anisotropy, verified by particle-in-cell simulations. However, the reduced anisotropy is the major cause of measured reduction of growth rate. In collisional systems, the anisotropy grows at a slower rate than a collisionless system, leading to a weaker anisotropy when the Weibel instability begins to develop. We confirm that the Weibel instability is suppressed when the collision rate approaches the rate of anisotropy growth in a collisionless system (i.e. the thermal crossing time), which leaves the Biermann battery as the dominant source of magnetic fields.

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