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Inverse magnetic catalysis from the properties of the QCD coupling in a magnetic field

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We compute the vacuum one-loop quark-gluon vertex correction at zero temperature in the presence of a magnetic field. From the vertex function we extract the effective quark-gluon coupling and show that it grows with increasing magnetic field strength. The effect is due to a subtle competition between the color charge associated to gluons and the color charge associated to quarks, the former being larger than the latter. In contrast, at high temperature the effective thermo-magnetic coupling results exclusively from the contribution of the color charge associated to quarks. This produces a decrease of the coupling with increasing field strength. We interpret the results in terms of a geometrical effect whereby the magnetic field induces, on average, a closer distance between the (electrically charged) quarks and antiquarks. At high temperature, since the effective coupling is proportional only to the color charge associated to quarks, such proximity with increasing field strength makes the effective coupling decrease due to asymptotic freedom. In turn, this leads to a decreasing quark condensate. In contrast, at zero temperature both the effective strong coupling and the quark condensate increase with increasing magnetic field. This is due to the color charge associated to gluons dominating over that associated to quarks, with both having the opposite sign. Thus, the gluons induce a kind of screening of the quark color charge, in spite of the quark-antiquark proximity. The implications of these results for the inverse magnetic catalysis phenomenon are discussed.

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