Joule heat in a two-dimensional electron gas exposed to a normal non-homogeneous magnetic field of a "chess" configuration

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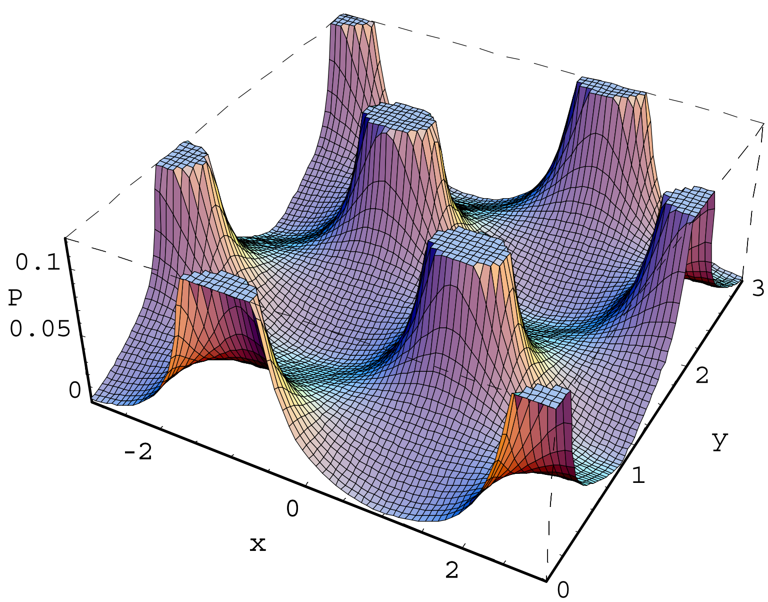
Presently the geometrical and non-homogeneous magnetic field induced effects are of interest [1,2]. I present a calculation of the Joule heat generation rate in a finite two-dimensional electron gas (2DEG) exposed to a normal non-homogeneous magnetic field. The non-homogeneous magnetic field B(x,y) is of a "chess" configuration, i.e. $B(x,y)=B_1$ on "black" fields and $B(x,y)=B_2$ on "white" fields, each field is a rectangle of the width *W* and of the length *L*. The number of fields is arbitrary. I obtain an electric field distribution in each of the contacting rectangles using a conformal mapping method. I use an approach, which is in the second step different from that of used in [3]. By direct application of the Schwarz's integral formula I find a solution of the electrostatics problem in terms of the Jacobian elliptic functions. Matching of these solutions at the magnetic interfaces gives a system of integral equations.



For particular anti-symmetric system $B_1=B$ and $B_2=-B$ I obtain an exact analytical solution, which allows calculating all physical quantities of interest: the electric field $\boldsymbol{E}(z)$, $z=x+iy$, the current $\boldsymbol{J}(z)$, and the voltage distributions, the linear density of charges accumulated along the magnetic interface. In the figure a spatial distribution of the Joule heat generation rate, $P(z)=\boldsymbol{J}(z)\cdot\boldsymbol{E}(z)$ (in arbitrary units), is shown for 3X3 "chess" configuration in B=0.1 T and for the aspect ratio L/W=1.54. The electron density is 1.94×10^{15} m^{-2}, and mean free path 4.5 μm. The delivery of the Joule heat from the 2DEG is concentrated near the singularity points at the current injection and removal corners and has zeros in other corners of the "chess" fields. Near the corners the generation rate has the following analytical behavior: $P(z)\propto(z-z_{corner})^{\pm 2|\delta|}$, δ is the Hall angle in units of $\pi/2$.

1. S. A. Solin, T. Thio, D. R. Hines, and J. J. Heremans, Science **289** (2000) 1530.
2. F. M. Peeters and J. De Boeck, in Handbook of nanostructured materials and technology, edited by N. S. Nalwa, Vol. **3** (Academic Press, N. Y., 1999), p. 345.
3. R. W. Rendell and S. M. Girvin, Phys. Rev. B **23** (1981) 6610.