Current Distribution in a Two-Dimensional Electron Gas Exposed to a Perpendicular Non-Homogeneous Magnetic Field of a ‘Chess’ Configuration

Samvel M. Badalyan\textsuperscript{a)} and Francois M. Peeters\textsuperscript{b)}

\textsuperscript{a)}Department of Radiophysics, Yerevan State University, 375025 Yerevan, Armenia
\textsuperscript{b)}Department of Physics, University of Antwerp (UIA), 2610 Antwerpen, Belgium

\textbf{Motivation}

Effects induced by the \textit{geometry} and by non-homogeneous \textit{magnetic fields} in low-dimensional semiconductor systems are of current interest \cite{1,2}. Energy dissipation processes and transport properties of these systems are mainly determined by the spatial distribution of the electric current and the potential. These distributions are essentially altered by the sample \textit{geometry} (the sample shape and size, the electrode configuration) and by the non-homogeneity of the applied \textit{magnetic field}.

\textbf{Analytical Results}

For the anti-symmetric system with \( B_{x} = -B_{y} = B \) we obtain the following exact solution for the electric field distribution

\[
-\frac{1}{\pi} \frac{d}{dz} \left( \frac{1}{z} \right) E_{x}, \quad \text{where} \quad z = x + iy, \quad \frac{1}{2} \pi \leq \alpha < \frac{3}{2} \pi, \quad \text{and} \quad mc^{2} = E_{z}.
\]

\textbf{Electric Field}

\textbf{Electric Field}

\textbf{Analytical Results}

For the anti-symmetric system with \( B_{x} = -B_{y} = B \) we obtain the following exact solution for the electric field distribution

\[
-\frac{1}{\pi} \frac{d}{dz} \left( \frac{1}{z} \right) E_{x}, \quad \text{where} \quad z = x + iy, \quad \frac{1}{2} \pi \leq \alpha < \frac{3}{2} \pi, \quad \text{and} \quad mc^{2} = E_{z}.
\]

\textbf{Summary}

We have calculated analytically the spatial distribution of the \textit{Joule heat generation rate} \( P(x,y) = E_{x}(x,y) / (x,y) \) (in arbitrary units) corresponding to the situation of Fig. 1 (the left figure). Line charge density accumulated at the magnetic interfaces along the \( y \)-direction (the right figure).

\textbf{Acknowledgments}

This work was partially supported by the Flemish Science Foundation (FWO-VI), the Inter-University Attraction Poles research program (IAP-W), the Concerted Action Program (GOA), and the Inter-University Microelectronics Center. S.M.B. acknowledges support by the Vacht and Tamar Manoukian Benevolent Association (VTMBA) to participate the Phonons 2001 conference, August 12-17, 2001, Hanover, USA.

\textbf{References}

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