Memory effects in transport properties of 2D systems

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We discuss classical magnetotransport in a two-dimensional system with strong scatterers. Even in the limit of very low field, when $\omega_c\tau \ll 1$ (ω_c is the cyclotron frequency, τ is the scattering time) such a system demonstrates strong negative magnetoresistance caused by non-Markovian memory effects. A regular method for the calculation of non-Markovian corrections to the Drude conductivity is presented. A quantitative theory of the recently discovered anomalous low-field magnetoresistance is developed for the system of two-dimensional electrons scattered by hard disks of radius a, randomly distributed with concentration n. For small magnetic fields the magentoresistance is found to be parabolic and inversely proportional to the gas parameter, $\delta\rho_{xx}/\rho \sim -(\omega_c\tau)^2/na^2$. In some interval of magnetic fields the magnetoresistance is shown to be linear $\delta\rho_{xx}/\rho \sim -\omega_c\tau$ in a good agreement with the experiment and numerical simulations. Magnetoresistance saturates for $\omega_c\tau \gg na^2$, when the anomalous memory effects are totally destroyed by the magnetic field. We also discuss magnetotransport at very low fields and show that at such fields magnetoresistance is determined by the trajectories having a long Lyapunov region.