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2007 J. Phys.: Condens. Matter 19 259001

(http://iopscience.iop.org/0953-8984/19/25/259001)

J. Phys.: Condens. Matter **19** (2007) 259001 (1p) doi:10.1088/0953-8984/19/25/259001

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Is there ballistic transport in metallic nano-objects? Ballistic versus diffusive contributions

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Published 7 December 2006

Abstract

When discussing the resistance of an atomic-or nanometre-size contact we should consider both its ballistic and its diffusive contributions. But there is a contribution of the leads to the resistance of the contact as well. In this context, the geometry and the roughness of the surfaces limiting the system will contribute to the resistance, and these contributions should be added to the ideal ballistic resistance of the nanocontact. We have calculated, for metallic materials, the serial resistance of the leads arising from the roughness, and our calculations show that the ohmic resistance is as important as the ballistic resistance of the constriction. The classical resistance is a lower limit to the quantum resistance of the leads. Many examples of earlier experiments show that the mean free path of the transport electrons is of the order of the size of the contacts or the leads. This is not compatible with the idea of ballistic transport. This result may put in serious difficulties the current, existing interpretation of experimental data in metals where only small serial resistances compared with the ballistic component of the total resistance have been taken into account. The two-dimensional electron gas (2DEG) is also discussed and the serial corrections appear to be smaller than for metals. Experiments with these last systems are proposed that may reveal new interesting aspects in the physics of ballistic and diffusive transport.

0953-8984/07/259001+01$30.00