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Relativistic space-charge-limited transport in Dirac semiconductor YEE SIN ANG, M. ZUBAIR, L. K. ANG, Singapore University of Technology and Design, PHILIPPE LAVOIE, University of Toronto — The theory of space-charge-limited (SCL) current was first formulated by Mott and Gurney more than 70 years ago based on the semiclassical transport of quasi-free electron in dielectric solids. Its validity for recently fabricated 2D materials, which can host different classes of exotic quasiparticles, remains questionable. Recently, SCL transport measurements in 2D Dirac semiconductor, such as MoS_2 and hBN monolayers, revealed anomalous current-voltage scaling of $J \propto V^{1.7}$ which cannot be satisfactorily explained by conventional theories. In this work, we propose a theory of space-charge-limited transport that takes into account the relativistic quasiparticle dynamics in 2D Dirac semiconductor based on semiclassical Boltzmann transport equation. Our relativistic SCL model reveals an unconventional scaling relation of $J \propto V^{\alpha}$ with $3/2 < \alpha < 2$ in the trap-free (or trap-filled) regime, which is in stark contrast to the Mott-Gurney relation of $\alpha = 2$ and the Mark-Helfrich relation of $\alpha > 2$. The $\alpha < 2$ scaling is a unique manifestation of the massive Dirac quasiparticles and is supported by the experimental data of MoS_2. The relativistic SCL model proposed here shall provide a physical basis for the modelling of Dirac-material-based devices

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