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The Taylor–Melcher leaky dielectric model as a macroscale electrokinetic description EHUD YARIV, Technion, ORY SCHNITZER, Imperial College — As the Taylor-Melcher electrohydrodynamic model hinges upon the presence of nonzero interfacial-charge density, it appears to be in contradiction with the aggregate electro-neutrality implied by ionic screening. Following a brief synopsis by Baygents & Saville (1989) we derive the macroscale description appropriate for leaky dielectric liquids, starting from the electrokinetic equations and addressing the double limit of thin space-charge layers and strong fields. Electrokinetic transport within the electrical 'triple layer' comprising the genuine interface and the adjacent space-charge layers is embodied in effective boundary conditions; these, together with the simplified transport within the bulk domains, constitute the requisite macroscale description, which essentially coincides with the familiar equations of Taylor & Melcher. A key quantity in our macroscale description is the 'apparent' surface-charge density, provided by the transversely-integrated triple-layer microscale charge. At leading order, this density vanishes due to the expected Debye-layer screening; its asymptotic correction provides the 'interfacial' surface-charge density appearing in the Taylor-Melcher model. Our unified electrohydrodynamic treatment provides a reinterpretation of both the Taylor-Melcher conductivity-ratio parameter and the electrical Reynolds number. Our procedure explains the oversight which has prevented Baygents & Saville from matching the triple layer with the bulk.

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