Waldram

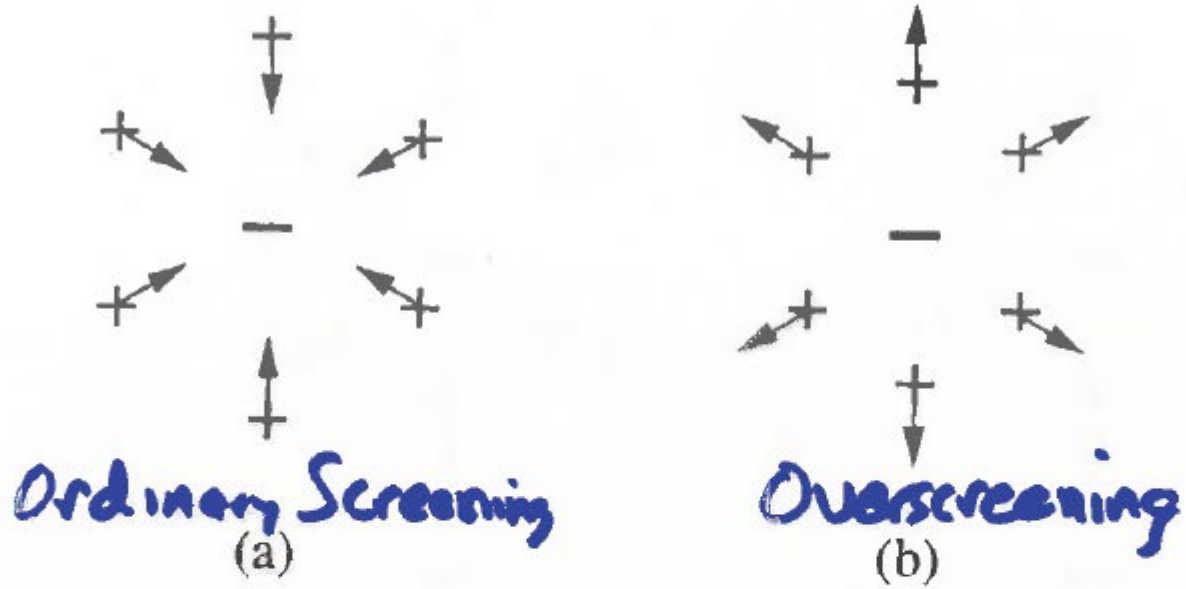

Figure 7.1. Response of the medium to a negative charge at the origin. In (a) we have ordinary screening: positive polarization charge has moved towards the origin, but the net charge near the origin remains negative and the electric field remains directed inwards. In (b) we have *overscreening*: the concentration of positive polarization charge has more than compensated the original negative charge at the origin, and the electric field points outwards. In case (b) there will be an *attractive* electric force between electrons, but it is not obvious how such a situation can arise.

John R Waldram, *Superconductivity of Metals and Cuprates. (IOP Publishing, Philadelphia, 1996).*

7.1, which shows the screening by the medium of a negative charge at the origin. In (a) we have the usual situation. The negative charge has pulled positive charge from the medium towards it, which, by generating its own field, has reduced the net inward field, thus reducing the repulsive force on any nearby electron, but not reversing it. In (b) we have *overscreening*. The negative charge has pulled so much positive charge towards it that the field near the origin is *reversed*. This is what is needed to make an electron attract another nearby electron, but it appears paradoxical: the net field is now *outwards*, so what is holding the positive screening charge in position against the restoring force of the medium?

Can overscreening ever arise in practice? In the case of the ionic lattice there are at least two possible situations in which it can. One possibility is dynamic. If the imagined charge at the origin is *oscillating*, and if the frequency of oscillation lies just below a resonance of the lattice, the dynamic polarization will have the same sign as the static polarization but will be much larger, and this can lead to overscreening. (Remember that for an oscillating system the total force acting on the system is a *restoring* force, acting in the *opposite* direction to the displacement: just below resonance the outward electrical field is simply providing part of this restoring force for the lattice ions.) The second and more extreme possibility becomes

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