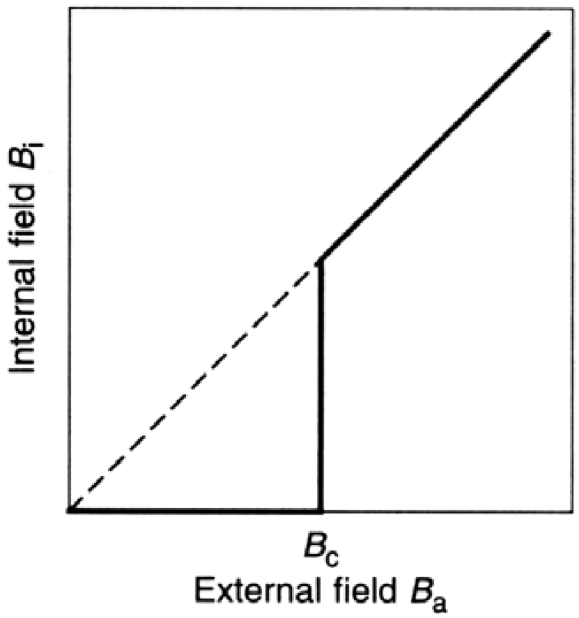
Electron-phonon interaction

Superconductivity is due to an effective attraction between conduction electrons. Since two electrons experience a repulsive Coulomb force, there must be an additional attractive force between two electrons when they are placed in a metallic environment. In classic superconductors, this force is known to arise from the interaction with the ionic system. In previous discussion of a normal metal, the ions were replaced by a homogeneous positive background which enforces charge neutrality in the system. In reality, this medium is polarizable– the number of ions per unit volume can fluctuatein time. In particular, if we imagine a snapshot of a single electron entering a region of the metal, it will create a net
positive charge density near itself by attracting the oppositely charged ions. Crucial here is that a typical electron close to the Fermi surface moves with velocity $v_F = \frac{\hbar k_F}{m}$which ismuch larger than the velocity of the ions, $v_I = V_F m/M$. So by the time $\tau \approx \frac{2\pi}{w_D} \approx 10^{-13}$ sec) the ions have polarized themselves, 1st electron is long gone (it’s moved a distance
$v_F \approx 10^8$cm/s ≈ 1000°A, and 2nd electron can happen byto lower its energy with the concentration of positive charge before the ionic fluctuation relaxes away. This gives rise to an effective attraction between the two electrons as shown, which may be large enough to overcome the repulsive Coulomb interaction.

Type I and II superconductors

High magnetic fields destroy superconductivity and restore the normal conducting state. Depending on the character of this transition, we may distinguish between type I and II superconductors. The graph shown in Figure(3)illustrates the internal magnetic field strength, Bi, within creasing applied magnetic field. It is found that the internal field is zero (as expected from the Meissner effect) until a critical magnetic field, B_c, is reached where a sudden transition to the normal state occurs. This results in the penetration of the applied field into the interior. Superconductors that undergo this abrupt transition to the normal state above a critical magnetic field are known as **type I superconductors**. Most of the pure elements tend to be type I superconductors. **Type II superconductors**, on the other hand, respond differently to an applied magnetic field, as shown in Figure (3.b) An increasing field from zero results in **two critical fields**, $\mathbf{B_{c1}}$and $\mathbf{B_{c2}}$. At Bc1 the applied field begins to partially penetrate the interior of the superconductor. However, the superconductivity is maintained at this point. The superconductivity vanishes above the second, much higher, critical field, B_{c2}. For applied fields between B_{c1} and B_{c2}, the applied field is able to partially penetrate the superconductor, so the Meissner effect is incomplete, allowing the superconductor to tolerate very high magnetic fields. Type II superconductors are the most technologically useful because the second critical field can be quite high, enabling high field electromagnets to be made out of superconducting wire



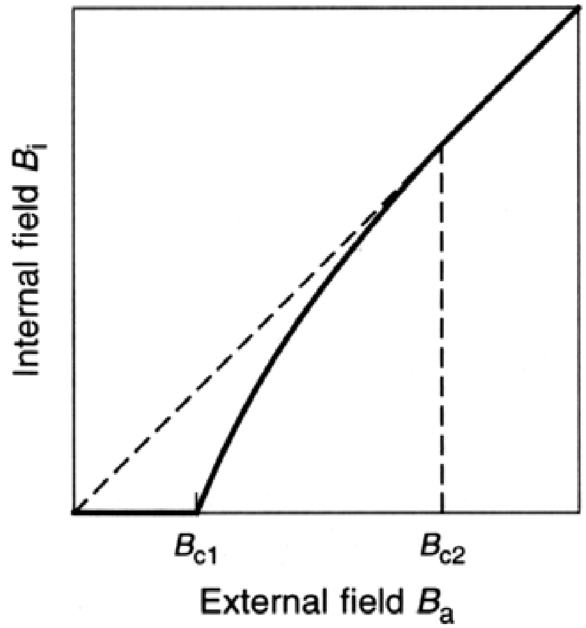


Figure 3. a-Type-I superconductor behaviour. B- Type-II superconductor