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8.512 Theory of Solids II  
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### Lecture 13: Tunneling and the Josephson Effect

We consider the tunneling Hamiltonian which transfers electrons from one side of a barrier to the other. For a superconductor, the coherence factor adds up to unity and the tunneling measures the quasiparticle density of states. Josephson made the remarkable observation that earlier workers had overlooked of the possibility of coherent pair tunneling, which gives a current at zero bias which is also second order in the tunneling matrix element.

We derive the formula for the critical Josephson current  $I_c$ ,

$$I_c R = \frac{\pi \Delta}{2e}$$

where  $R$  is the resistance of the tunnel junction in the normal state. The importance of the Josephson effect lies in its sensitivity to the phase difference on the left and right side, which leads to interference phenomena on a macroscopic scale.

**Reading:** Schrieffer, *Theory of Superconductivity*, Chapter 3.6