Block 7

Step 2 – Time reversal and what it means for the molecular state (#3 §60)

Landau states in §60: the operation of time reversal on a spinor wave function ψ corresponds to taking the complex conjugate and applying a spectral phase factor – for a spin-½ system, $T: \psi \to i\sigma_y \psi^*$.

The important consequence of this is that the spin operator $\hat{S}$ changes sign under time reversal: $T\hat{S}T^{-1} = -\hat{S}$. This means any state with $\langle S \rangle \neq 0$ is not time-reversal symmetric, it distinguishes a preferred spin direction, which is exactly what time reversal would flip. For an isolated molecule in a stylet state, time reversal symmetry is preserved by construction: the two electrons pair with opposite spins and the net moment vanishes. $\langle S_n \rangle = 0$ exactly.

When the molecule is coupled to the reservoir, the coherences $\langle S_{m+1,m} \rangle$ become complex valued, the reservoir introduces dissipation that breaks the constraint $\langle S_{m+1,m} \rangle = \langle S_{m,m+1} \rangle^*$ that would otherwise force M_0 to be real. Once M_0 gets an imaginary part, the spectrum $e_g(q)$ shifts asymmetrically. A specific spin configuration is selected, $\langle S_n \rangle \neq 0$, and the system is in a state that is not invariant under T. Time-reversal symmetry is spontaneously broken by the chirality and dissipative coupling to the reservoir.