Project topics

1. Consider spin waves in a ferromagnet and in an antiferromagnet to show that the dispersion relations are quadratic ($\omega \propto q^2$) and linear ($\omega \propto q$), respectively, in the long wavelength limit ($q \to \infty$). Discuss the difference.

2. Consider an Ising chain of total length N.
(a) Compute the spin-spin correlation function $\Gamma_k \equiv \langle s_0 s_k \rangle$ for an open chain (free-end boundary conditions) and for a ring (periodic boundary conditions). Discuss the softening of the order parameter near the boundary relative to that in the bulk.
(b) Compute the partition function for an open chain in the presence of an external field h and show that in the thermodynamic limit the result is independent of the boundary conditions.

3. Explain the symmetries (and their breaking) of a life in comparison with those of the universe (spacetime). Specifically, discuss them from the viewpoint of coarse graining and information.