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Multiplets in the Entanglement Spectrum

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Often, spin chains do not have any long range order, because of quantum mechanical fluctuations. Surprisingly, there can be phase transitions between two such phases, which suggests the existence of a hidden order. In this talk, I demonstrate that the entanglement spectrum can be used to distinguish between these subtly different phases. The central idea is to reduce a one-dimensional chain to a zero-dimensional imaginary system, called the entanglement Hamiltonian. One can then understand the phases of the original spin chain simply by looking at the spectrum of the entanglement Hamiltonian, just as one deduces the properties of atoms from their spectra. The next question is what the physical meaning of the entanglement Hamiltonian is. Properties of the entanglement Hamiltonian are in fact often reflected in physical properties of the ends of a finite chain, such as the appearance of gapless degrees of freedom or surface charge; I will give some examples in higher dimensional systems such as topological insulators as well as one dimension.