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Thermal Reduced Density Matrices in Fermion and Spin Ladder Systems XIAO CHEN, EDUARDO FRADKIN, University of Illinois at Urbana-Champaign — A recent numerical study [1] found that the reduced density matrix of a spin 1/2 system on a two-leg ladder is the same as the spectrum of a spin 1/2 chain at a finite temperature determined by the spin gap of the ladder. We investigate this interesting result by considering two-leg ladders of free fermions and spin systems with a gapped ground state using several controlled approximations. We calculate the entanglement entropy for the cut made between the chains. In the fermionic system we find the explicit form of the reduced density matrix for one of the chains and determine the entanglement spectrum explicitly. In the case of the spin system, we consider both the strong coupling limit by using perturbation theory and weak coupling limit by using replica trick method. The calculation shows that, 1) the Von Neumann entropy equals to the thermal entropy of one chain, 2) the R'enyi entropy is equivalent to the free energy of one chain, and 3) the coupling constant (gap) plays the role of effective temperature. This result can be generalized to other coupled critical systems with a bulk gap. This work was supported in part by the NSF grant DMR-1064319 at the University of Illinois [1] D. Poilblanc, Phys. Rev. Lett. **105**, 077202 (2010)

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