Entanglement of Interacting Coulombic Systems

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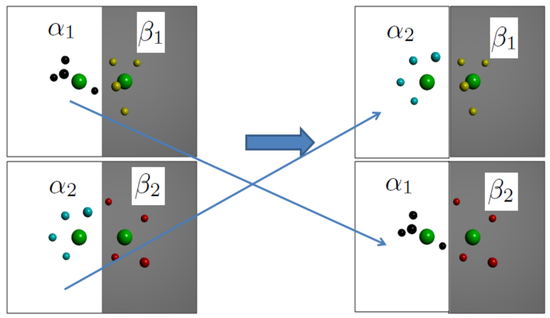
Entanglement of Interacting Systems

New methods developed for quantum Monte Carlo allow for efficient calculation of Renyi entropies of 2D and 3D Hamiltonians. This allows entangled systems beyond 1D Hamiltonians to be explored, and testing of various ideas such as the Widom conjecture.

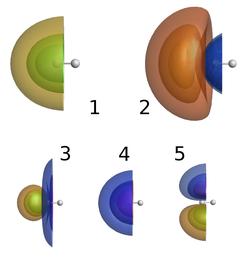
QMC Renyi entropies are calculated through the Swap operator which involves cyclic swapping of configurations between replicated copies of a wave function.

$$O(\alpha_1,\alpha_2,\beta_1,\beta_2)=\frac{\Psi_T(R(\alpha_2,\beta_1))\Psi_T(R(\alpha_1,\beta_2))}{\Psi_T(R(\alpha_1,\beta_1))\Psi_T(R(\alpha_2,\beta_2))}$$

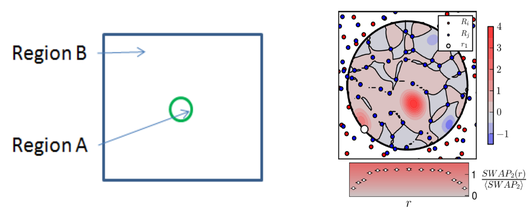


Hamiltonians

Entanglement of molecules may lead to better quantum descriptions of how molecules are bonded. We consider half space partitions through diatomic molecules

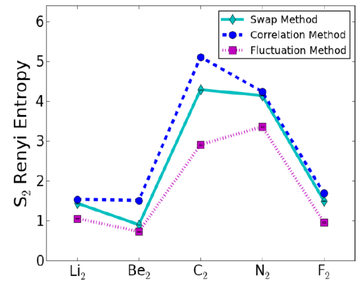


Scaling laws for the 2D/3D Fermi Liquid can tell us about entanglement of systems with Fermi surfaces. We consider a circular partition for region A

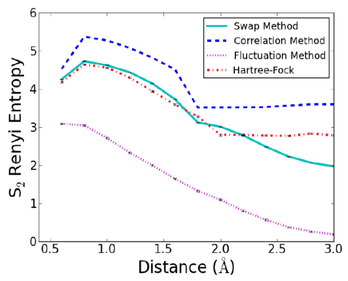


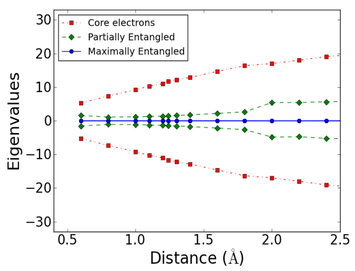
Molecular Entanglement

Entanglement results for several diatomic molecules at their equilibrium geometries.



Renyi Entropy and entanglement Hamiltonian eigenvalues for stretched carbon dimer





2DEG: Test of the Widom Conjecture

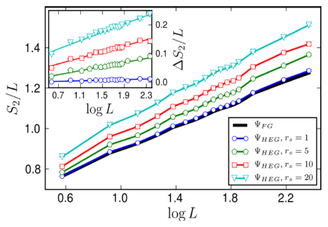
Widom Conjecture for systems with Fermi surfaces

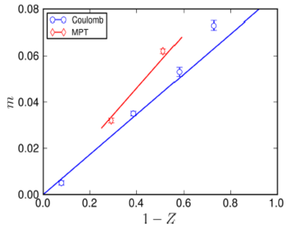
$$S\sim\frac{L^{d-1}\log L}{(2\pi)^{d-1}}\frac{1}{12}\int_{\partial\Omega}\int_{\partial\Gamma}|n_x\cdot n_p|dS_x dS_p$$

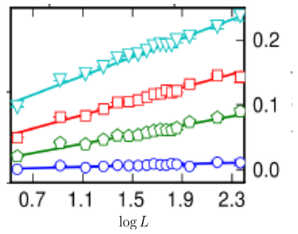
Test of coulomb and short range interactions

$$H_{HEG}=-\sum\frac{\nabla^2}{2}+\sum r_{ij}^{-1}+C(r_s)$$

$$H_{MPT}=-\sum_i\frac{\nabla^2}{2}+V_0\sum_{i<j}cosh^{-2}(r_{ij})$$



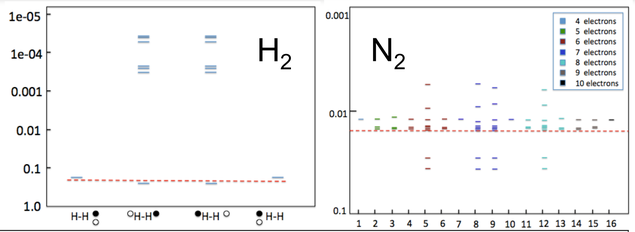




Violations of the Widom conjectures are seen in the low density/strongly interacting Fermi liquid

Entanglement Spectrum.

We have recently developed methods to calculate the full entanglement spectrum in quantum Monte Carlo simulations.



References

[1]Tubman,McMinis, ArXiv:1204.4732,2012

[2] McMinis, Tubman, (PRB) ArXiv:1207.4188,2012

[3]Swingle, McMinis,Tubman, (PRB) ArXiv:1211.0006,2012

[4} Tubman, Chang Mo, ArXiv:1402.0503