Onset of broad distributions of static and dynamic correlations in many-body localized phases

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1 Deer response

We consider the random field Heisenberg model

$$H = J\sum_{i=1}^{N} \mathbf{S_i} \cdot \mathbf{S_{i+1}} + \sum_{i=1}^{N} h_i S_i^z \tag{1}$$

where $S_i^{\{x,y,z\}} = \sigma_i^{\{x,y,z\}}/2$, σ's being the Pauli spin matrices on the lattice site i, N is the chain length and h_i's are choosen from a uniform distribution $[-\eta, \eta]$.

We first apply a $\pi/2$-pulse at some site call it site-1 on a random initial state, then evolve the system with this Hamiltonian by the Schrödinger equation. At time $t/2$ we apply a π-pusle at site-1 and a π-pulse at some other site which is r lattice site away from site-1 call it site-2. After time $t/2$ we again apply a $\pi/2$-pulse on site-1 to get the echo signal (known as Deer echo). The Deer echo is averaged over a 50 random inital states and 100 realizations of the disorder.

The time evolved many body wave function under Deer sequence is

$$|\psi(t)\rangle = R_1^{\pi/2} e^{-iHt/2} R_1^{\pi} R_2^{\pi} e^{-iHt/2} R_1^{\pi/2} |\psi(0)\rangle \tag{2}$$

where $R_i^{\pi/2} = (\mathbb{1} - i\sigma_i^y)/\sqrt{2}$ and $R_i^{\pi} = (R_i^{\pi/2})^2$. And the Deer response itself is calculated as

$$\mathcal{D}(t) = \langle\psi(t)|\sigma_1^z|\psi(t)\rangle \tag{3}$$

For the plots presented below the values of different parameters are $N = 10$, $\eta = 10$, $J = 1$, averaged over initial random state = 50 and 100 disorder realizations unless otherwise stated.

1.1 Deer vs t

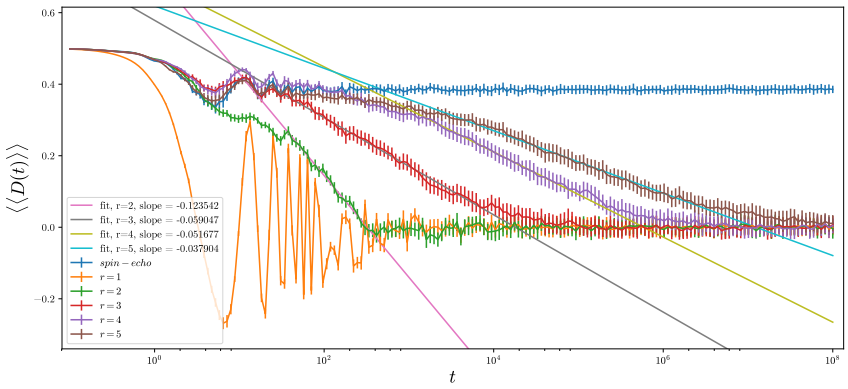

Figure 1: site-1= 3, site-2 = site-1 + r, Fbc, bulk spin.

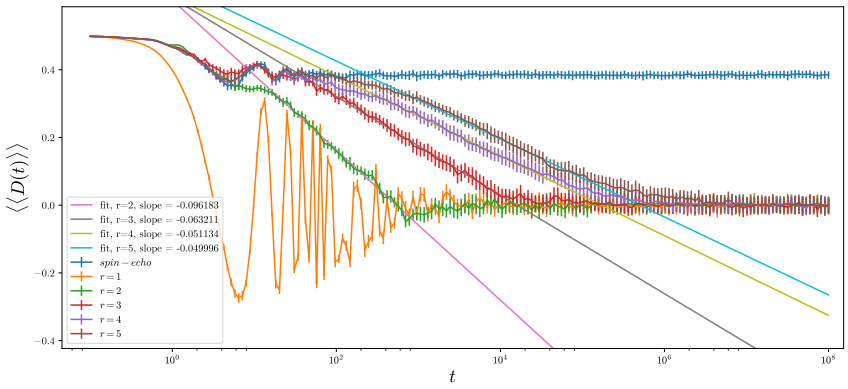

Figure 2: site-1= 3 Pbc, bulk spin.

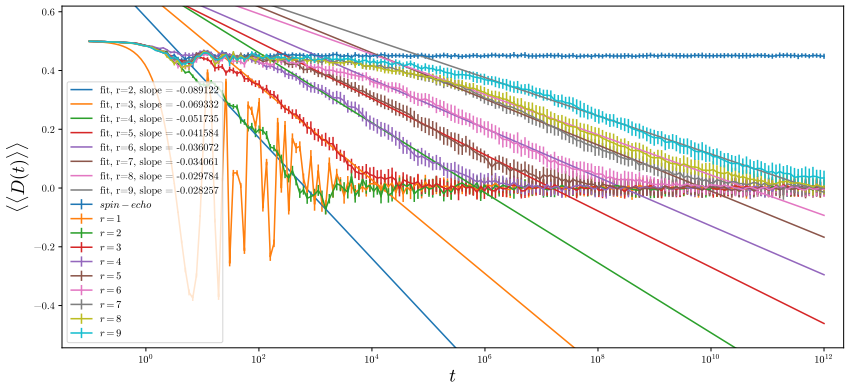

Figure 3: site-1= 1 Fbc, edge spin.

1.2 Slope vs r

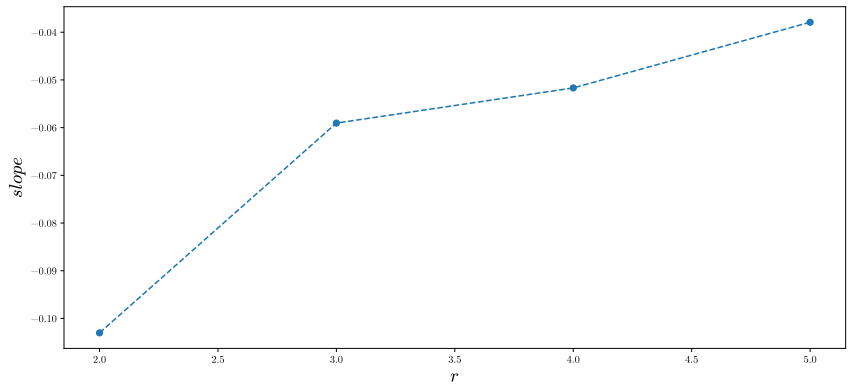

Figure 4: Fbc, bulk spin.

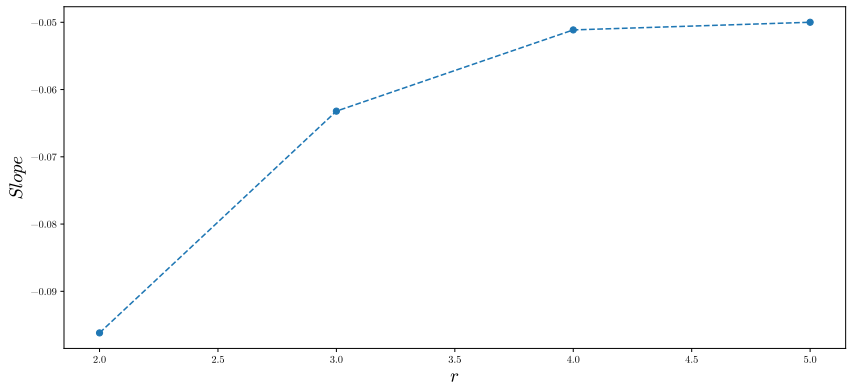

Figure 5: Pbc, bulk spin.

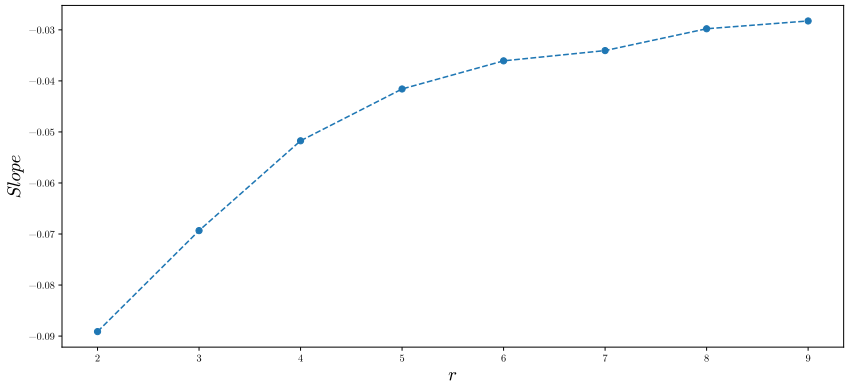

Figure 6: Fbc, edge spin.

1.3 Onset-time vs r

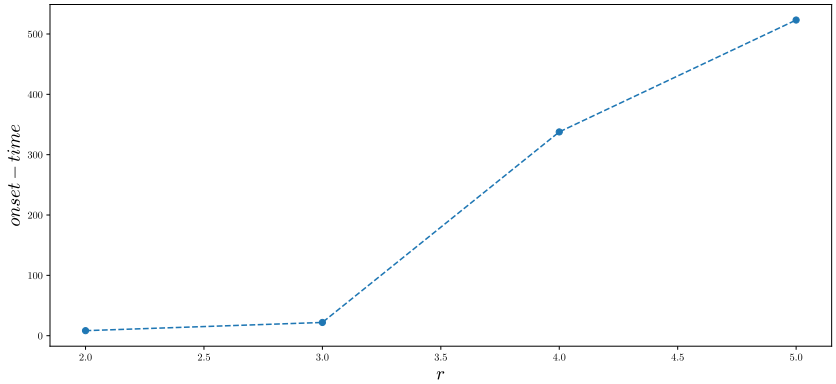

Figure 7: Fbc, bulk spin.

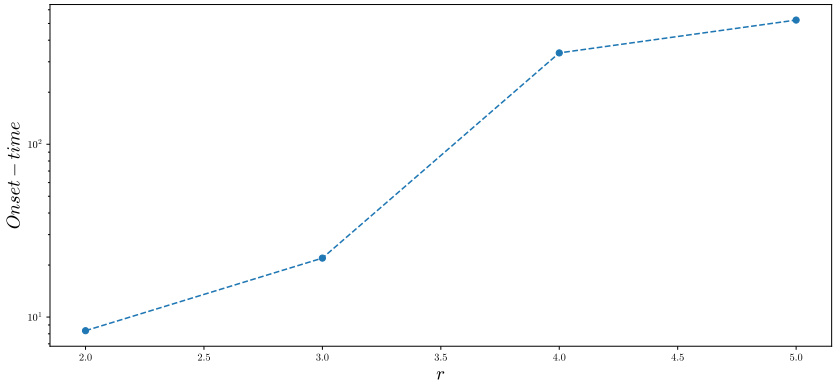

Figure 8: Fbc, bulk spin.

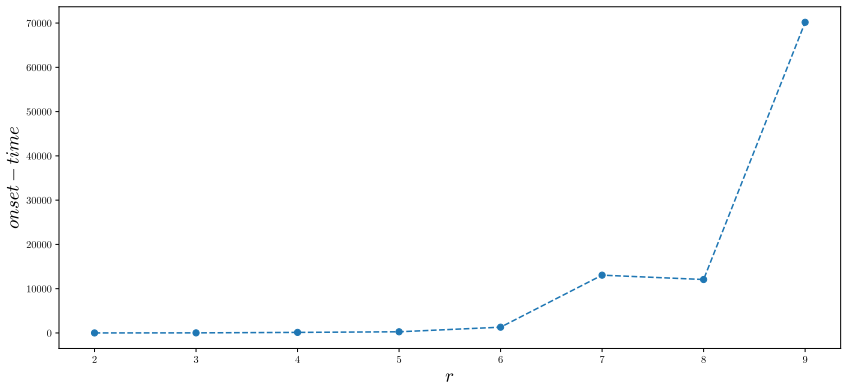

Figure 9: Fbc, edge spin.

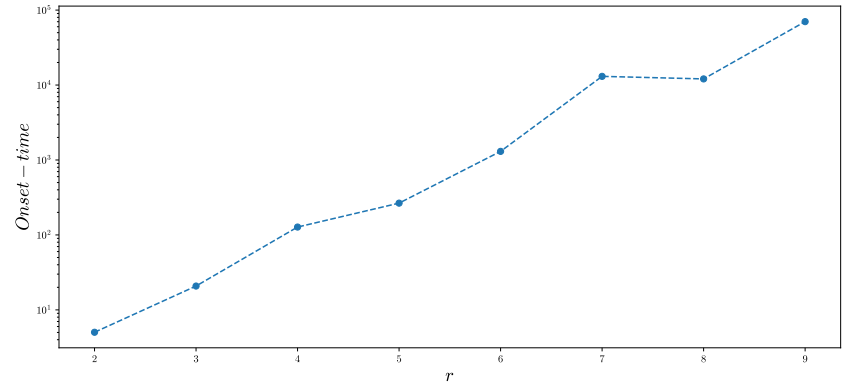

Figure 10: Fbc, edge spin.

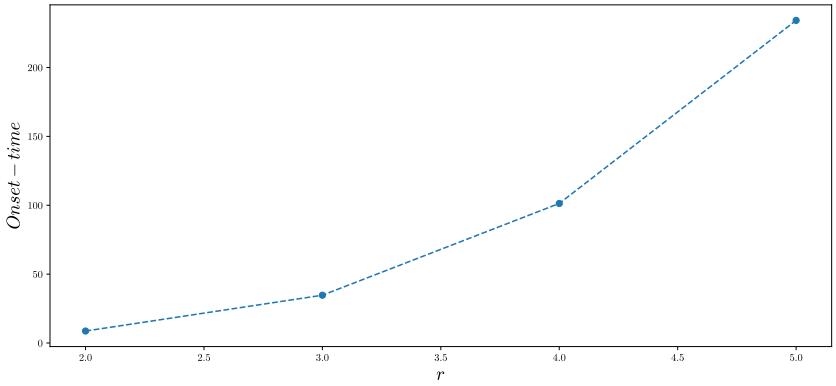

Figure 11: Pbc, bulk spin.

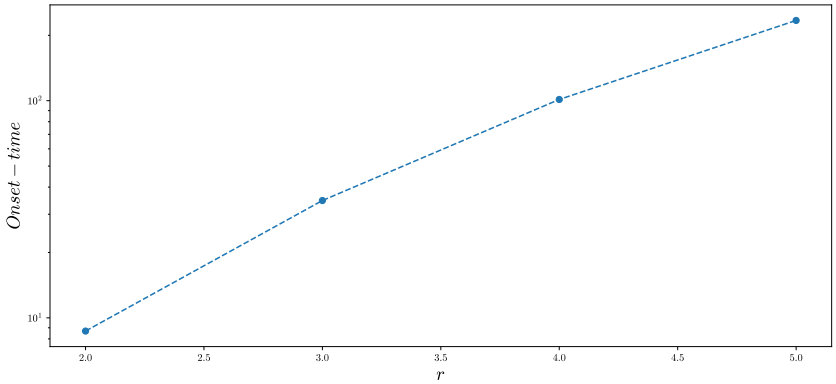

Figure 12: Pbc, bulk spin.

1.4 Sat-time vs r

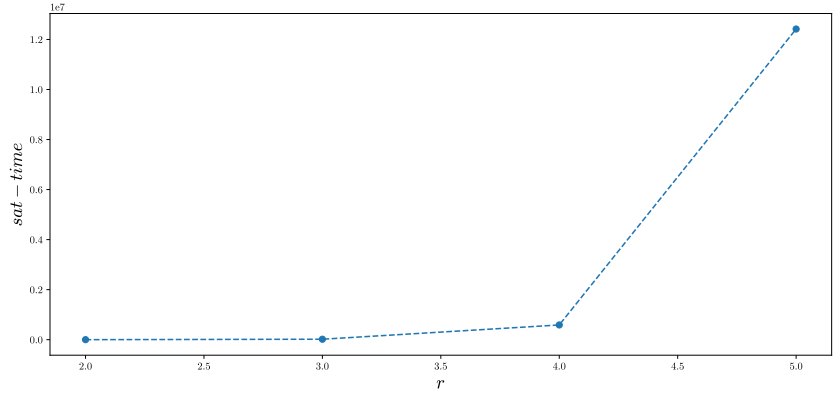

Figure 13: Fbc, bulk spin.

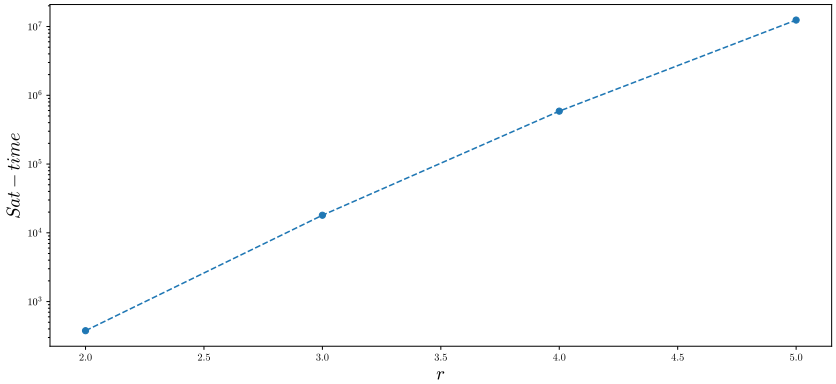

Figure 14: Fbc, bulk spin.

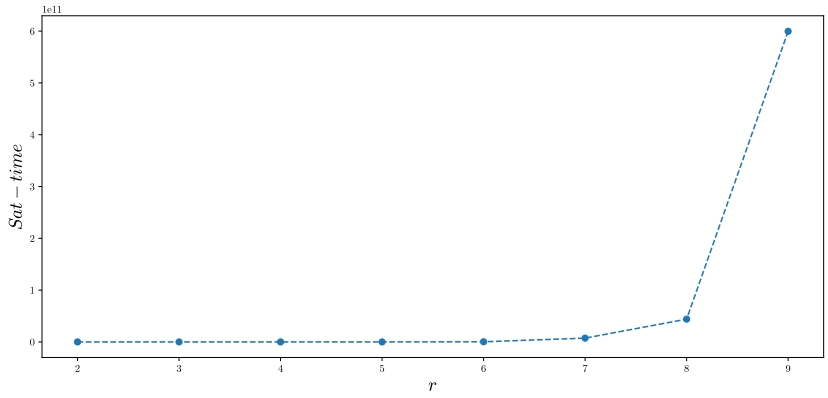

Figure 15: Fbc, edge spin.

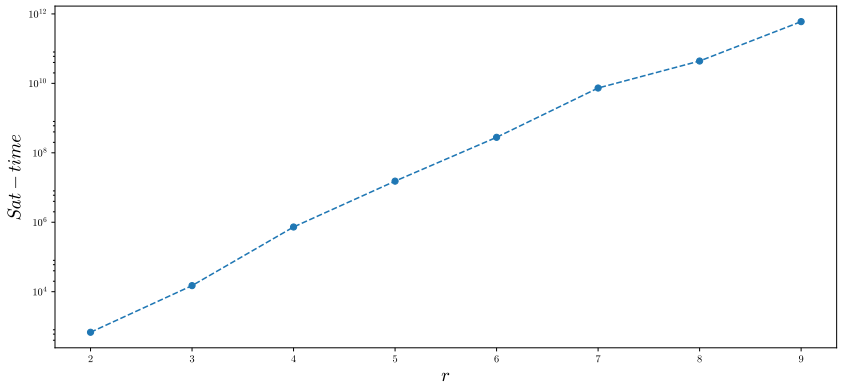

Figure 16: Fbc, edge spin.

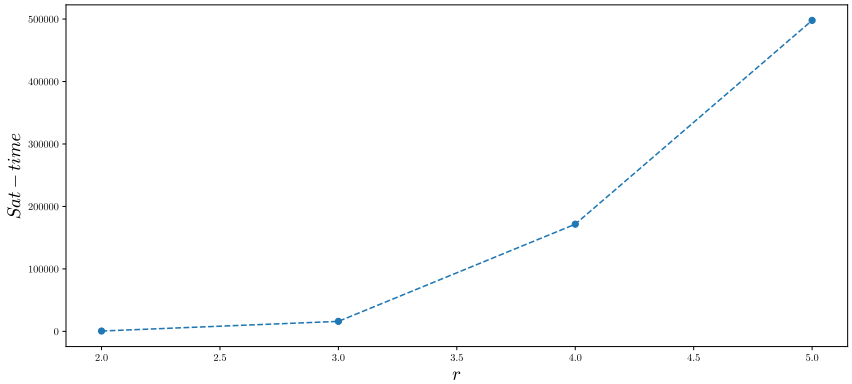

Figure 17: Pbc, bulk spin.

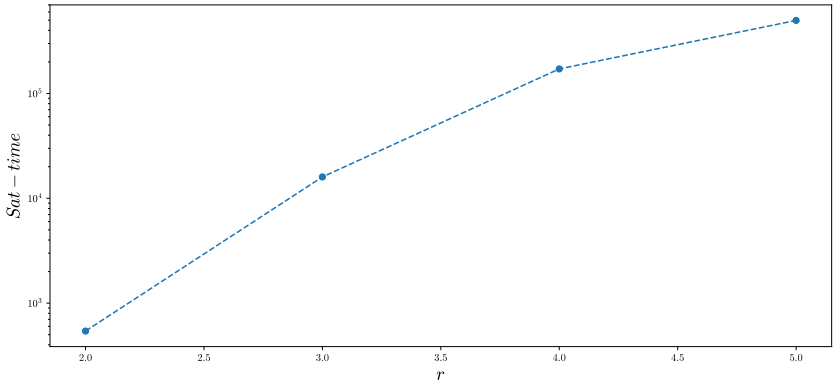

Figure 18: Pbc, bulk spin.

2 zz correlators