

**SEMINAIRE COMMUN  
IPCMS / CESQ / EUR QMAT**

(Centre Européen de  
Sciences Quantiques)

**Mardi 23 avril 2019  
à 11h à l'auditorium**

**« A 51-qubit quantum simulator with ultracold  
Rydberg atoms »**

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Arrays of interacting ultracold atoms have recently emerged as a versatile tool for quantum many-body physics. In this context, we have built at Harvard an experimental platform to create reconfigurable one-dimensional defect-free arrays of neutral atoms with Rydberg-Rydberg interactions. Our technique is based on a “bottom-up approach” where 100 tightly focused optical tweezers are generated and controlled by an acousto-optic deflector, and stochastically loaded from an optical molasses with at most one atom per trap. We use site-resolved imaging to probe the atomic distribution without destroying it, and deterministically arrange the atoms into the configuration of interest, hence removing the entropy associated with probabilistic loading. By coupling the ground state of the atoms to a Rydberg state, we create strong tunable interactions between them, resulting in a programmable quantum simulator. I will describe our recent results with this platform [1-3], including the high-fidelity adiabatic preparation of various phases of an Ising-type Hamiltonian, the study of the quantum critical dynamics associated with the corresponding quantum phase transitions, and the observation of surprisingly robust oscillations after a quantum quench that were subsequently described as a consequence of weak ergodicity breaking from quantum many-body scars [4].

[1] H. Bernien, S. Schwartz, A. Keesling, H. Levine, A. Omran, H. Pichler, S. Choi, A. S. Zibrov, M. Endres, M. Greiner, V. Vuletic and M. D. Lukin, *Nature* **551**, 579-584 (2017).

[2] H. Levine, A. Keesling, A. Omran, H. Bernien, S. Schwartz, A. S. Zibrov, M. Endres, M. Greiner, V. Vuletic and M. D. Lukin, *Physical Review Letters* **121**, 123603 (2018).

[3] A. Keesling, A. Omran, H. Levine, H. Bernien, H. Pichler, S. Choi, R. Samajdar, S. Schwartz, P. Silvi, S. Sachdev, P. Zoller, M. Endres, M. Greiner, V. Vuletic and M. D. Lukin, arXiv:1809.05540, to appear in *Nature* (April 2019).

[4] C. J. Turner, A. A. Michailidis, D. A. Abanin, M. Serbyn and Z. Papić, *Nature Physics* **14**, 745 (2018).