QSS16 - Immanuel Bloch - Questions & Answers

Immanuel Bloch

Bill Phillips: Could you say more about your NA=0.68 lens?

IMMANUEL: It's a custom made objective that can be used for several wavelengths of Rubidium (780 nm + 420 nm), although right now we are only using it at 780 nm.

Ilian Despard: Could you discuss some of the limitations that are currently preventing you from achieving unitary filling?

IMMANUEL: We can typically reach fillings of about 97% (if we try hard a bit better). Since we are not implementing active sorting to remove defects, we are mainly limited by residual temperatures or non-adiabatic processes when loading the lattices into the Mott insulating regime.

Bill Phillips: Most methods for making a spin system half up and half down will produce a distribution of up vs. down. Could you say more about that.

IMMANUEL: Indeed, in our experiments, we do not control the up-down spin distribution down to the level of single spins. Typically the distribution is slightly below Sqrt(N) standard deviation, most likely due to collisional processes in the cooling. When seeing all spins in the detection process, we can, however, always **postselect** to specific spins sectors in the analysis.

Mehedi Hasan: Would you comment on, how can we understand physically the different group velocities of holon and spin pairs?

IMMANUEL: The holon propagates at the single particle tunnel coupling t and the spins move at the spin exchange velocity, which is a factor t/U lower (with U being in the onsite repulsion between the atoms).

Tobias Grass: What happens when there are two holes on neighboring sites? Does it still squeeze to an AFM when removing the holes?

IMMANUEL: Indeed it does! You can put arbitrary many holes, it will always squeeze to a perfect Heisenberg AFM.

Luis Ardila: when you go from the polaron to the crossover regime, what would be the effect of the polaron-polaron interaction (if any)?

IMMANUEL: That's what we hope to see and probe in future experiments at slightly lower temperatures. The question whether polaron binding is the microscopic process for density instabilities in the system is a big unsolved question.

Bill Phillips: Further to my question about wanting half up and half down, but getting a distribution–on one slide, it said that there was post-selection to $M_z = 0$, which I guess is exactly half and half. But for large number of atoms, the postselection is really inefficient. How much will it matter that you have EXACTLY half up and half down? How far away from exact half filling before it makes a difference?

IMMANUEL: This depends on the system size and effective magnetization normalized to the size of the system (M/N). Indeed postselection always comes at the cost of having to take a larger number of measurements.

M KN: Could you tell us how the temperature is measured?

IMMANUEL: We look at microscopic fluctuations in the system (in the density or spin sector) and compare to reference numerical calculations.

What are other problems where you think that optical lattice based quantum simulators can contribute understanding?

IMMANUEL: Our team and others have looked at a vast array of questions, just to name a few: topological systems, high-energy systems (lattice gauge theories, relativistic quantum field theories), non equilibrium dynamics, localisation, spin squeezed states (for metrological purposes), statistical physics (see e.g. our experiments on negative absolute temperatures), spin models (with short and long range interactions)…

What are, in your opinion, the biggest challenges in quantum simulation?

IMMANUEL: Increasing programmability & coherence times (especially many-body coherence times), lowering temperatures.

Ilian Despard: You talk about running the experiment tens of thousands of times, however the cycle time for these experiment can be quite high. Could you discuss any improvements you have implemented to speed it up?

IMMANUEL: A very good point. He hope that maybe a combination of advanced laser cooling techniques or techniques you have heard about in the context of tweezer arrays can be used to bring down cycle times a lot. Already now, several experiments reported on sub-second cycle times and maybe this can be pushed even further.

How can you scale that approach towards 3D?

IMMANUEL: Actually we started out in 3D! The problem is that the optical detection exhibits a shallow depth of focus and we can typically only see a single plane in focus. Sor techniques that 'slice' the cloud during detection similar to MRI could help to give rise to single atom sensitive 3D single site resolution.