Numerical methods

numbers and interaction strengths. With our knowledge of the trap parameters we used ~~the LDA~~ to calculate profiles within the LDA that could be compared to the measurements. The reader is reminded that, to realize the LDA, one must have a solution for the homogeneous Hubbard model at a grid of values for the Hubbard parameters U/t, T/T and μ/t. For example, in Chapter 5 we used the HTSE to second order, as a solution for a homogeneous system, to carry out the LDA. For our experiments, we find that, to reproduce the measured data, we had to realize the calculations at a much lower temperature. The validity of the HTSE breaks down at around $T/t \approx 2.4$, so we turned to a set of solutions using NLCE and DQMC which were provided by our theory collaborators. At the end of Chapter 3, we have briefly described the NLCE and DQMC techniques; refer to Appendix B for more details.

In Fig. 11.3 we show the comparison between the experimental data and the numerical calculations for the central density at two different values of the temperature T/t_0. For the calculations, it is assumed that the entire sample is in equilibrium at a temperature T. The local value of T/t then varies according to the variation of t in our lattice. Figure 11.3 is very revealing. First of all, it shows dramatically the Mott insulating behavior obtained at large interaction strengths, where the central density of the cloud does not depend much at all on atom number. Secondly, a clear Mott insulating behavior can be observed down to $U_0/t_0 = 11.1$. This is in contrast with previous observations of the Mott insulating regime [34, 35] which required significantly larger values of U/t to obtain evidence for an incompressible state. (Because of higher T) Discuss comparison in more detail?

The low values of U_0/t_0 at which we can detect Mott insulating behavior are revealing of the temperature of the sample, which by comparison with the numerical calculations shown in Fig. 11.3 can be bounded to be $T/t_0 < 1$. This value is consistent with the value that was obtained using light-scattering thermometry, as will be explained later on in Chapter 12.

?(In addition to the results obtained from global fits to the column density distribution, we also went ahead and analyzed the spatial dependency of the column density profiles. One of the advantages of realizing the Hubbard model with an external confinement potential

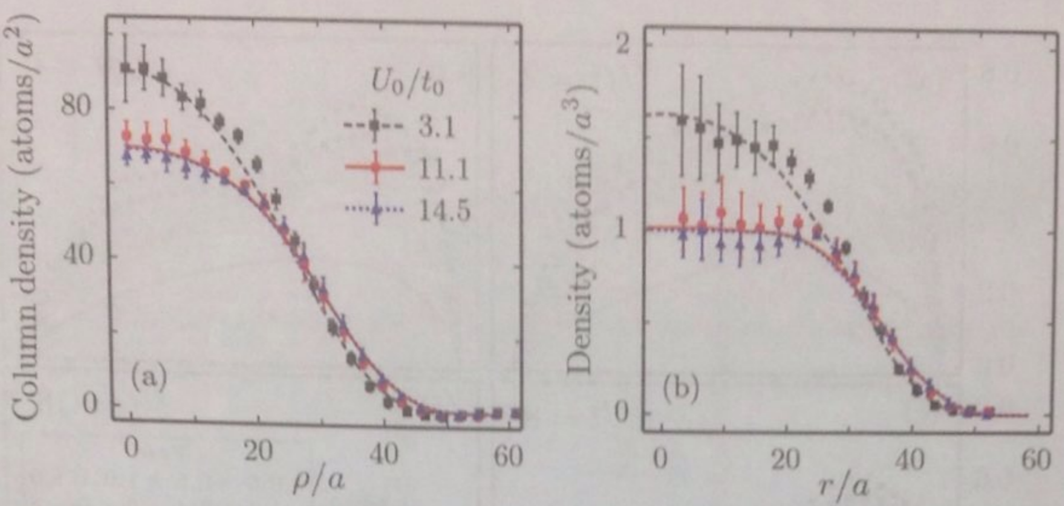

Figure 11.5: (a) Azimuthally averaged column density (includes both spin states) vs. distance from the imaging axis ρ, for different values of U_0/t_0. Data points represent the average of eight individual realizations, with error bars corresponding to the standard deviation. The lines in (a) are obtained by integrating the density, calculated for $N = 2 \times 10^5$ atoms at $T/t_0 = 0.6$, along the imaging axis. (b) Data points correspond to density profiles extracted from the column densities using the inverse Abel transform, where r is the distance from the center of the trap. The lines in (b) show the density calculated for our trap along a body diagonal of the lattice.

and temperatures. Figure 11.4 shows that the calculated compressibility diminishes at half-filling, as the system enters the Mott insulating regime, and at $\tilde{n} = 2$, where a band insulator forms.

The *in-situ* column density measured in the experiment is azimuthally averaged, and the inverse Abel transform[2] is used to obtain the density profile of the cloud. Figure 11.5 shows the column density and density profiles for three different values of U_0/t_0, compared with profiles obtained from numerical calculations for our trap potential. For the calculations we set T and the global chemical potential, μ_0; local values of U/t, T/t, and μ/t are then calculated using the known trap potential. As was explained above, the local value of the density is obtained from linear interpolation between NLCE and DQMC results for a homogeneous system calculated in a $(U/t, T/t, \mu/t)$ grid. YOU CAN ADD THE COMPARISON TO MUNICH THAT WE HAD IN THE LETTER TO EDITOR. YOU MIGHT

[2]The inverse Abel transform is a way to obtain the density profile from the column density profile, assuming spherical symmetry of the sample.

SAY THIS IS THE FIRST ~~OBSR~~ DIRECT OBSERVATION OF A MOTT PLATEAU W FERMIONS.

Below $T/t_0 \approx 1$, the density and the compressibility are nearly insensitive to temperature, since most of the entropy in the system resides in the spin degree of freedom.

We have found in this analysis, that the systematic uncertainty in the trap parameters prevents us from using the compressibility for a more precise quantitative determination of temperature. In the same system, a measurement of AFM correlations using Bragg scattering of light showed $T/t_0 = 0.58 \pm 0.07$ as will be explained in the next chapter.

I WOULD ELABORATE ON HOW THIS WORK HAS GONE BEYOND PREVIOUS. IT SHOULD REF THOSE PAPERS AND HAVE MUCH THE SAME DISCUSSION AS THE PRL.