Abstract

This thesis reports on the realization of a two-dimensional Bose-Einstein Condensate of cesium atoms in an optical surface trap, where the condensate is produced a few micrometers above a dielectric surface.

The optical trap is a combination of a repulsive evanescent wave created on a horizontal dielectric surface and a focussed 1064 nm-laser beam. Vertically the atoms are confined by a combination of the optical and gravitational potential, horizontally by the 1064 nm light. To load the surface trap we release the cesium atoms from a magneto-optical trap into the gravito-optical surface trap which first prepares a cold atom reservoir. The atoms are then loaded by thermalization into the conservative trap potential generated by the red-detuned 1064 nm laser beam. After loading we optically pump the atoms in the lowest spin state $F = 3, m_F = 3$, where cesium offers very favorable scattering properties and the scattering length can be tuned to positive values. To introduce forced evaporative cooling we ramp down the power of the red-detuned beam from 5 W by more than three orders of magnitude to a few milliwatts within 5 seconds.

After the evaporation we observe a vertical release energy of $\frac{1}{2}k_B \times 16\,\mathrm{nK}$ which is well below the vibrational energy quantum $\hbar\omega = k_B \times 26\,\mathrm{nK}$ and close to the zero point energy of $\frac{1}{2}\hbar\omega$. Thus a two-dimensional gas is realized. To prove the presence of a condensate we use a method which relies on a controlled collapse of the condensate when the scattering length is tuned to negative values. A second method relies on the horizontal expansion of the sample which is slowed down when a condensate is present.

With these two methods we can observe the onset of condensation. We observe the transition at approximately 100 nK in a 3D regime, where about 5 quantum states of the vertical motion are occupied. For lower final values of the evaporation a two-dimensional condensate is realized. The vertical motion is then dominated by the zero-point energy.