# Phys635, MBQM II-Semester 2022/23, Tutorial 4, Wed 15.3.

**Stage 1** Condensate: ground-states and dynamics

(i) Consider a Bose-Einstein condensate in the double well potential below for the given chemical potential. Discuss how you would expect the ground-state density to look like, qualitatively. Which cases should we distinguish?

(ii) Starting from this ground-state, if one now suddenly increases the potential $V_L$ and decreases $V_R$ what should happen in time and why? How can you know? When does it get complicated?
*Hints: What do the hydrodynamic equations tell you about condensate behavior? We stated the ones following from the TDGPE. Can you guess the ones following from the TIGPE and use them here?*

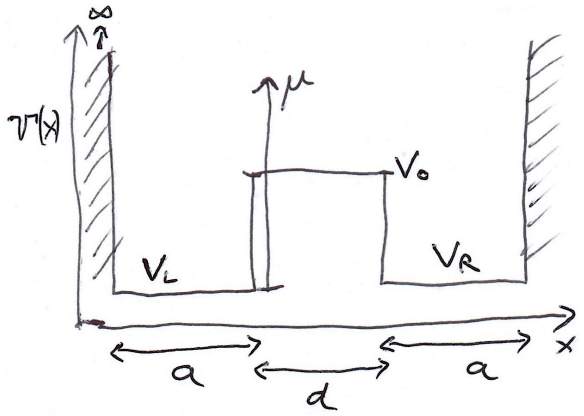


Abbildung 1: Double square well potential, $V(x) = \infty$ for $x < 0$ and $x > 2a+d$, $V(x) = V_L$ for $0 < x < a$, $V(x) = V_0$ for $a < x < a + d$, $V(x) = V_R$ for $a + d < x < 2a + d$.

**Stage 2** Bogoliubov-excitations:

(i) What are "Bogoliubov-excitations"?

(ii) What can we learn from them?

(iii) Under which conditions can you learn about their time-evolution from the GPE?

(iv) How would you create any?

**Stage 3** Condensate stability:

(i) Consider an infinitely extended 1D BEC in a homogenous initial state of density $\rho$ with attractive interactions $U_0 < 0$. If we perturb this from perfect homogeneity with the perturbation having a wavelength (i) $\lambda = \hbar\pi/\sqrt{m|U_0|\rho}/4$, (ii) $\lambda = \hbar\pi/\sqrt{2m|U_0|\rho}$, (iii) $\lambda = 2\hbar\pi/\sqrt{m|U_0|\rho}$,

which of these perturbations do you expect to remain small, which grow exponentially?

(ii) If the same BEC was contained in a large square well potential of size $a = \hbar\pi/\sqrt{2m|U_0|\rho}$, would you expect this to be stable or not?