1 Project Objectives

For over 20 years the community of physicists works intensively on in-depth knowledge of a new state of matter - quantum gases. At temperatures close to absolute zero our common intuitions fail. Atoms, which we usually imagine as small balls, start to reveal their wave nature i.e. once untwisted gas does not want to stop its move. Such behaviour is governed not only by the collisions between atoms, but also by dipole-dipole interactions. They have a long-range character caused by the magnetic dipole moment of atoms. Modern laboratories allow researchers to investigate dynamics of particles in a constrained space e.g. one can trace particles moving in a circular motion or in a one-dimensional harmonic trap. It was recently discovered that such a dipolar gas exhibits black solitons. A black soliton - roughly speaking - is a hole in the gas that does not disappear irrespective of the movements of atoms. The main objective of our project is to explore statistical properties of a few dipolar atoms both in a harmonic trap and on a circumference of a circle. Our solution will bring us closer to an answer to the question whether soliton-like solutions are natural for the dipolar systems.

2 Method

We will base our studies on a construction of the Hamiltonian of the system. Hamiltonian can be often identified with the total energy of the system. In our case the Hamiltonian is a sum of the kinetic energy of atoms, the potential energy related to a presence of the harmonic trap and the interaction energy between atoms - the dipole-dipole and contact (collisions) interactions. Complexity of the problem enforces us to gradually increase the number of atoms. Next step will be to investigate statistical properties of the solutions. In particular, we will answer the question what is the most probable position of Nth particle if one knows the positions of $N-1$ remaining.

3 Motivation

The main reason of our project is curiosity. We do not know, how a few dipolar atoms behave in a constrained space. We have some evidence that such a system exhibits interesting phenomena. We would like to check it. Our results may induce an experimental interest in quasi one-dimension dipolar systems. In the past interplay between experiment and theory led to discovery of such interesting objects like solitronic vortices.