All of the atoms in the periodic table of elements are a part of one of the two groups: they are either fermions or bosons, depending on the elusive quantum property called spin. Regardless of other properties, which come into play at the temperatures closer to what we experience everyday, fermions and bosons differ fundamentaly even when cooled close to the temperature of absolute zero.

Bosons share the property of being able to occupy the same quantum state. Fermions, on the other hand, are under strict limitations not to behave the same way as other fermions in the close vicinity if their spin projections are the same. This is the reason why historically it's been way harder to describe the behavior of fermions rather than bosons – interactions between every pair of particles must be taken into account in a very particular way to properly describe the system.

Experimental physicists nowadays are able to cool atoms up to unimaginable temperatures very close to the absolute zero. By using well tuned lasers they are able to manipulate the matter and shape it to their will. Some of the systems of great interest to physicists are the highly confined systems similar to straight lines on the paper – quasi one-dimensional strings of atoms. Those systems in very low temperatures naturally behave in a different way depending on whether the atoms in question are of bosonic or fermionic nature. For example, when ultracold fermions are trapped in a one-dimensional string and made to repel each other very strongly by using the magnetic field, they form a crystal-like structure called the Tonks-Girardeau gas. Of course it would be the case if they did share the same spin projection, as they would naturally avoid being in the same state as the others, but here it is the case even if they don't share the spin projection. On the other hand, if they are made to attract each other very strongly, they create a boson-like very tightly bound duos of atoms.

Behavior of those exotic forms of matter is very interesting for the experimental and theoretical physicists. Of course, the experiments in a laboratory are the final and only way to confirm what the real physics around us looks like, but being able to deduce from pure reason and theoretical framework of quantum mechanics the behavior of such exotic systems as the ultracold gases of fermions in one dimension should indeed be considered the triumpf of human thought.

This project aims at implementing a novel theoretical method taken from the field of quantum chemistry that will allow us to describe systems like the ones above in great detail. It's a pity that quantum mechanics doesn't allow us to calculate with infinite precision the properties of every system in existance. In fact, when the size of the system exceeds two particles, it's usually impossible to precisely describe it. But there are many methods that try to describe the physical reality while taking the liberty of making certain approximations.

The so called explicitly correlated methods, that we will adapt and implement, will provide higher accuracy than the methods used currently, because they treat the description of every pair of particles with unprecedented precision, especially when they are very close to each other. This is of utmost importance when describing a system of fermions.