An Investigation into the Parameters of Quantum Degeneration of an Ultra Cold Non–Neutre Plasma of Identical Ions of Zero Spin in a Paul Trap

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ABSTRACT

The ultra – cold non – neutre plasma of identical zero spin bosons and high density in a Paul trap allow quantum degeneration parameters: high range order, diagonalisation of matrix density and the order parameter. The theory is symmetric al with regard to electric charge.

Keywords: Identical Bosons, Non–Neuter Plasma, Paul Trap, Quantum, Zero Spin

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1. INTRODUCTION

For decades, theoretical and experimental studies on charged particles (leptons, atomic nucleus, ions) trapped in electric and magnetic field have been conducted. They aim among other things, at quantum computer science, the trapped ions stand for an interesting candidate for implementing quantum memory (Removille S., 2009). In the Paul trap, the plasma of identical particles stuck in the electric field is non-neutre (Cohen-Tannoudji C., 1985).

In the eighties, the overall goal of theoretical and experimental work conducted on charged particles was to slow down, cool and trap a charged particle, in such a way as to observe it in as pure conditions as possible in order to eliminate all the disturbances related to collisions, to Doppler effect, to the extension due to transit time (Cohen-Tannoudji C., 1985). Two big application fields were to be distinguished following that the charged particles were leptons (electrons, positrons, muons, or ions). In the first case, the precise measure of the magnetic moment of the spin of the particle allowed to evaluate radiative corrections at this magnetic moment and thereby to test such theories as the quantum electro-dynamics and such fundamental symmetries as particle-antiparticle symmetry. In the second case, a high resolution study of various transitions of trapped ions had important applications to various fields like the mass spectroscopy, optical and microwave spectroscopy, the standards of frequency (Cohen-Tannoudji C., 1985).

In 2008, Daniel Comparat wrote: “the observation of correlated plasma has always been the researchers’ inquiry into the ultra-cold plasmas. One can even envisage the quantum degeneration states by approaching Fermi’s temperatures, theoretical predictions by Dresde’s team demonstrated for instance, that by ionizing a perfectly ordered atomic gas, as coming from Mott’s transition, it is possible to reach correlated atomic system. The same team also predicted that a laser cooling of plasma ions allows to execute an optical molass (treacle) slowing down the expansion of plasma and allowed to reach a correlated ionic system. The trapping of ultra-cold plasmas is in out an important stake. It is useful to note that in trapping but only one type of particle (ion or electron), the other is almost automatically trapped by the space charge. G.Raithel’s team, for example, has just recently performed the trapping of a plasma but in a trap of Penning type where the magnetic field effects are very important(Comparat D., 2008).

In 2009, Sebastien Removille developed, in his PHD dissertation, an experimental set capable of confining, cooling and observing several millions of ions. A Paul’s linear trap of centimetric dimensions has been drawn and made in a laboratory to confine ions and to facilitate a very low temperature system. In using the laser cooling technique, he reached the system in which ions take a periodical spatial structure, the Wigner’s crystal (Removille S., 2009).

2. PAUL’S LINEAR TRAP

2.1. Operation Principle

Figure 1 highlights a Paul linear trap. It is made up of six two- two electrically connected electrodes in order to make three
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