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Thèse de doctorat

Characterization of SuperNEMO demonstrator calorimeter timing performance
Study of 208Tl background rejection influence on the 0nubb decay sensitivity

Thèse de doctorat de l'Université Paris-Saclay
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Introducion

It is always interesting to take a historical approach when talking about a scientific discovery. This allows us to put into perspective knowledge that is now considered to have been acquired.

available energy for the reaction

The Standard Model of Elementary Particle Physics attempts to describe the world around us on scales that were inconceivable two centuries ago. A little over a hundred years ago, Henri Becquerel discovered what we today call radioactivity, with the observation of beta decay. This historical discovery was nevertheless accompanied by profound questioning, since the beta particle emitted during this decay, which turned out to be an electron, only carries away part of the available energy. This observation was contrary to the first principle of thermodynamics on the conservation of energy, and some scientists postulated that this fundamental law was being violated. It took 35 years for an eminent scientist by the name of Wolfgang Pauli to propose the existence of the *neutrino* - for small neutron in Italian - as a solution to the problem of missing energy. Three years later Enrico Fermi laid the foundations for the first mathematical formulation of what is today the Lagrangian of weak interaction. It was another 25 years, 60 years after the discovery of beta radioactivity, before the neutrino was experimentally observed by Clyde Cowan and Frederick Reines. The neutrino adventure had only just begun.

energy conservation

naturally produced in the sun, in the athmosphere, and in the earth

Why is this particle, although abundantly produced in the sun, so difficult to detect? It is because it interacts very little with the matter - electrons and quarks - that constitutes us, being sensitive only to the weak interaction (of short range), and to the gravitational force (very weakly since the mass of the neutrino is extremely low, so much so that it was believed massless for a long time).

In the current model of particle physics, neutrinos are actually described as massless. It was Bruno Pontecorvo who proposed in 1957 that neutrinos could oscillate between their different mass states, based on the already known model of oscillation of neutral kaons. To be valid, this model then presupposed that neutrinos had a non-zero mass. It was the SuperKamiokande experiment that first observed this phenomenon in 1998, demonstrating that at least two of the three neutrino flavours have a non-zero mass. The Standard Model of particle physics is then no longer sufficient to describe the neutrino, making this particle a pathway to physics beyond the Standard Model.

suggestion : The Standard Model is therefore no longer sufficient to account for this particle propreties, opening the way to new and exciting physics.

It now remains to be discovered how this particle acquires its mass. Indeed, Peut-être citer la date da validation du Higgs mechanism.

préciser (avec les main) pourquoi le fait d'être son anti particule lui procure une masse.

Tu introduis la notation 0nußß, mais ce serait alors logique d'introduire plus haut le "nu", et le ß quand tu en parles. Du coup, le choix de notation 0nußß devient plus comprhensible.

no "by" but "in" the standard

In the former desintegration , ….

having a neutral charge under the three fundamental interactions described by the Standard Model, two mass generation mechanisms are foreseeable. The first is to assume that, like all other fermions, the neutrino obtains its mass through the Higgs mechanism, leading irremediably to the assumption of the existence of a sterile neutrino. The second, proposed by Ettore Majorana, assumes that the neutrino is its own antiparticle. If this assertion is the one that applies to neutrinos, then a disintegration, prohibited by the Standard Model, is possible. It is called *neutrinoless double beta decay* ($0\nu\beta\beta$), to contrast with the *two neutrinos double beta decay* ($2\nu\beta\beta$) allowed by the Standard Model and already observed for several isotopes. In this disintegration, two simple beta decays take place simultaneously in the same nucleus, in which the two neutrinos are absorbed, allowing the total energy of the reaction to be distributed between the two exiting electrons. For reasons that will be detailed in the first chapter of this manuscript, which deals with the phenomenology of the neutrino, this disintegration is only possible if the neutrino is a Majorana particle. which chapter exactly? mmm LOL !

is expected to be extremely rare

pas thesis, mais PhD !

- pas très jolie les - tirets - partout - je trouve

These generation of experiments

These generation of experiments

Several experiments, also described in the first chapter, are dedicated to the search for this disintegration which, if it exists, is extremely rare. The SuperNEMO experiment, on which I conducted my thesis, is one of them. Successor of the NEMO experiments, it uses a unique combination of technologies, described in detail in the second chapter, allowing to trace the path of the electrons resulting from double beta disintegrations -with a wire chamber-, and also to measure their energies - with a segmented electromagnetic calorimeter.

These experiments differ from one another in the technology they use, and also in the sensitivity they can achieve in the search for this decay. Within the framework of this thesis, I carried out, together with another thesis student on SuperNEMO, Axel Pin, a sensitivity study of this experiment presented in the third chapter, determining the influence that several characteristics of the detector can have on it.

All these experiments are designed to observe, should this process exist, an extremely rare physical event. They are thus constrained to focus on the background which may disturb the measurement and have a non-negligible impact on their sensitivity to this disintegration. In this perspective, I conducted a study aimed at identifying the events resulting from one of the main background for this experiment, which is the natural disintegration of an isotope from the uranium 238 decay chain, found in the detector's components. To effectively reject this background, I study in the fourth chapter the impact on the sensitivity of the accuracy with which we measure the arrival time of particles in the calorimeter. This theoretical study, based on simulations of the detector, was completed by taking data at Modane with the SuperNEMO calorimeter, aiming to characterise this parameter for a large part of the ~~calorimeter~~ optical modules of the experiment.

When I joined the LAL team at Orsay (now IJCLab) as a PhD student, SuperNEMO was already largely built in the Modane underground laboratory. I had the opportunity to actively participate in the completion of its assembly, as well as in the analyses of the first commissioning data described in the last chapter, thus completing the experimental knowledge acquired during this thesis.

PhD

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