Introduction

Seventy years ago occurred one event which is considered for many like the birth of the nuclear structure: the discovery of the neutron by Chadwick [1]. Short time after, also in 1932, Heisenberg introduced the concept of isospin by which neutrons and protons are two different states of a same particle [2]. The following years were rich in the observation of new phenomens but, in spite of the efforts, the development of a nuclear model was rather slow, mainly due to the failure to reproduce nuclear binding energies, which were the most extensively investigated data at that time. In 1949, after a suggestion by Fermi, M. Goeppert-Mayer [3] and O. Haxel, J. Jensen and H. Suess [4] introduced a strong spin-orbit term to the single-particle nuclear potential, reproducing the single particle energies and solving the problem of the magic numbers. It was the origin of the nuclear shell model and up this moment its usefulness in correlating many experimental data began to be widely accepted. The improvement of the experimental facilities have allowed to obtain many new experimental data and in consequence the shell-model methods used to systematize these data have been developed much further too.

Another milestone in the nuclear structure was the discovery of the phenomenon of nuclear rotation for nuclei far from the closed shells. This phenomenon gave origin to the collective-model of the nucleus by A. Bohr and B. Mottelson in 1953 [5]. It consists basically in considering the nucleus like a deformed system which rotates around an axis different from the nuclear symmetry axis. The principal advances in the study of the nuclear rotation came in the 60's with the development the heavy-ion reactions, which made possible for the first time to populate fast-rotating states. Many peculiar properties of the nuclear rotation were discoverd and understood in terms of the coupling between rotational and other nuclear degrees of freedom.

In attempts to connect the shell-model and collective structures, many models were proposed in the 70's. One of the most successful and widely used for the study of the so-called transitional nuclei has been the proposed by A. Arima and I. Iachello [6]: the Interacting Boson Model (IBM). In a completely algebraic description, this approximation arises from the basic ideas of paired nucleons for nuclei between shell-model structures and collectivity.

The model, which emphasizes dynamical symmetries of the collectivity, can be used to study collective quadrupole spectra of nuclei [7].

In spite of their success, this three nuclear models (shell-model, collective and algebraic) are in continuous development. The problems of the effective interactions still open due the fact that the exact nature of the nucleon-nucleon interaction is unknown or at least very complex. In the last decade experimental facilities have been broadly developed. New powerful $\gamma-$ray spectrometers like GAMMASPHERE in the USA [8], EUROGAM (UK/France), GASP (Italy) [9] and EUROBALL (a joint project between Denmark, France, Germany, Italy, Sweden and the UK) [10] have allowed to observe in more detail the Table of the Nuclides in regions and conditions not possible before. Many new structures and excitation mechanisms have been discovered, such as superdeformation, halo nuclei, magnetic rotation and band-termination. We may then say that the nuclear espectroscopy are experimenting a renaissance [11].

One of the milestones in the present nuclear structure is the study of ^{100}Sn and its region. ^{100}Sn is the heaviest doubly magic N = Z nucleus which can exist and its structure is expected to be described by the spherical shell model. After almost two decades of search at GSI, Darmstadt, this nucleus was finally produced in 1994 in a heavy-ion reaction using online mass separation and in-beam techniques [12]. Many facts make the study of this region of experimental and theoretical interest. For example, there are theories which predict the change of the average potential close to the dripline. Knowing the structure of this region it is possible to deduce directly the single particles energies and the residual interactions with respect to the ^{100}Sn core, and with that, to deduce information on this average potential. The single-particle energies of the neutron with respect to the ^{100}Sn core could be measured from the ^{101}Sn nucleus and from ^{99}In the proton-hole energy. The residual $\pi^{-1}\pi^{-1}$ interaction could be deduced from the ^{98}Cd nucleus, the $\pi^{-1}\nu$ from ^{100}In and the $\nu\nu$ interaction from ^{102}Sn. These nuclei also represent an excellent test for large-scale shell-model calculations. The ^{100}Sn region in the Table of Isotopes is represented in the figure 1.

The high-spin structure in the ^{100}Sn region using different Doppler-shift techniques for the lifetime measurements has been studied in the last years by the Göttingen Group. Recent studies have shown that in this region the structures of high spin states in neutron-deficient nuclei below the Sn isotope chain are dominated by the interplay between proton holes in the $g_{9/2}$ orbit and neutrons distributed over several single-particle orbits extending in angular momentum from $j = 1/2$ up to $j = 11/2$. In nuclei close to N = 50, this interplay can either be competitive, leading to well separated families of either neutron particle or proton-hole configurations, or cooperative at higher spin values, where both spin-aligned protons and neutrons contribute to the total angular momenta of the states. Examples for this interplay

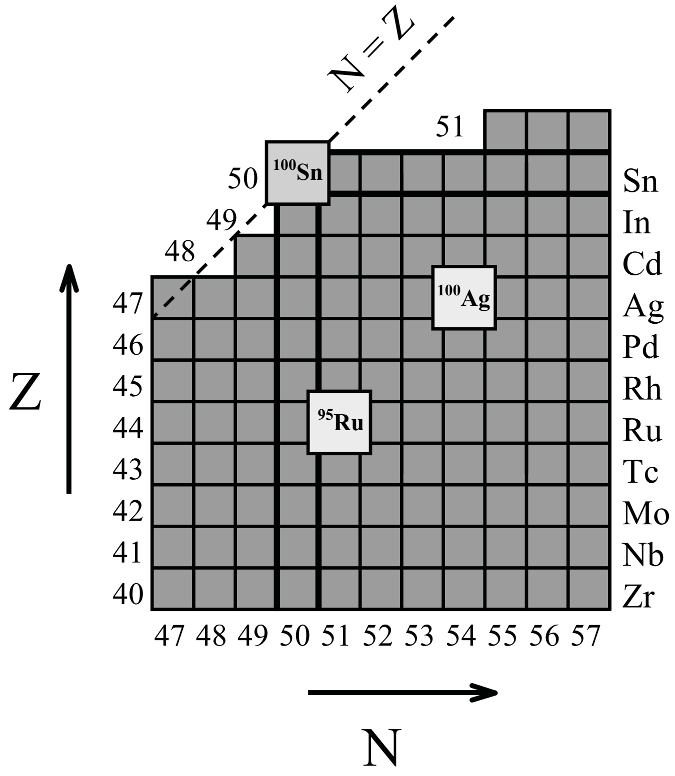

Figure 1: The ^{100}Sn region with Z<50 and N>50. The nuclei here studied are noted.

have been established in the light In and Cd isotopes [13]-[18] for N $>$ 50 as well as in some N $=$ 50 isotones with Z $<$ 50 [19]-[22]. Given this situation, measurements of electromagnetic transition strengths and magnetic moments are most appropriate to check such multi-particle configurations, as we have recently demonstrated for a number of nuclides in this mass region, e.g. ^{94}Ru, ^{95}Rh, ^{102,104}Cd and ^{104,105}In [13]-[22]. It has been also observed for the N=50 isotones ^{94}Ru and ^{95}Rh [20] that neutron core excitations ($g_{9/2} \rightarrow d_{5/2}$) are neccesary to describe high spin states. More recent studies have also observed this neutron core-excitations in ^{101,102}In and ^{99}Cd [23, 24, 25]. Strongly retarded E2 and M1 transitions connecting families of different structures as well as $\Delta I = 1$ cascades of strong magnetic dipole transitions have been established. The competition between proton holes and neutron particles, $f_{5/2}, p_{3/2} \rightarrow g_{9/2}$ proton excitations and $g_{9/2} \rightarrow d_{5/2}$ neutron core-excitations and, in particular, the influence and number of active $h_{11/2}$ neutrons, relative to neutrons in lower-j orbits, turned out to sensitively depend on the so far unknown single-particle energies near ^{100}Sn. For increasing neutron number, collective vibrational motion and/or intruder states start to compete with shell model excitations. Lifetime measurements in

^{95}Ru and ^{101}Ag nuclei by using Doppler-shift techniques is the object of the present study. The first nucleus, ^{95}Ru, with 44 protons and 51 neutrons is close to the N=50 shell closure and therefore its structure is expected to be described by the spherical shell-model. On the other side its neighboring isotopes occur in the middle of the $g_{9/2}, p_{1/2}$ proton subshell (38-50 protons), where some collective effects within the subshells might be maximized. The second nucleus, ^{101}Ag (47 protons, 54 neutrons) presents a rich scenario in mechanisms of excitation due to the competition between single-particle and collective (rotational and/or vibrational) wave functions. In the chain of odd Ag-isotopes different structures are observed: the lighter neighboring odd isotope, ^{99}Ag ($N = 52$), displays a single-particle excitation pattern [26], while the low-spin yrast structure of the heavier $N = 56$ isotope ^{103}Ag is dominated by collective transtitions [27].

This work is laid out in 4 chapters. The first chapter describes the foundations of the Doppler-shift and recoil distance techniques for the measurement of nuclear lifetime in the time range from 10^{-13} to 10^{-9} s, namely, the Recoil Distance Doppler Shift and Doppler Shift Attenuation methods with emphasis in the so-called methods of analysis DDCM and NGTB respectively. The second chapter describes the principles of two of the nuclear models above mentioned: the spherical shell model and an extension of the IBM, the Interacting Boson-Fermion plus Broken Pair Model (IBFBPM), which combines collective and single-particle degrees of freedom. In the third chapter the results of the lifetime measurements in ^{95}Ru are presented and interpreted in the frame of the spherical shell model. The fourth chapter is devoted to the presentation of the lifetime measurements in ^{101}Ag, as well as its interpretation in the frame of the IBFBPM.