Experimental g Factors and Lifetimes of $^{58-64}$Ni(2_1^+) in Comparison with Shell Model Calculations ◇

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The even-even Ni isotopes $^{58-64}$Ni are characterized by 2 to 8 valence neutrons outside doubly-magic ^{56}Ni (N=Z=28) which naively implies a gradual transition from single particle to collective structures with increasing number of neutrons. One therefore expects that the energies of the first 2^+ states decrease, the B(E2) values increase and the g factors vary from negative towards positive values of Z/A when going from ^{58}Ni to ^{64}Ni. Such a behaviour can only be a crude estimate since excitations of the ^{56}Ni are likely to contribute to this scenario which has been emphasized in several theoretical papers e.g. [1]. That ^{56}Ni is not such a good closed shell nucleus has also been stressed in a recent paper by Otsuka et al. [2]. On the other hand for all fp-shell nuclei, extensive shell model calculations with ^{40}Ca as core are now available. The large capability of such calculations has been recently shown in the context of high precision g factor measurements on Ti and Cr isotopes [3]. In the present work we have remeasured the g factors of the first 2^+ states of all even Ni isotopes as the only known data suffered from rather low accuracy [4].

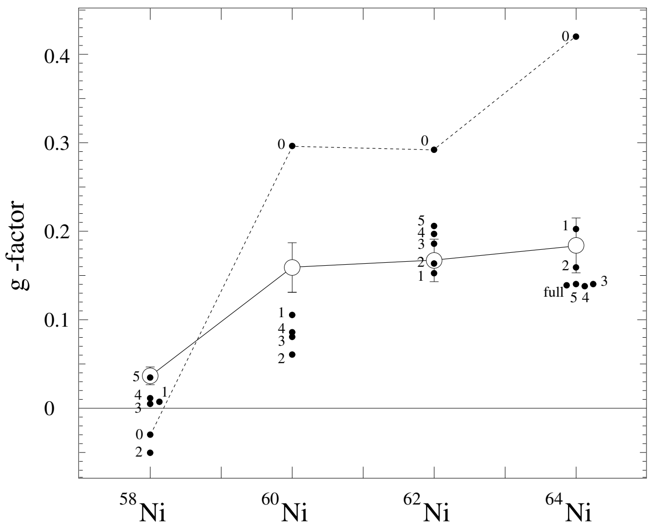

Fig. 1: Experimental g factors of the 2_1^+ states in comparison with shell model calculations (lines are to guide the eye).

In the experiments the combined technique of transient magnetic fields with Coulomb excitation in inverse kinematics was used. Isotopically pure Ni beams were provided by the Munich tandem accelerator with energies of 155 MeV which were excited by natural carbon of a single multilayered target consisting of layers of C-Gd-Ta-Cu. The deexcitation γ-rays were measured with BaF_2 scintillators in coincidence with the forward recoiling C ions which were detected in a 0° Si counter. This technique has been described in more detail in [5]. From precessions in the Gd layer and with a calibration of the effective TF, using the known g factor of ^{56}Fe(2_1^+) by Coulomb exciting ^{56}Fe beams of 155 MeV on the same target, we obtained the g factors displayed in Fig. 1. In addition, the lifetimes of the 2_1^+ states were newly determined using the Doppler-Shift-Attenuation method by measuring simultaneously the Dopplerbroadened lineshapes with a Ge detector placed at 0° to the beam direction. The deduced B(E2) values in Weisskopf units are shown in Fig. 2. The data are compared with results from shell model calculations including the excitation of up to 5 particles from the $f_{7/2}$ shell to the rest of the fp shell. In case of ^{64}Ni even a full calculation was feasible. As seen from the figures both the g factors and the B(E2) values are rather well described.

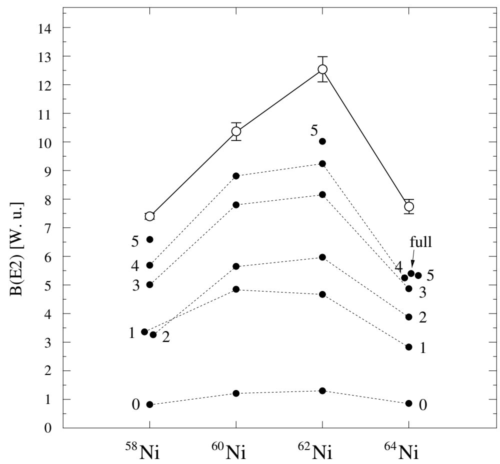

Fig. 2: Experimetal B(E2) values of the $2_1^+ \rightarrow 0_1^+$ transitions in comparison with calculations (lines are to guide the eye).

It is noteworthy that the calculations show a clear convergence with the number of particle-hole excitations and succeed to explain for the first time the surprising result of a positive g factor for ^{58}Ni(2_1^+). The course of the new B(E2) values is also well confirmed, however, the strengths are not fully reproduced. Finally, it should be mentioned that the whole wealth of information was obtained in a 4 days run due to the high detection efficiency of our new technique.

References

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