Measurements of $g$-Factors with Transient-Field Techniques (*)

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**Summary.** (**) — The basic ingredients of the transient-field technique to measure $g$-factors of short-lived nuclear excited states are outlined. The result of recent experiments to determine the $g$-factors of yrast states in the backbending region of $^{152}$Dy is shown. Then the application of the same technique to $g$-factor measurements in $^{20}$Ne and $^{24}$Mg is presented in detail.

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1. — Introduction.

The structure of nuclear states is generally determined by single-particle as well as collective degrees of freedom. Whereas the collective structure is well probed by the quadrupole moment, it is the magnetic-dipole moment which is more sensitive to the single-particle structure. This is due to the fact that the spin $g$-factor of a nucleon is several times larger than the collective $g$-factor. Moreover, the difference in sign of the $g$-factors for protons and neutrons eventually enables one to distinguish experimentally between these two nuclear species.

Nuclear $g$-factors have already been measured in the early days of nuclear physics and over the years a large variety of techniques has been developed, their specific applications depending almost exclusively on the nuclear life-

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times involved. Only recently, \( g \)-factor measurements on high-spin states in the picosecond lifetime range became feasible. The particular interest in these investigations is the so-called backbending phenomenon which appears in fast-rotating nuclei due to the interplay of single-particle with collective excitations. Because of the short lifetimes of the levels in question strong magnetic fields of the order of \( \approx 1000 \) T are needed. Such intense fields are available in free ions from electrons, in particular from \( s \)-electrons of inner atomic orbits, \( e.g. \) the magnetic field of a \( 1s \) electron at an oxygen nucleus is 8600 T.

For a sign determination of \( g \)-factors also a well-defined and controllable orientation of the field is needed which requires a polarization of the active electrons. This particular situation—intense fields in defined directions—exists in the case of the transient magnetic fields (TF). These fields which are of atomic origin are experienced when ions move through a polarized ferromagnet, \( e.g. \) a magnetized iron foil. On the basis of many experimental data \( ^{(1)} \), one knows that TF generally increase with ion velocity and are of dynamical nature due to electron exchange processes which occur in collisions with the atoms of the ferromagnet. As these fields cannot be calculated from first principles a calibration for \( g \)-factor measurements is, therefore, inevitable. This procedure which is necessarily linked to a considerably longer-lived state of the same nucleus or an isotope requires certain experimental restrictions which have to be adapted to each specific case.

With respect to the backbending phenomenon mainly observed for deformed nuclei in the rare-earth region I will only briefly mention the results of a recent measurement \( ^{(2)} \) in which TF have been employed. Then I would like to concentrate exclusively on two experimental studies for the light \( sd \)-shell nuclei \( ^{20} \)Ne and \( ^{24} \)Mg. For these measurements ion beams of tandem accelerators were used. Here, in particular, the results for \( ^{20} \)Ne have evoked a considerable amount of controversy, since they are not understood by current theories.

2. \( - g \)-factors of yrast states in the backbending region of \( ^{158} \)Dy.

As many other rare-earth nuclei \( ^{158} \)Dy shows a pronounced first irregularity in the yrast sequence at spins \( I^* \approx 14^+ \). This behaviour is illustrated in the alignment plot (fig. 1) where the backbending is attributed to the rotational alignment of valence nucleons. In the figure, the expectation value of the total angular momentum \( I \) in the direction of the rotational axis (\( x \)) has been