

02.64.23

ACTA UNIVERSITATIS UPSALIENSIS

Abstracts of Uppsala Dissertations in Science

45

C. N. E. A. Biblioteca

ARCHIVO PUBLICACIONES

Nº

1

ABO.

1964

**PERTURBED ANGULAR CORRELATIONS
STUDIED WITH THE
TIME DIFFERENTIAL METHOD**

BY

MARTIN SALOMON



UPPSALA 1964

1. BO JUNG: Experimental Studies of Nuclear Levels in Some Neutron Deficient Thallium and Mercury Isotopes. 1961. Price Sw. Cr. 2: —.
2. ARNE G. B. STRÖMBERG: Tectonic Studies on a Part of the Southern Caledonides of Sweden. 1961. Price Sw. Cr. 2: —.
3. ARNE JOHANSSON: Elastic and Inelastic Scattering of High Energy Protons by Nuclei. 1961. Price Sw. Cr. 2: —.
4. KARL-ERIK ERIKSSON: On Electromagnetic Scattering Processes at High Energies. 1961. Price Sw. Cr. 2: —.
5. ANDERS RAPP: Studies of the Postglacial Development of Mountain Slopes. 1961. Price Sw. Cr. 2: —.
6. ZBIGNIEW GRABOWSKI: Nuclear Characteristics Derived from Directional Correlation and Resonant Scattering Experiments. 1961. Price Sw. Cr. 2: —.
- X 7. TYTO SUTER: Single Particle and Collective Aspects of Some Odd-A Nuclei. Studies of decay schemes by high resolution and coincidence spectrometers. 1961. Price Sw. Cr. 2: —.
- / 8. PILAR REYES-SUTER: Experimental Studies of Nuclear Levels and Transition Probabilities. 1961. Price Sw. Cr. 2: —.
9. BÖRJE LARSSON: On the Application of a 185 MeV Proton Beam to Experimental Cancer Therapy and Neurosurgery. 1962. Price Sw. Cr. 4: —.
10. MOHAMED SAAD AHMED EL-NESEB: Studies of Nuclear Structure by Electron-Gamma Directional Correlation and Coincidence Measurements. 1962. Price Sw. Cr. 4: —.
11. B. ERIK KARLSSON: Studies of Excitation Modes of Atomic Nuclei by Means of Magnetic Moment Determinations and General Decay Investigations. 1962. Price Sw. Cr. 2: —.
12. BENGT V. HOFSTEN: Some Aspects of the Growth and Enzyme Formation of *Escherichia Coli*. 1962. Price Sw. Cr. 4: —.
13. GÖRAN BERGSON: Some New Aspects of Organic Disulphides, Diselenides and Related Compounds. 1962. Price Sw. Cr. 6: —.
14. INGRID U. OLSSON: A Study of some Problems Connected with C^{14} Dating. 1962. Price Sw. Cr. 2: —.
15. JOHN-ERIK THUN: Studies of Nuclear Properties and Decay Modes of Radioactive Nuclei. Directional correlation and coincidence investigations. 1962. Price Sw. Cr. 2: —.

PERTURBED ANGULAR CORRELATIONS
STUDIED WITH THE
TIME DIFFERENTIAL METHOD

INAUGURAL DISSERTATION

BY

MARTIN SALOMON

FIL. LIC., S.N.

BY DUE PERMISSION OF THE FACULTY OF SCIENCE
OF THE UNIVERSITY OF UPPSALA
TO BE PUBLICLY DISCUSSED IN THE LECTURE HALL
OF THE INSTITUTE OF PHYSICS
ON MAY 21, 1964 AT 10 A.M.
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

UPPSALA 1964

ALMQVIST & WIKSELLS BOKTRYCKERI AB

Already at the time when the first theories of angular correlation of two successive nuclear radiations were developed, physicists expected that in some cases this correlation could be distorted due to the interaction of extranuclear fields with nuclear electromagnetic moments.

As this correlation was used mainly to determine some parameters like the spins of the involved nuclear states and multipolarities of the emitted radiations, studies were carried out to avoid this perturbations or at least to reduce them to a minimum in order to obtain the "true" correlation.

It was soon realized that this perturbation also offered a tool for the determination of other nuclear properties. The first experiments of this kind were performed for the determination of nuclear magnetic moments. When an external magnetic field is applied, the interaction of the applied field with the nuclear magnetic dipole moment causes the nuclei to precess and therefore a shift in the angular correlation is observed.

Theoretical investigations on the theory of perturbed angular correlations were carried out and for the case of static extranuclear fields a general expression was derived which allows the determination (or numerical computation for some complex cases) of the angular correlation expression. Important advancements have been made in recent years for time dependent extranuclear fields. A summary of theoretical investigations on perturbed angular correlation may be found in the first chapter of the recent book "Perturbed Angular Correlations" (Ed. by E. Karlsson, E. Matthias and K. Siegbahn, North-Holland Publ. Co., 1964).

Most of the earlier experiments about perturbed angular correlations were done with the integral correlation method, i.e. the resolution time of the coincidence circuit was much bigger than the half-life of the intermediate state of the cascade.

One of the most important results of the theory is that the angular correlation when perturbed by external fields becomes time dependent. Thus the experimental study of the time dependence (referring to the time elapsed between the emission of the first radiation and the emission of the second radiation) of the angular correlation is a very valuable method for the determination of the strength and the type of the perturbation.

On the other hand it has to be pointed out that the method is limited to those cases where the half-life of the intermediate state is longer than the time resolution of the equipment.

This type of investigations became convenient when multichannel analyzers were available. By including a time-to-pulse-height converter plus a multichannel analyzer

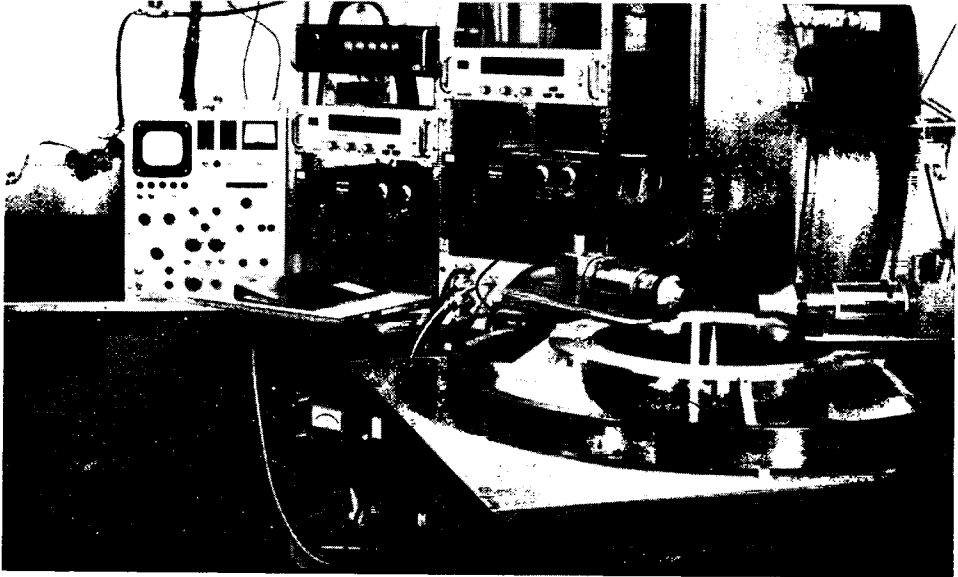


Fig. 1.

in a conventional fast-slow coincidence system it is possible to perform a "multi-time" analysis of the coincidences.

All the experiments reported in this thesis were carried out with such a system, and detailed information about the experimental equipment is given in the first paper. A general view of the equipment is shown in Fig. 1 of this summary.

The following papers are included in this thesis:

- I. E. MATTHIAS, L. BOSTRÖM, ALICE MACIEL, M. SALOMON, and T. LINDQVIST: Magnetic dipole interaction studied by the differential angular correlation method. *Nuclear Physics* 40 (1963), 656-669.
- II. M. SALOMON, L. BOSTRÖM, T. LINDQVIST, E. MATTHIAS, and MARTHA PEREZ: Measurements of g -factors of excited states in Cd^{111} and Pb^{204} . *Nuclear Physics* 46 (1963), 377-382.
- III. M. SALOMON: Electron Capture After-effects in Cd^{111} . *Nuclear Physics* 54 (1964), 171-176.
- IV. M. SALOMON, L. BOSTRÖM, T. LINDQVIST, MARTHA PEREZ, and M. ZWANZIGER: Studies of the electric quadrupole interaction with the differential angular correlation method. *Arkiv för Fysik* 27, 97 (1964).
- V. M. SALOMON, R. BALLESTERO, and M. ZWANZIGER: Attenuation of the Angular Correlation in Liquid Sources. *Arkiv för Fysik* 26, 521 (1964).

Paper I, which deals only with magnetic interaction, contains a description of the equipment used in all the following papers. Some details of the data treatment are given, and the influence of finite time resolution and time dependent perturbations on the coincidences as a function of time are studied. The g -factors of the 482 keV state in Ta¹⁸¹ and the 247 keV state in Cd¹¹¹ are measured with the differential method. The observed time range was 100 ns and 200 ns respectively. A comparison with earlier g -factors is done.

In paper II the g -factor of the 247 keV in Cd¹¹¹ was measured by accepting a longer time range. Also the g -factor of the 1274 keV level in Pb²⁰⁴ was measured. In both cases we used a long time-range (800 ns) time-to-pulse-height converter.

Paper III deals with the possible after effects of electron capture on the angular correlation. In some crystals the recombination time of the ionized atoms is long enough to produce an appreciable perturbation in the angular correlation. This effect is found in In₂O₃ polycrystalline sources. It was also found that the perturbation depends on the temperature of the source.

In paper IV a summary of the theory of electric quadrupole interaction is given. Several experimental corrections are discussed. The experimental results for a single crystal of Hf metal and other Hf compounds in polycrystalline form are reported.

Finally paper V deals with the perturbation of the angular correlation in several liquid sources. The effect of the viscosity on the attenuation factor and possible perturbations due to complex formation are investigated. Results are compared with theoretical predictions for this type of interactions.

Acknowledgements

I would like to express my sincere gratitude to Professor Kai Siegbahn for his kind support and his stimulating interest in this work. The excellent working conditions of his institute are gratefully acknowledged. To the late Prof. J. A. Balseiro, former Head of the Institute of Physics, Bariloche, Argentina, I want to express my unlimited gratitude which I extend to all my teachers there.

I am greatly indebted to Dr Torsten Lindqvist, who offered me the possibility to work in this field and guided me during the work reported in this thesis.

I would very much like to thank Dr Eckart Matthias as well as my other friends and coworkers Alice Maciel, Martha Pérez, Lennart Boström, Marcus Zwanziger, Rómulo Ballester, David A. Micha and Göran Liljegren for interesting discussions and their pleasant and stimulating cooperation.

Special thanks are due to Curt Bergman for chemical preparations of many sources, to Karin Abrahamsson for typing all our manuscripts and to Göran Pettersson and the computer staff for their cooperation.

I want to express my sincere gratitude to the Swedish Agency for International Assistance (NIB) and the Argentine Atomic Energy Commission who made my stay in Sweden possible.

This work has been financially supported in part by the Swedish Atomic Research Council and the US Air Force Research and Development Command EOAR.

Uppsala, April, 1964.

MARTIN SALOMON

16. STIGVARD AXENSTEN: Atomic Beam Investigations of Radioactive Polonium, Bismuth, Thallium and Tellurium Isotopes. 1962. Price Sw. Cr. 2:—.
17. OLLE HÖRNFELDT: Studies of Atomic Level Energies and Auger Spectra. 1962. Price Sw. Cr. 2:—.
18. GÖSTA ZETTERBERG: On Mutagenesis in Ophiostoma. 1962. Price Sw. Cr. 2:—.
19. SVEN SVENNERSTEDT: Studies of Linear and Toroidal Pinch Discharges. 1963. Price Sw. Cr. 2:—.
20. ANNA ABOLINŠ-KROGIS: The Morphological and Chemical Basis of the Initiation of Calcification in the Regenerating Shell of *Helix pomatia* (L.). 1963. Price Sw. Cr. 6:—.
21. LENNART EGARDT: On the Leptonic Decays of Strange Particles. 1963. Price Sw. Cr. 2:—.
22. JAN LINDSKOG: Studies of Nuclear Properties by Coincidence Spectrometer Methods. Decay schemes and transition probabilities. 1963. Price Sw. Cr. 2:—.
23. ECKART MATTHIAS: Experimental and Theoretical Investigations of Perturbed Angular Correlations. 1963. Price Sw. Cr. 4:—.
24. ÖSTEN LEVIN: Electron Microscope Studies on Protein Molecules with Special Reference to the High Molecular Weight Respiratory Proteins. 1963. Price Sw. Cr. 8:—.
25. WERNER SCHNEIDER: Applications of Digital Computer Techniques to Theoretical Investigations and to the Analysis of Experimental Data in Nuclear Spectroscopy. 1963. Price Sw. Cr. 2:—.
26. HANS WALLIN: Studies in Potential Theory. 1963. Price Sw. Cr. 2:—.
27. PAUL GORDON JARVIS: Comparative Studies in Plant Water Relations. 1963. Price Sw. Cr. 4:—.
28. GUNNAR TIBELL: Investigations of Nuclear Structure and Interaction Symmetries with High Energy Protons. 1963. Price Sw. Cr. 2:—.
29. ANNA NILSSON: Studies on Occurrence, Estrogenic Activity and Metabolism of Plant Estrogens, Especially Biochanin A. 1963. Price Sw. Cr. 4:—.
30. MATTS ESSÉN: Studies on a Convolution Inequality. 1963. Price Sw. Cr. 2:—.
31. ANDREAS EHN: Aspects of Determination in the Spider Embryo. 1964. Price Sw. Cr. 4:—.
32. PETER WEISSGLAS: Electrostatic Waves in Bounded Plasma. 1964. Price Sw. Cr. 2:—.

ACTA UNIVERSITATIS UPSALIENSIS

Abstracts of Uppsala Dissertations in Science

Editor: The Dean of the Faculty of Science

33. ANGELICA V. HOFSTEN: Some Aspects of the Morphogenesis in Ophiostoma. 1964. Price Sw. Cr. 4: —.
34. KUNO THOMASSON: Plankton and Environment of North Patagonian Lakes. 1964. Price Sw. Cr. 6: —.
35. ERIK NORELAND: Studies of Energy Bands in Solids by X-Ray Spectroscopy. 1964. Price Sw. Cr. 2: —.
36. CARL-OLOF JACOBSON: Experimental Investigations on the Development of the Urodele Brain. 1964. Price Sw. Cr. 4: —.
37. SVEN NILSSON: Studies on Freshwater Hyphomycetes. 1964. Price Sw. Cr. 4: —.
38. ELISABET HENRIKSSON: Studies in the Physiology of the Lichen Collema. 1964. Price Sw. Cr. 6: —.
39. SETH BERGLUND: Experimental Studies of the Toroidal Pinch, Especially with Axial Magnetic Field Reversal. 1964. Price Sw. Cr. 2: —.
40. JAN LINDERBERG: Role of Correlation in Electronic Systems. 1964. Price Sw. Cr. 2: —.
41. OLOV BERGMAN: Experimental Studies of Nuclear States and Transitions. 1964. Price Sw. Cr. 4: —.
42. HEIKKI AMRÉN: Studies on the Ecology and Taxonomy of Zooplankton Especially the Rotifers from Spitsbergen. 1964. Price Sw. Cr. 2: —.
43. MARTIN JOHANSSON: Growth and Alkaloid Production by *Claviceps Purpurea* (Fr.) Tul. 1964. Price Sw. Cr. 2: —.
44. PER OLOF SCHÖRLING: Studies of Some Flash X-ray Lines. 1964. Price Sw. Cr. 2: —.
45. MARTIN SALOMON: Perturbed Angular Correlations Studied with the Time Differential Method. 1964. Price Sw. Cr. 2: —.

Doctoral dissertations in Science are published either as monographs or as summaries of articles previously printed. It is these summaries that are collected in the series "Abstracts of Uppsala Dissertations in Science".

Distributed by

Almqvist & Wiksell

Gamla Brogatan 26

STOCKHOLM, SWEDEN

Price Sw. Cr. 2: —.