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PROGRESS REPORT TO E.A.N.D.C. FROM DANISH AEC RESEARCH ESTABLISHMENT RISØ

H. Bjerrum Møller, Editor

December 1966

PROGRESS REPORT TO EANDC

FROM

DANISH AEC RESEARCH ESTABLISHMENT RISØ

FOR THE PERIOD UNTIL OCTOBER 1966

Content:

I POLARIZATION OF NEUTRONS

I. Kopecky[x)], W. Ratynski[xx)], F. Stecher-Rasmussen and E. Warming.

As a continued work on the Soller collimators for polarizing neutrons, a permendur plate has been polished. By measurements of neutron reflection for 10 meV neutrons the reflectivity is determined to 80%.

A new collimator system is under construction according to the calculation shown in last annual report.

II INVESTIGATION OF CAPTURE GAMMA RAYS USING POLARIZED NEUTRONS

I. Kopecky, W. Ratynski and E. Warming

1. Parity-non-conservation in internucleon potentials

Investigation of the asymmetry of the gammas from the capture of polarized neutrons: $Cd^{113}(n,\gamma)Cd^{114}$ has been repeated and the preliminary result obtained is in agreement with the result stated last year.

2. Circular polarization of capture-gammas

In the gamma spectrometer the NaI has been interchanged to Ge(Li) detectors (size 17 cm^3). The response curves for the energy interval 2.23 - 10.83 MeV has been determined. Further circular polarization for $Cl^{35}(n,\gamma)Cl^{36}$ has been measured (the result not yet available).

A paper on the collimator system will be published in Risø Report 122 and in Nucl. Inst. and Methods.

x) on leave from Nucl. Research Inst., Prague-Rez

xx) on leave from Nucl. Research Inst., Warsaw.

III INVESTIGATION OF CAPTURE GAMMA RAYS USING NONPOLARIZED NEUTRONS

H. Baader, H.R. Koch and B.P. Maier, Technische Hochschule, München

For the reason of reconstruction and improvement of the bent crystal spectrometer the program of investigations was strongly reduced. The low energetic γ-spectrum of Ho 166 was scanned again to improve the data for the γ-intensities,(to appear soon in Phys.Rev.)

The following papers were published last year:

1) Niederenergetisches Neutroneneinfangs Gammaspektrum und Niveauschema von Erbium 168. H.R. Koch, Z. f. Physik 192 142 (1966)
2) Energy Levels of Tm 170
   B.P. Maier, U. Gruber, R.H. Koch, O.W.B. Schult, Phys. Rev. 143, 857 (1966)
3) Level Scheme and γ Transitions in V 52
   P. Van Assche, U. Gruber, B.P. Maier, H.R. Koch, O.W.B. Schult, J. Vervier, Nucl. Phys. 79, 565 (1966)

IV STRUCTURE INVESTIGATIONS

1) The full-wavelength time-of-flight neutron spectrometer

B. Lebech and K. Mikke

Since the last progress report part of the work has been concentrated on measuring the neutron spectrum incident on the sample. Two different methods have been used.

In the first method the neutron counter was placed in the direct beam and the wavelength distribution of the neutrons in the primary beam was measured at low power. For the second method diffraction experiments were performed at different scattering angles on a well known simple structure (e.g. Si powder). The neutron spectrum could then be deduced from the integrated intensity in the low-index well resolved diffraction peaks. By a proper choice of scattering angles it was possible to cover a large range of neutron wavelengths.

The measured neutron distribution can be analyzed as

$$S_\omega(\lambda) = P_1 T_\omega(\lambda) B'(\lambda)$$

where λ - the neutron wavelength

$S_\omega(\lambda)$ - the neutron spectrum at a given chopper speed

$T_\omega(\lambda)$ - the chopper transmission function at a given chopper speed

$B'(\lambda)$ - a Boltsmann distribution multiplied by the counter efficiency

P_1 - a normalization constant

The direct spectrum was measured at different chopper speeds in order to check the reliability of the chopper transmission function given by Larsson[1]. The $B'(\lambda)$ computed from the measured $S_\omega(\lambda)$ and the theoretical $T_\omega(\lambda)$ showed good agreement for chopper speeds from 6000 RPM to 1000 RPM.

The analysis of the measured spectrum are not finished yet, but the preliminary result show agreement between the direct measured spectrum and the spectrum computed from a known structure.

2) <u>Magnetic structure investigations of Cr-Re alloys</u>

B. Lebech and K. Mikke

The structure investigations of Cr-Re alloys described in

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[1] K.E. Larsson et al. Arkiv f. Fysik <u>16</u>, 199 (1960)

the previous progress report have continued.

The work has concentrated on the study of three samples, pure chromium, 0.07 atomic pct and 0.78 atomic pct Re-alloy, and the temperature dependence of the spin density wave periodicity is shown in fig. 1. For the 0% Re-alloy a spin flip from transverse to longitudinal polarisation is observed at 121°K in slight disagreement with results published elsewhere[1]. A similar spin flip is expected between 95°K and 120°K in the 0.07% Re-alloy, but has not been observed yet. For the 0.78% Re it is found that the spin density wave vector is commensurate with the atomic lattice at high temperature. This structure remains down to 185°±5°K. Below this temperature the spin density wave vector is incommensurate with the atomic lattice, and the periodicity as defined in fig. 1 has been determined. No spin flip has been observed down to 95°K.

The amplitude of the spin density wave have been measured, but the results cannot be treated satisfactorily before the measurements of the incident spectrum are fully analyzed.

The preliminary results have been reported at the 7th International Union of Crystallography in Moscow, July 1966, and at the 2nd Nordic Solid State Conference in Tylösand, August 1966.

V CRITICAL NEUTRON SCATTERING

J. Als-Nielsen and O.W. Dietrich

The magnetic spiral structure in Tb appears in a neutron diffraction pattern as satellite peaks about the Bragg reflections

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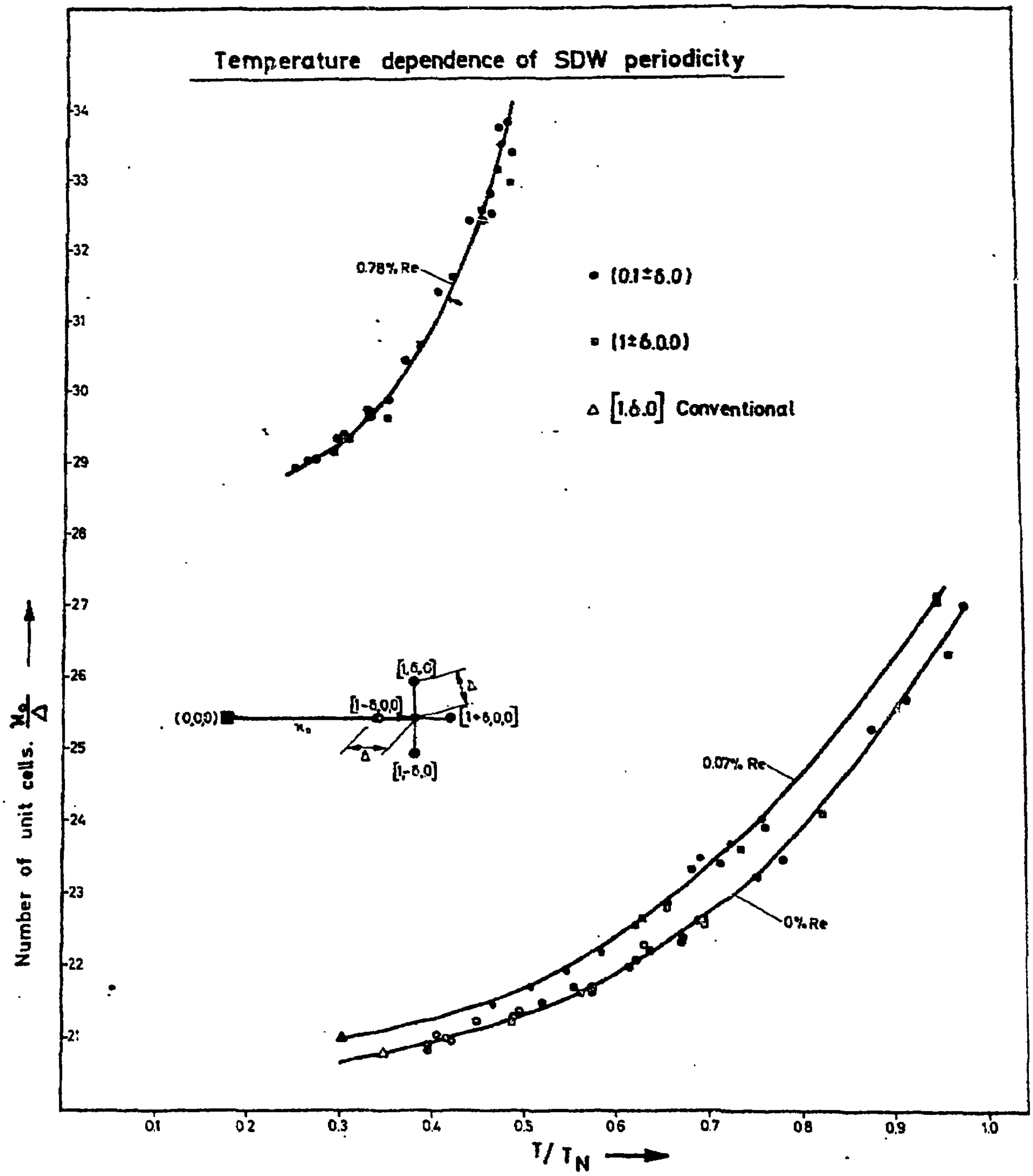
[1] W.C. Koehler, R.M. Moon, A.L. Trego, and A.R. Mackintosh Phys. Rev. 151, 405 (1966)



Temperature dependence of SDW periodicity
0.78% Re
0.07% Re
0% Re
(0,1±δ,0)
(1±δ,0,0)
[1,δ,0] Conventional
Number of unit cells
T/T_N

from the nuclear lattice. Even above the Néel temperature $T_N = 226^{\circ}K$, broader and much less intense satellites can be observed (critical scattering). The satellites at $(0,0,2\pm Q)$ have been examined in the temperature range $.002 < T/T_N < .08$ with the following results for the critical scattering:

a) The peak intensities are proportional to $(\Delta T/T)^{-\gamma}$ with $\gamma = 1.33\pm.03$. This value agrees with the prediction from the Heisenberg model ($\gamma = 4/3$), which has been verified for Fe and $KMnF_3$.

b) The scattering is anisotropic around $(0,0,2\pm Q)$. The half width in the spiral axis direction is at any temperature 2.6 times the half width κ_1 in a direction in the basal plane. Thus the short range order regions have the form of short and wide spirals. κ_1 obeyed the power law $\kappa_1 = k(\Delta T/T_N)^{\nu}$ with $k = (0.55\pm0.02)$ Å^{-1} and $\nu = 0.66\pm0.01$.

c) The line profile, corrected for instrumental resolution, deviates from a Lorentzian in the spiral axis direction. This can be accounted for by the spin diffusion model proposed by van Hove, if the dimensionless spin diffusion parameter $\Lambda^* = \frac{2m}{n} \cdot \Lambda = 21\pm5$ at all temperatures (cf. $\Lambda^* = 11$ independent of temperature for Fe). However, fourth order terms in the expansion of the critical cross section may not be negligible and could also contribute to the deviation from the Lorentzian. A separation of these two effects is not possible before a direct determination of Λ^* has been carried out.

VI OPTIMIZATION OF NEUTRON DIFFRACTION INSTRUMENTS

O.W. Dietrich

Work has been started on the calculation of resolution and intensity in neutron diffraction and time-of-flight instruments using the Monte Carlo technique.

VII INELASTIC NEUTRON SCATTERING

H. Bjerrum Møller and J.C. Gylden Houmann.

The measurements of the spin wave dispersion relations for magnons propagating in the symmetry directions in ferromagnetic Tb. at 90°K have been finished and published[1]. These measurements were analyzed in terms of $J(0) - J(\bar{q})$, where $J(\bar{q})$ is the fourier inverted exchange parameter

$$J(\bar{q}) = \sum_{\bar{R}_j} J(\bar{R}_j) e^{i\bar{q}\bar{R}_j}$$

From $J(0) - J(q)$, interplanar exchange parameters were determined by fourier inversion. A Hamiltonean containing an isotropic Heisenberg exchange term plus a crystal field anisotropy term was assumed in this analysis.

In a narrow temperature region around 217°K the structure of Tb. is helical with a turn angle of $\sim 18^{\circ}$. This requires a minimum of $J(0) - J(\bar{q})$ at $q = Q = 0.11\ \text{Å}^{-1}$. This minimum was not observed at 90°K.

Measurements of the temperature dependence of the spin wave dispersion relation for the c-direction have now been performed in the ferromagnetic and helical region, and an analysis analogous to the above mentioned has been carried out. The following two major effects were observed.

1. A change in the shape of $J(0) - J(\bar{q})$, so as to approach the condition for stability of the helical structure as the temperature approaches the Curie temperature.

2. A decrease of magnon energies with increasing temperature due to magnon-magnon interactions, the spin wave energies being approximately proportional to magnetization $\langle S^z \rangle$, in agreement

with current theories[2].

These measurements have been published at Nordic Solid State Conference, Tylösand, Sweden, and Conference on Rare Earth, Durham, England.

VIII THE NEUTRON β - DECAY HALF LIFE

C.J. Christensen, Arne Nielsen
and A. Bahnsen[x)], W.K. Brown[xx)], B.M. Rusted[xxx)].

This experiment has been described in previous progress reports. The main idea of the experiment is as follows. The β's from the decaying neutrons are detected by two plastic scintillation counters. The scintillators are placed in a homogeneous magnetic field so that the two 5 x 10 x 93 cm scintillators and the field lines connecting the edges of the scintillators define a rectangular "box" of 5 x 10 x 20 cm size. When a neutron beam is passing this box parallel to the 10 cm side of the scintillator the part of the beam which is inside the box will be the effective source. The geometrical efficiency of the detectors for this source is 100%. By means of this detector system the energy spectrum of the neutron decay β's can be studied.

Besides the decay rate, it is necessary to know the neutron density in the source. This is measured by means of a He^3-proportional counter.

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1) H. Bjerrum Møller and J.C. Gylden Houmann, Phys.Rev.Letters 16 737 (1966)

2) S.V. Tycblikov, Ukr.Mat.Zh. 11 287 (1959)
F. Keffer and R. London, J.Appl.Phys. 32 25 (1961)
H.B. Callon, Phys.Rev. 130 890 (1963)

x) present address: The University of Rochester, N.Y., U.S.A.
xx) present address: Los Alamos Scientific Laboratory, New Mexico, U.S.A
xxx) deceased.

In the period covered by this report some further studies of the ß-spectra of Au-198 showed up to be necessary in order to understand the ß-decay chamber. At the end of the period preparations to the final half life measurements were made. Presumably these measurements will now be possible in the next period.

IX MÖSSBAUEREFFECT FOLLOWING NEUTRON CAPTURE

J. Fenger and L. Løvborg.

As shown by e.g. Hafemeister and Brooks Shera[1] Mössbauer-nuclei can be formed in the excited level by (n,γ) reactions; this offers a possibility of studying the chemical effects of recoil from neutron capture γ-rays.

At the Danish reactor DR2 an experiment is being set up, in which chemical compounds of ^{56}Fe, placed in a beam of thermal neutrons, are used as sources in a Mössbauerspectrometer. The spectrometer is based on a drive of the constant velocity type[2] in conjunction with a 512-channel analyzer which samples the velocity signal.

It is hoped that the measurements will yield information on the chemical state of ^{57}Fe after emission of a cascade of γ-quanta leading to the 14 KeV Mössbauer level.

X PILE OSCILLATION MEASUREMENTS

The work with the Pile Oscillator has been concentrated on the following subjects:

i: A study of the optimum thickness of the boron layer in an

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1) D.W. Hafemeister and E. Brooks Shera, Phys.Rev.L. 14 593 (1965)

2) L. Løvborg, Nuclear Instruments and Methods, 34 307 (1965)

ionization chamber has been performed by means of a computer program in a one group, collision probability theory. Experimental verification of the theory is in progress.

ii: The measurements of neutron temperatures with non- $\frac{1}{v}$ - absorbers are carried on.

iii: Oscillations of samples of uranium dissolved in D_2O have been performed in order to determine the accuracy with which the enrichment can be measured.