ON THE MODULATED MAGNETISM IN RARE EARTHS AND THE ORIGIN OF THE α*-RH_x SOLID SOLUTION PHASE

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INTRODUCTION

Rare earth metals absorb hydrogen readily forming solid solutions (α-phase) and hydrides (β- and γ-phases), depending on the concentration and the temperature interval. Some of them, comprising the heavy lantha–nides Ho, Er, Tm, and Lu as well as the assimilated Sc and Y, exhibit, below a limiting concentration $x_{max,}$ metastable solid solutions, α*-RH_x, which exist down to the lowest temperatures (Table).

	Sc	Y	Ho	Er	Tm	Lu
x_{max}	0.35	0.21	0.03	0.06	0.11	0.20

Below a critical temperature, in the range 150 to 180 K, they organise into quasi-linear chainlike structures formed of H-R-H pairs located on second-neighbour tetrahedral sites along the c-axis of the hcp unit cell (see ref.[1] for a review of the phenomenon).

RESULTS AND DISCUSSION

Despite theoretical efforts to derive these structures through elastic and/or electronic interactions (e.g. ref.[2,3]), the problematics as to the exclusivity of the α∗-phase, existing for certain rare earths only, remained unsolved.

In order to understand the origin of the phenomenon, we have tried to relate the periodicity of these configurations to the periodicity of specific modulated magnetic phases observed in some of the heavy lanthanides. Thus, it was noted that the interlayer turning angle between successive hexagonal planes, ω_i, was roughly the same, ω_i = 48 to 50 deg, both for the α∗-phase and for the modulated magnetic configurations of Ho, Er, and Tm (fig.1), which also possess this phase, while the ω_i of the other hcp magnetic rare earths, Gd, Tb, and Dy, turned out much smaller or even zero.

This analogy between magnetic and structural modulations (spin-density waves *vs* charge-density waves), in particular the existence of a critical angle ω_i, incites to relate the effects to electronic topological transitions on the Fermi surface, as e.g. discussed by Andrianov [4] for the case of the magnetism of the pure rare earths.

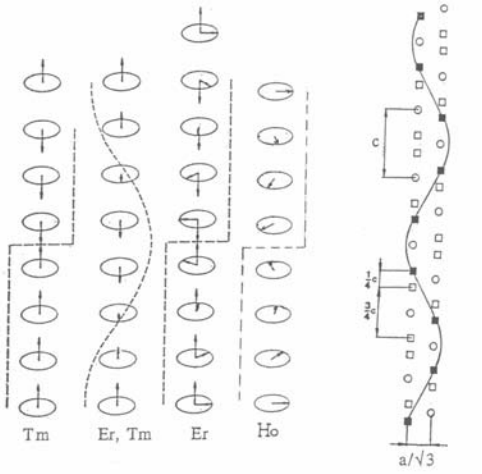

Fig.1: Modulated magnetic configurations observed in Ho, Er, and Tm (left part) and a structural H-R-H chain in the α∗-phase of the same metals (right part).

To test this model, we have undertaken to investigate the interaction of hydrogen with the magnetic configurations present in some Y-R

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alloys by electrical resistivity and X-ray diffraction measurements. Experiments on $Y_yTb_{1-y}H_x$ and $Y_yGd_{1-y}H_x$ [5,6] show a clear correlation between the y-dependent value of ω_i and the $\alpha*$-phase existence, supporting the proposed model.

CONCLUSIONS

A model involving the Fermi surface topology is proposed for the existence of the $\alpha*$-phase in certain rare earths only.

REFERENCES

[1] P. Vajda, « Hydrogen in rare earths, including RH_{2+x} phases » in K.A Gschneidner (Ed.) *Handbook on the Physics and Chem–istry of Rare Earths*, vol. 20, North Holl. (Amsterdam) p. 207, 1995.

[2] Y. Wang, M.Y. Chou, Phys. Rev. B **49**, 13357, 1994.

[3] V.A. Tatarenko, C.L. Tsynman, Solid State Ionics **101/3**, 1061, 1997.

[4] A.V. Andrianov, J. Magn. Magn. Mat. **140/4**, 749, 1995.

[5] P. Vajda, O.J. Zogal, Phys. Rev. B **59**, 9467, 1999 *and* **61**, 11232, 2000.

[6] Y. Nakamura, P. Vajda, O.J. Zogal, E. Akiba, J. All. Compds. 2003, in press.