



HAL
open science

CASCADE EFFECTS IN NON EQUILIBRIUM PHASE TRANSITIONS WITH METALLURGICAL RELEVANCE

P. Bellon, G. Martin

► **To cite this version:**

P. Bellon, G. Martin. CASCADE EFFECTS IN NON EQUILIBRIUM PHASE TRANSITIONS WITH METALLURGICAL RELEVANCE. Journal de Physique Colloques, 1989, 50 (C3), pp.C3-133-C3-134. 10.1051/jphyscol:1989321 . jpa-00229462

HAL Id: jpa-00229462

<https://hal.science/jpa-00229462>

Submitted on 4 Feb 2008

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

CASCADE EFFECTS IN NON EQUILIBRIUM PHASE TRANSITIONS WITH METALLURGICAL RELEVANCE

P. BELLON and G. MARTIN*

CECM-CNRS, 15 rue G. Urbain, F-94407 Vitry Cedex, France

**CENS-SRMP, F-91191 Gif-sur-Yvette Cedex, France*

The order disorder transition (antiferromagnetic with conserved total spin) in the B2 structure is studied when atomic interchanges result from two processes in parallel, as is the case under energetic particle irradiation: thermally activated jumps and ballistic jumps. The latter favor fully disordered configurations (infinite temperature dynamics), while the former tend to restore some degree of order. The appropriate mean-field phase diagram is established, based on a deterministic description of the order disorder kinetics : in the latter, the thermally activated interchange frequencies have been chosen in such a way that in the absence of forced interchange, the steady state value of the order parameter as predicted by the kinetic model coincides with the equilibrium value given by a simple mean-field thermodynamic description of the equilibrium state of the alloy. When the infinite temperature dynamics is operating, a tricritical point is identified below which the non-equilibrium order disorder transition becomes first order.

Stochastic effects are addressed by a Master Equation, the transition probabilities of which are built from the atom jump frequencies entering the deterministic description. It is shown that in the absence of forced exchanges, the steady state probability of the order parameter coincides with that of the mean-field thermodynamics. When forced interchanges are operating, the free energy function is replaced by a stochastic potential which can be computed explicitly and helps comparing the respective stability of competing states. Introducing forced interchanges by bursts (replacement cascades) does not change the order parameter values with extremal steady state probability, but definitely affects their respective stability. The latter cannot anymore be evaluated from the Master Equation, but from a Fokker Planck equation obtained by a Taylor expansion of the former with respect to the inverse volume of the system. Below the tricritical temperature, cascade effects shift the phase boundary of the first order transition towards the spinodal ordering line.

A similar treatment is given for the DO_{23} and $D1_a$ structures which are superstructures of the FCC lattice and for which irradiation is known to induce inversions of respective stability (Ni_4Mo). The full dynamical phase equilibrium diagram is constructed following the above technique ; the phase boundary between the two ordered structures is very sensitive to the size of the cascades (cf. Fig.).

The details of this work are published in the following references:

P.Bellon and G.Martin:

- in "Non linear phenomena in materials science", edited by L.Kubin and G.Martin (Trans Tech,1988) p.109;
- Phys. Rev. **B38**,2570(1988);
- Phys. Rev. **B** in the press;
- Proc. MRS Boston 1988, Symposium Q, in the press.

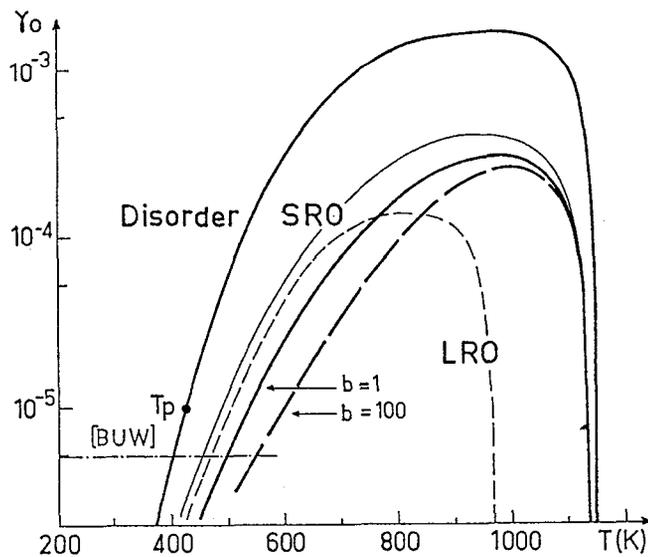


Fig. Dynamical equilibrium diagram for Ni_4Mo under irradiation : T is the temperature, γ_0 the ratio of the forced interchange frequency to the prefactor of the thermally activated frequency. LRO (SRO) point respectively to the $D1_a$, (DO_{23}) stability field, ----- is the $D1_a$ ordering spinodal, T_p the tricritical point, b (1 or 100) is the cascade size, i.e. the number of forced interchanges per unit ballistic event. [BUW] : existing experimental data.