Foreword

This volume collects the contributions to the International C.N.R.S. Meeting held in Aussois (France) by September 10-18, 1987. This conference was intended to illustrate the improvement of understanding of Non Linear Phenomena in Materials Science. It is hoped that these Proceedings will be of some help for those interested in a synthesis of present achievements and potential developments.

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Preface

J. Friedel

Most physical and chemical properties vary in a *continuous* way with imposed parameters such as temperature, pressure, velocity, concentrations... It is then a useful practice to *linearise* the reaction of the medium considered to the applied perturbation. One talks in terms of "susceptibilities". The success of this approach is such that one often forgets its limitations.

Weakly non linear phenomena can be described with generalised higher order susceptibilities. These deviations from linearity are well known in electron physics : in pn junctions as in prewar diodes, but also in optically active media. In semiconductors as in laser physics, the driving interest is the possibility of signal amplification, although localisation effects in space cannot be neglected.

These phenomena have there counterpart at atomic level. One of the first examples was the study of "soliton" waves at the surface of a liquid in a narrov channel, with its later applications to dislocations and epitaxy.

Indeed one of the main characteristics of materials science is that it deals with properties which often deviate easily from the continuous linearised approximation. There are in fact two reasons :

- the speed of linear reaction can often be varied over large ranges
- one is often near to an abrupt change of static or dynamic state of self organisation.

This meeting, held in Aussois in 1987, compares descriptions of such *strong* non linear effects in various cases of materials sciences. The following fields were considered :

- solid solution precipitation
- cellular and dendritic growth from a melt
- hydrodynamic instabilities under thermal or concentration gradients or electric field
- structuration of dislocations, precipitates, voids during plastic deformation or irradiations
- plastic instabilities of various kind
- amorphisation by diffusion.

Some talks of general interest summarise our present knowledge of non linear effects either in static conditions (e.g. fluctuations near a first order transition) or in steady dynamic ones (bifurcations, approach to chaos).

I found particularly illuminating the systematic comparisons of these two conditions. For instance, in sudden transitions due to reantrant bifurcations, one can have a nucleation and growth process as in a first order transition, with similar roles played by defects such as dislocations.

It is also clear however that many complicating factors limit the use of simple approximations. As stressed here, elastic stresses and strains due to inhomogeneities in solid media are long range and can be a dominating factor spoiling any local analysis; continuous approximations are probably not valid in "spinodal" precipitations ...

In all fields involving dislocations, two such difficulties are perhaps not stressed enough :

- at low temperatures, motion of dislocations involves solid friction (against the lattice or lattice defects). The principle of any linearisation is then probably at fault
- even at high temperatures, where dislocation motion is limited by viscous diffusion, their properties and organisations are very difficult to represent by a few simple parameters.

In conclusion, I think the appearance of this book is particularly timely. It shows convincingly the usefulness but also the limitations of an integrated approach of many phenomena of importance in materials sciences, using the concepts of non linearity.