DRAFT - 11/15/85
For Conference Distribution Only

TOWARDS THE UNITY OF SCIENCES: FROM PHYSICS TO OTHER SCIENCES

by

Carl Rau
Professor of Physics
Rice University
Houston, Texas USA

DISCUSSION PAPER

on

Manuel G. Velarde's

Self Organization and Evolution through Fluctuations and Instabilities

The Fourteenth International Conference on the Unity of the Sciences
Houston, Texas November 28-December 1, 1985

TOWARDS THE UNITY OF SCIENCES: FROM PHYSICS TO OTHER SCIENCES

by

CARL RAU
Professor of Physics
Rice University, Houston, TX 77251

DISCUSSION PAPER

on

Manuel G. Velarde's

SELF-ORGANIZATION AND EVOLUTION

THROUGH FLUCTUATIONS AND INSTABILITIES

These remarks on Velardes paper are more appreciative and additive than critical. His paper gives an excellent review of the enormous progress and breakthroughs achieved in the past few decades. He discusses the new concepts , approaches and models which are successfully introduced in the natural sciences and which can be transferred to other sciences. He points out the enormous influence H. Haken has played on a deeper comprehension of a variety of model systems in various fields of science which nowadays can be described by introducing synergetic behavior as a key feature to understand many systems (Benard convection, ferromagnetism, laser action, etc.).

He discusses to what extent the new concepts (bifurcation of solutions under certain boundary conditions, multistability of states for one set of boundary conditions, emergence of ordering, self-organization, cooperative behvavior, chaotic behavior, etc.) from the natural sciences provide clues for the understanding of nature and human culture (economy, sociology, political sciences).

Velarde dicusses examples in the natural sciences and explains the meaning of important parameters being used to successfully describe a variety of systems and structures.
He points out how useful the new concepts, introduced in the natural sciences, can be transferred to other disciplines.
In the following, using the language of synergetics, we add to Velardes notes a few interesting remarks on the transfer (analogies) of the meaning of established physical parameters to other fields of science.
Synergetics explains in a unified picture how the creation of order out of chaos or the self-organized collective behavior of indiviual parts of a system is subject to general laws. The creation of ordered states in nature can often be understood as a phenomenon of large fluctuations and instabilities where one accidential fluctuation causes the breaking of symmetry in a system and enslaves other fluctuations thereby stabilizing a system towards ordered behavior. Order parameters (angular orientation of magnets in ferromagnetism, electric field strength in lasers, angular orientation of fishes, length of hairs or skirts in a group of people, orientation of the opinion of individuals, etc.) rule the behavior of the individual parts of a system which themselves create the the order parameter by their cooperative behavior.
We point out a few analogies: Magnets break symmetry in groups: they align parallel. Fish break symmetry in groups: they align parallel. People break symmetry in groups: they become mad, they wear hair or skirts at same lengths.
In the past the theories on ferromagnetism (models on the crea-

tion of order out of chaos through collective behavior) have been successfully applied to a variety of systems. We mention a few examples of ordered self-organized systems:

1. Midges fly stationary in groups. 2. Ducks fly suddenly in one direction. 3. Fish break symmetry and align. 4. Insects fire light flashes collectively and sychronously. 5. Humans follow the dictates of fashion (groupthinking). 6. Millions of people become simultaneously impressed with one delusion (military glory, religious scruples, new literature, new political direction, etc.).

We conclude with a few challenging questions, which carefully answered and described by an adequate model, can lead us towards a more unified picture of our world.

What causes on a microscopic scale the orientation of atomic magnets? Is it the interaction between neighboring atomic magnets? What causes the orientation of public opinions? Is it the interaction between the individual with his neighbors? How can small fluctuations (in opinions) in a crisis flip the public opinion? Or: How can a small group of strongly oriented people flip large groups of people towards a new oriented structure?

Is the emergence of chaos in a theory describing the cooperative behavior of individual parts (synergetics) a contradiction? Here, fortunately, the answer was already given by Haken: A synergetic system can often be governed by several order parameters which cooperate. However, in evolution several order parameters can often compete with each other. For a certain time, one order parameter enslaves the others, then another order parameter dominates. Such a change in domination is totally irregular (chaotic).