1.
Introduction

1.1 General remarks

Essentially this is a listing of experimental and theoretical work performed in the working group "Nonlinear Systems and Pattern Formation" at the Institut für Angewandte Physik of the University of Münster. The main subject of this work is the experimental and theoretical investigation of self-organized patterns in dissipative systems. The reason for presenting this summary is the fact that so far there is no concise and exhaustive review of the numerous results that have been achieved. On the topic of dissipative solitons a short review is presented in [Pu118] and a rather extensive review will be submitted for publication by [Purwins, Amiranashvili and Bödeker in 2009]. For the motivation of this work and further information the reader is referred to the internet page

http://www.uni-muenster.de/Physik.AP/Purwins/ .

The experimental systems are quasi 1- and 2- dimensional electrical transport devices in the form of electronic circuits, gas-discharge systems and semiconductor devices. The corresponding experimental results are discussed in the chapters Electrical Networks: Experiment and Theory, DC Gas-Discharge Systems: Experiment, AC Gas-Discharge Systems: Experiment and Semiconductors: Experiment. As a spin-off of these investigations an ultra-fast infrared to visible converter has been developed that allows for the today fastest series record of IR images. This topic and some other possible applications are summarized in the chapter Applications.

A successful quantitative theoretical description of the experimental findings related to electrical networks is also given in Electrical Networks: Experiment and Theory. An approach to a system specific quantitative description of self-organized patterns and their bifurcation behaviour in a certain class of gas-discharge systems is discussed in the chapter Gas-Discharge: Theory. A corresponding treatment for a special semiconductor device is given in Semiconductors: Theory. The qualitative theoretical work is centred on the treatment of a 3-component reaction-diffusion equation. The latter is derived in chapter A Model for Pattern Formation

and related numerical and analytical results are the subject of the chapter Reaction-Diffusion Equations. Apparently the 3-component reaction-diffusion equation represents a kind of "normal form" for a universal qualitative description of the experimentally recorded patterns.

Topics being loosely related to the foregoing mentioned subjects are discussed in Miscellaneous.

In the experimental chapters, in the listings measurements and theoretical results are presented at the same time. This is to stress that to large extent the experimental observations can be understood in terms of certain field equations. On the other hand, often the theoretical results are of considerable value by their own. Therefore they have been collected separately from the theoretical point of view in the theoretical chapters.

An interesting kind of self-organized patterns are solitary localized structures (LSs) that in many respect behave like particles and that we refer to as dissipative solitons (DSs). Within the scope of the present work DSs will be defined as follows:

- DSs are stable well localized solitary deviations of a state variable from an otherwise homogeneous stable stationary background distribution.
- DSs are defined in driven systems well inside a large enough domain that is homogeneous by construction such that the DSs are not effected by the boundary.
- DSs vanish below a finite strength of the driver.
- Amplitude and shape of individual DSs do not depend on their number provided their mutual distance is sufficiently large.
- DSs coexist with a stable stationary homogeneous solution and far away from any DS their background state coincides with this solution.

In reality often measurements have been carried out that do not prove directly the existence of DSs in the strict sense of the above definition. One problem arises in real systems and in numerical investigations due to the presence of boundaries. In general we consider only situations where boundaries are unimportant and we will mention them explicitly if the contrary is the case. Another problem arises when global restrictions are present. Under these conditions, usually e.g. the background state depends on the number of localized objects. Also in this case we will call the observed localized objects DSs if there is good evidence that corresponding DSs will exist in the absence of the global restraints too, thereby fulfilling the above conditions. We also mention that in the presence of global constraints the background state may not change much with the number of LSs, due to the peculiarities of some local characteristic. Also in this case we

may refer to the observed LSs as DSs. This subject will be discussed in more detail in chapter A Model for Pattern Formation. In addition, occasionally we use the term DS after having introduced a small inhomogeneity.

In each chapter the listing of observed phenomena is accompanied by a series of pictures that reflect the main results.

1.2 Abbreviations

Pu…	**reference number from the chapter List of Publications**
Patent …	**reference number from the listing of patents in the chapter List of Publications**
r-d system	**reaction-diffusion system**
1k-, 2k-, 3k-	**1-, 2-, 3-component system**
gc	**global coupling; absent if not mentioned**
R^n, S^n	**n-dimensional Euclidian, cyclic space**
nd-ENW	**quasi n-dimensional electrical networks (n = 1.2)**
nd-dc-GDS	**quasi n-dimensional dc gas-discharge system (n = 1.2)**
nd-ac-GDS	**quais n-dimensional ac gas-discharge system (n = 1.2)**
nd-SCD	**quasi n-dimensional semiconductor device (n = 1,2)**
R_0	**resistor in series with an ideal external voltage source; $R_0 = 0$ if not otherwise mentioned, $R_0 \neq 0$ implies a real voltage source going along with global coupling**
exp , theo	**experimental, theoretical result**
anal, num	**analytical, numerical treatment**
(quant)	**quantitative agreement between experiment and theory**
LS, DS	**localized structure, dissipative soliton**
n-DS	**cluster made of n approximately spherical symmetric DSs (molecule)**
f , n-f	**solitary filament, cluster made of n approximately radial symmetric fs**
hom, hex	**homogeneous state, hexagonal pattern**
trav , rot	**travelling, rotating pattern**
breath, pend	**breathing, pendulating pattern LS**
gen, anni	**generation, annihilation**
scat, ref	**scattering, reflection**
int	**interaction**
bif	**bifurcation**
… ↔ …	**bifurcation from … to**