Self–Organization generates Information.

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Abstract.

Self–orgnization takes place in a specific kind of dynamical systems – e.g. from physics, chemistry or biology – which operate in the view of physics far from thermo–dynamical equilibrium searching for quasi–stable internal states. Such a system can be excited by a wide range of stimuli which it accepts together with influences from outside world as compact input for an internal reflection on its complete actual situation (taking into account the system's total history and actual situation as well). The reflection informs fluently about something that has been created completely new, the system produces information in the fullest sense of the word.

1. Information under Consideration.

Informing in subsequent discussions means a process creating something new, which was formerly unknown and is apparently appropriate to build knowledge. This kind of information is generated by self–organization, it is considered pragmatically, which brings about context dependent, originating meanings; their pragmatism will base on syntax– and semantics–aspects as well. Processes of mere signal–handling will mostly neglect the meaning of information for the purpose of concentration on statistical aspects only (SHANNON & WEAVER), these kinds of processes are not under consideration currently.

Self–organization can be observed in the behaviour of specific dynamical systems which reside in states far from thermo–dynamical equilibrium where the evolution is confronted with so called bifurcations. At the bifurcation–points the system is forced to consider several competitive development–paths in order to take the appropriate one finally. These proceedings enable generations of new qualities and place the process in a position to provide new information. One can say, such a process will fluently generate new events and this flow of events is to be understood as an information–flow. Because the generating processes are self–organizing, their information–product must be self–organized too. Therefore processes providing information and self–organizing processes are equivalent in current context.

2. Main Differences between Organization and Self–Organization.

An organization system – theoretically may be specified as relations (causalities) between specific causes and associated effects – is realized by an intermediate system which reacts quasi–passively on the stimuli from outside. Causality only exists as a pre–planned transformation which tolerates stimuli without any incitements of the system for a self–contained modification–work.

Compared with organization, self–organizing systems will show its self– contained initiative, in which mediation between cause (input) and effect (output) takes the decisive influence. Theoretical onsets came from W. HOFKIRCHNER [3] based on former discussions from e.g. H.HAKEN [1 ∧ 2], S. A. KAUFFMAN [4] or I. PRIGOGINE [7]. Input is no more necessary and sufficient for a specified output, it is only necessary for it. The system determines its influence on the proper causality by mirroring the cause (input) in a specific way and finally selects the appropriate effect. Without input (initiation) there will be no output (effect), but a cause will only partially decide about the effect, the system reflects the cause and then decides about the final effect. The system makes decisions and this decision–making is nothing less than the generation of information. The effect is separated from the cause by a quality– and level–jump. Self–organization is at an origin of information.

The differences between organizing and self–organizing systems may be summarized by the following scheme between terms and appropriate activities acting on them:

●⟨organization-system⟩ ●⟨self-organization-system⟩	●				●		
⬇⟨realized on base of⟩	⬇				⬇		
●⟨fixed plan⟩	●	●	●	●			
●⟨variable algorithm⟩					●	●	●
⬇⟨accepts⟩	⬇				⬇		
⬇⟨reproduces⟩ ⬇⟨creates⟩		⬇				⬇	
⬇⟨rejects⟩			⬇				⬇
⬇⟨unable to create⟩				⬇			
●⟨specified input⟩ ●⟨specified output⟩ ●⟨¬specified input⟩ ●⟨variable input⟩ ●⟨context extraneous input⟩	●	●	●		●		●
●⟨new information⟩				●		●	

Main Differences between Organization and Self-Organization

3. Self–Organization under Considerations.

Self–organization in following discussions will happen in physical, chemical or biological systems operating far from thermo–dynamical equilibrium working towards pseudo–stable states. They will be represented by a system of n differential equations of first order in time for n coupled time–dependent variables. The variables representing physical entities will be modified by $0 < p \leq n$ parameters simulating the environmental influence on the system. The system's internal states will happen due to the integration of the variables which in turn are influenced by modified parameters.

●⟨self-organizing system⟩	●					●
↓⟨realized by⟩ ↓⟨driven by⟩	↓					↓
●⟨" $n \in \mathbb{N}^*$ " dependent, $\neg$linear DG's of first order in time⟩	●			●	●	
●⟨initial conditions⟩						●
↓⟨for⟩						↓
●⟨integration⟩						●
↓⟨evaluating⟩ ↓⟨of⟩	↓					↓
↓⟨producing⟩				↓	↓	
●⟨" $n \in \mathbb{N}^*$ " time-dependent variables⟩	●	●	●			●
●⟨time-dependent system-internal modes⟩ ●⟨parameter-dependent information-structure⟩				●	●	
↓⟨representing⟩ ↓⟨are modified by⟩ ↓⟨describing⟩		↓	↓	↓		
●⟨time-dependent physical entities⟩ ●⟨" $0 < p \leq n$ " parameters⟩ ●⟨flow-lines⟩		●	●	●		
↓⟨introducing⟩ ↓⟨contained in⟩			↓	↓		
●⟨parameter-dependent environmental influence⟩ ●⟨" $\mathbb{R}^n$ "⟩			●	●		
↓⟨scaled by⟩				↓		
●⟨n-dimensional coordinate-system " $\{x_1, x_2, x_3, ...\}$ "⟩				●		
↓⟨with⟩				↓		
●⟨axes corresponding to proper variables⟩				●		

A General Characterization of Self-Organization

Associated with its internal dynamics the system created a flexible data–structure which can be understood as information generated by the system as consequence of the stimuli manufactured by its internal processing.

3.1. A general Characterization of Information–Structure generated by Self–Organization.

Depending on its environmental parameters a self–organizing system will form statements about the effects from its internal development on account of stimuli (causes) acting initiatively. The system will permanently inform about its internal reflections while it is constantly developing.

The generated information–structure is built of three aspect–levels (syntactical, semantic and pragmatic aspects) in hierarchal order. The syntactical level contains a set of basic entities together with their fundamental interrelationships. On semantic level meaningful amalgamations are formed on the base of elements from syntactical level. The pragmatic level finally detects highlights – appropriate for an actual analysis – within the permanently developing information flow, directly or indirectly depending on the elements of the semantics. The following interaction–scheme may give some insight into this mechanism.

●⟨information-structure⟩	●				
↓⟨hierarchically built by⟩	↓				
●⟨pragmatic aspects⟩	●				●
↓⟨select from ∧ combines appropriately⟩					↓
	∧				
●⟨semantic aspects⟩	●			●	●
↓⟨select from ∧ combine appropriately⟩				↓	
	∧				
●⟨syntactical aspects⟩	●	●	●	●	
↓⟨specify⟩ ↓⟨interrelate⟩		↓	↓		
●⟨information-entities⟩		●	●		
↓⟨adequate for⟩		↓	↓	↓	↓
●⟨self-organizing process⟩ ●⟨information-entities⟩ ●⟨expressions⟩ ●⟨information-complexes⟩		●	●	●	●
↓⟨on⟩		↓	↓	↓	↓
●⟨theoretical base⟩		●	●		
●⟨parameter-base⟩ ●⟨parameter-range⟩				●	●
↓⟨during⟩				↓	
●⟨integration of variables⟩				●	

Hierarchy Information-Structure generated by a self-organizing System

4. Self–Organization studied in more Details by the LORENZ–System.

The general remarks on self–organizing systems will now be discussed by the specific example of a fluid–cell, initially modelled by E. N. LORENZ (1963) [1] and later on intensively investigated on numerical base by C. SPARROW [8]. The so–called LORENZ–system may briefly be sketched by the following interaction–scheme.

●⟨fluid-cell⟩	●	●	●											
↓⟨warmed up⟩ ↓⟨cooled down⟩ ↓⟨performs⟩	↓	↓	↓											
●⟨from below⟩ ●⟨from above⟩ ●⟨" $\mathbb{R}^3$ "⟩	●	●												●
●⟨time dependent bottom-up convection⟩			●	●										
↓⟨modelled by⟩ ↓⟨scaled by⟩				↓										↓
●⟨3 coupled, ¬-linear DG's of first order in time⟩				●	●									
●⟨cartesian coordinate system " {x,y,z} "⟩														●
↓⟨containing⟩ ↓⟨adapted to⟩					↓									↓
●⟨variable " x "⟩					●	●			●				●	●
					∧				∧				∧	∧
●⟨variable " y "⟩					●		●		●				●	●
					∧				∧				∧	∧
●⟨variable " z "⟩					●			●	●				●	●
↓⟨representing⟩					↓	↓	↓	↓						
↓⟨coupled with ∧ modified by⟩ ↓⟨together with⟩									↓				↓	
●⟨point in " $\mathbb{R}^3$ "⟩ ●⟨rate of convective over-tuning⟩					●	●								
●⟨horizontal temperature-variation⟩ ●⟨vertical temperature-variation⟩							●	●						
●⟨parameter = " σ "⟩									●	●			●	
									∧				∧	
●⟨parameter = " r "⟩									●		●		●	
									∧				∧	
●⟨parameter = " b "⟩									●			●	●	
↓⟨representing⟩									↓	↓	↓	↓		
↓⟨leads to⟩													↓	
●⟨environmental-influence on system-behaviour⟩									●					
●⟨proportion of PRANDTL-number⟩ ●⟨proportion of RAYLEIGH-number⟩										●	●			
●⟨physical proportions of considered region⟩ ●⟨trajectories⟩												●	●	
↓⟨by⟩													↓	
●⟨integration⟩													●	

LORENZ-System, Example of Self-Organization-Processes

The results from numerical integrations of the LORENZ–system numerical obtained from investigations of C. SPARROW [8] are considered in essence as appropriate for the discussions of the self–organization and the information–structure generated by the proper processes. The scope of [8] is only partially required to support the outcomes of the subsequent discussions. The following considerations are mainly concentrated on parameter–values $\sigma = 10$, $b = 8/3$ and $0 < r \leq \infty$, a parameter–range which E. N. LORENZ in [5] had already been focussed on 1963.

5. Information–Structure generated by the LORENZ–System.

The LORENZ–system numerically integrated with regard to its variables (which on their parts are modified by the environmental parameters) will stepwise generate a data–structure, which – as already mentioned – is to be understood as information the proper self–organization–process is attending to. State of information–development is adequate to the number of integration–steps and modification–extent of the environmental parameters. This means, the more integration–steps and modifications of the parameters have been carried out the more information about the process will be available. The information–outcome is ordered hierarchically into levels of syntactical, semantic and pragmatic aspects.

5.1.1. Syntactical Aspects, Structure–Elements and their Properties.

The entities of the lowest hierarchical level – the syntactical aspects – can be derived on theoretical base only. Initially they start from original properties and relationships. These properties and relationships maybe confined or appropriately extended for the necessities of semantic aspects.

●⟨structure-elements ⟩	●												
⬇⟨comprehend⟩	⬇												
●⟨trajectories⟩	●	●	●	●						●	●	●	
	∧												
●⟨stationary points⟩	●												●
⬇⟨represent⟩ ⬇⟨wind clockwise around⟩ ⬇⟨show⟩ ⬇⟨violating⟩ ⬇⟨exist as⟩		⬇	⬇	⬇								⬇	⬇
⬇⟨starting on⟩ ⬇⟨tending towards⟩										⬇	⬇		
●⟨flow-lines in $\mathbb{R}^3$⟩ ●⟨" z > 0 "⟩ ●⟨" x = 0, y = 0, z ≥ 0 "⟩ ●⟨" (x,y,z) = 0 "⟩		●	●							●	●		
●⟨transient behaviour⟩				●	●								
				∨									
●⟨recurrent behaviour⟩				●		●							
⬇⟨represented by⟩					⬇	⬇							
●⟨one way⟩ ●⟨sinks⟩					●								●
⬇⟨passing through⟩ ⬇⟨will stay on⟩ ⬇⟨terminating in⟩					⬇					⬇	⬇		
●⟨" $[x_e\text{-}x_a, y_e\text{-}y_a, z_e\text{-}z_a]$ "⟩ ●⟨" x = 0, y = 0, z ≥ 0 "⟩ ●⟨" (x,y,z) = 0 "⟩					●					●	●		
●⟨orbit⟩						●			●				
⬇⟨existing as⟩ ⬇⟨keeps ¬changed for⟩						⬇			⬇				
●⟨periodic orbit⟩						●	●						
●⟨symmetry-operation " (x ,y) ↔ (-x. -y) "⟩									●			●	
						∨							∨
●⟨¬periodic orbit⟩						●		●					
⬇⟨counts⟩							⬇	⬇					
⬇⟨exist as⟩												⬇	
●⟨rotations around " z > 0 "⟩							●	●					
							∧						
●⟨intersections with appropriate plane in $\mathbb{R}^3$⟩ ●⟨symmetric pairs⟩							●					●	
●⟨saddle-points⟩													●
Syntactical-Aspects, Structure-Elements and their Properties													

5.1.2. Symbolic Description of Orbits.

In order to identify orbits in subsequent discussions individually a symbolic description of the following kind is appropriate. As earlier mentioned, orbits will spiral around the positive z–axis and important for each of them are the numbers of consecutive revolutions performed in $(x > 0) \vee (x < 0)$ of $\mathbb{R}^3$. Each time a $(x > 0)$–event happens a *" R "* is inserted in the orbit's individual symbol–sequence $k(re)$ and for each $(x < 0)$–event a *" L "* is inserted into $k(re)$. For non–periodic orbits therefore an interchanged series of consecutive $R's$ or $L's$ with different lengths will compose its private symbol–sequence. In case of a periodic orbit the symbol–sequence is periodic with respect to the R– and L–series (of possibly different lengths) and only one of these periods is needed for the symbolic description of the orbit.

●⟨orbit⟩ ●⟨periodic orbit⟩ ●⟨¬periodic orbit⟩	●		●	●
⬇⟨identified by⟩ ⬇⟨rotating⟩	⬇		⬇	
●⟨number of consecutive revolutions⟩	●	●		
●⟨p-times⟩ ●⟨random number of revolutions⟩			●	●
⬇⟨in⟩	⬇	⬇	⬇	⬇
●⟨" x > 0 " of " $\mathbb{R}^3$ "⟩	●		●	●
⬇⟨followed by⟩			⬇	⬇
●⟨q-times⟩ ●⟨random number of revolutions⟩			●	●
⬇⟨in⟩			⬇	⬇
●⟨" x < 0 " of " $\mathbb{R}^3$ "⟩		●	●	●

⬇⟨occurring ⌐finitely in⟩				⬇
●⟨modifications⟩				●
⬇⟨expressed by⟩	⬇	⬇	⬇	
⬇⟨for example expressed by⟩				⬇
●⟨consecutive " R's "⟩ ●⟨consecutive " L's "⟩ ●⟨" k(re) = (R^pL^q).... "⟩ ●⟨" k(re) = RRRLRRLLLLR.... "⟩	●	●	●	●
			∨	
●⟨" k(re) = (R^pL^q) "⟩			●	
Syntactical-Aspects, Symbolic Description of Orbits				

5.2. Semantic Aspects.

So far the LORENZ–system's immanent entities and relationships with their original properties have been specified as the syntactical base for a dynamical information–structure. Now will be demonstrated by special extracts (in order to show the principles) how the information–structure will be further evaluated if the LORENZ–equations are step–wise integrated under influence of changing parameters. These processes may add new properties and relations to the original syntactical ones appropriate for the particular needs of the semantics and will gather the entities in a meaningful kind of amalgamations as semantics aspects.

5.2.1. Residence of Structure–Elements and System–immanent dynamic Properties.

First semantic aspects are concerned within the space–area where all syntactical entities must reside and all their interesting development will take place. This area called the non–wandering–set is of zero–volume and shaped as an ellipsoid depending on the environmental parameters in size. Pairs of closely starting trajectories sometimes may show sensitivity on initial conditions in the area. The attracting part of the non–wandering–set is called strange–invariant–set described by an appropriate return–map which orbits permanently leads back to an associated return–plane in $\mathbb{R}^3$.

Cardinalities of the complete set of trajectories forming the information–structure are considered (one–ways– and orbit–sets) as well a structure orbits have to pass through when they permanently are leaded back to the return–plane. Stable and/or unstable manifolds in $\mathbb{R}^3$ will decide between non–stable saddle–points or stable sink–points among set of the stationary points.

●⟨⌐wandering-set⟩	●		●	●	●							●					
●⟨pairs of adjacent elements from ⌐variant set⟩																	●
⬇⟨comprehends⟩ ⬇⟨valid for⟩ ⬇⟨out of⟩	⬇		⬇														⬇
⬇⟨contains⟩				⬇	⬇							⬇					
●⟨recurrent flow-behaviour⟩	●																
●⟨" z ≥ 0 "∧" ∀(σ,r,b) "⟩			●														
●⟨strange ⌐variant set⟩				●										●			
●⟨stable manifold in $\mathbb{R}^3$⟩												●	●				
												∧	∧				
●⟨⌐stable manifold in $\mathbb{R}^3$⟩												●	●				
●⟨stationary points⟩					●	●											
⬇⟨are⟩ ⬇⟨for⟩ ⬇⟨define⟩ ⬇⟨contains⟩						⬇						⬇	⬇	⬇			
●⟨stability properties of stationary points⟩													●				
●⟨appropriate plane in $\mathbb{R}^3$⟩														●	●	●	
●⟨" (x, y, z) = 0 "⟩						●						●					
						∧						∧					
●⟨" $(x = -[b(r-1)]^{½}, y = r-1, z = 0) = C_1$ "⟩						●						●					
						∧						∧					
●⟨" $(x = +[b(r-1)]^{½}, y = r-1, z= 0) = C_2$ "⟩						●						●					
					∧												
●⟨⌐countable ⌐finity⟩					●		●										
					∧												
●⟨countable ⌐finity⟩					●			●									
⬇⟨within⟩ ⬇⟨as⟩ ⬇⟨associated with⟩	⬇			⬇										⬇			
⬇⟨of⟩							⬇	⬇									
⬇⟨intersected by⟩ ⬇⟨when intersected by⟩															⬇	⬇	

●⟨bounded set of zero-volume in $\mathbb{R}^3$⟩	●	●															
●⟨attracting subset⟩ ●⟨return-map⟩				●										●			
↓⟨permanently leading back⟩														↓			
●⟨one ways⟩							●								●		●
							∧								∧		∧
●⟨periodic orbits⟩								●						●	●	●	●
														∧	∧	∧	∧
●⟨⌐periodic orbits⟩							●							●	●	●	●
↓⟨represented by⟩ ↓⟨will be structured into⟩ ↓⟨show⟩		↓														↓	↓
●⟨ellipsoid⟩		●							●	●	●						
↓⟨extended up to⟩									↓	↓	↓						
●⟨volume of " $b^2r^2/(b-\sigma)$ "⟩ ●⟨volume of " $b^2r^2/(b-1)$ "⟩									●	●							
●⟨ volume of " $4\sigma r^2$ "⟩ ●⟨CANTOR-set⟩											●					●	
●⟨sensitive dependence on initial conditions⟩																	●
↓⟨if⟩									↓	↓	↓						
↓⟨crossed by⟩ ↓⟨by moving apart with⟩																↓	↓
●⟨" $(b \geq 2\sigma) \wedge (\sigma \leq 1)$ "⟩ ●⟨" $(b \geq 2) \wedge (\sigma \geq 1)$ "⟩									●	●							
●⟨otherwise⟩ ●⟨alternate CANTOR-set⟩											●					●	
●⟨increasing number of integration-steps⟩																	●
Semantic-Aspects, Residence of Structure-Elements and System-immanent Properties																	

5.2.2. Stability of stationary Points, original homoclinic Orbit and Explosion.

When $r > 1$ there is a $2-$dimalsional sheet of initial points – (x,y,z) – in $\mathbb{R}^3$ (the stable manifold of the origin $(x,y,z) = 0$) from which trajectories tend towards the origin. The stable manifold of the origin divides $\mathbb{R}^3$ into two halves. Trajectories starting in one halve of the space tend towards C_1, trajectories starting in alternate part of the space tend towards C_2. Trajectories starting on stable manifold of the origin tend towards the origin. As soon as $13.926 < r < 24.74$ becomes, the flow–behaviour will bifurcate (in the original homoclinic explosion), which causes trajectories to cross over. Trajectories are attracted now by for the time being alternate stationary point.

For $1 < r < 24.74$ the stationary points $C_1 \wedge C_2$ are stable points, later on $r > 24.74$ both will become non–stable saddle–points.

●⟨original homoclinic explosion⟩										●	●	●		
↓⟨means⟩										↓	↓	↓		
●⟨" $(x, y, z) = 0$ "⟩	●	●	●	●	●							●		
●⟨" C_1 "⟩						●	●			●			●	
●⟨" C_2 "⟩								●	●		●			●
↓⟨is⟩	↓	↓		↓		↓		↓					↓	↓
↓⟨strived for by⟩					↓		↓		↓	↓	↓	↓		
●⟨sink⟩	●					●		●						
●⟨saddle-point⟩		●		●									●	●
↓⟨for⟩	↓	↓				↓		↓					↓	↓
↓⟨has⟩			↓	↓										
●⟨trajectories⟩	●	●			●	●	●	●	●	●	●		●	●
●⟨original homoclinic orbit⟩												●		
↓⟨starting on⟩					↓					↓	↓	↓		
↓⟨starting in⟩							↓		↓					
●⟨stable manifold in " $\mathbb{R}^3$ "⟩			●	●	●									
↓⟨divides⟩ ↓⟨contains⟩			↓	↓										
●⟨" $\mathbb{R}^3$ "⟩			●											
●⟨⌐stable manifold⟩				●						●	●	●		
↓⟨into⟩			↓											
↓⟨in⟩										↓	↓	↓		
●⟨" $[(x,y)<0, z \geq 0]$ " ⊂ " $\mathbb{R}^3$ "⟩			●				●				●			
			∧											
●⟨" $[(x,y)>0, z \geq 0]$ " ⊂ " $\mathbb{R}^3$ "⟩			●						●	●				
●⟨" $(x, y, z) = 0$ "⟩												●		
↓⟨within⟩	↓	↓				↓		↓		↓	↓	↓	↓	↓
●⟨" $0 < r < 1$ "⟩ ●⟨" $1 < r$ "⟩	●	●												
●⟨" $1 < r < 24.74$ "⟩						●		●						

●⟨" 13.926 < r < 24.74 "⟩										●	●	●		
●⟨" 24.74 < r "⟩													●	●
Semantic-Aspects, Stability of stationary Points, original homoclinic Orbit and Explosion														

5.2.3. HOPF–Bifurcation.

For the parameter–range $13.926 < r < 24.74$ one may find two non–stable periodic orbits from the strange invariant set which were born in the first homoclinic explosion. The period of the orbits is relatively short, they pass somewhere near the origin $(z, y, z) = 0$ and are involved in the HOPF–bifurcation at $r = 24.74$ (they shrink towards $C_1 \vee C_2$ and will become too small to be drawn).

●⟨simple ⌐stable period orbits⟩	●	●	●	●
⬇⟨born in⟩ ⬇⟨changing rather rapidly⟩	⬇		⬇	
●⟨original homoclinic explosion⟩ ●⟨their positions⟩	●		●	
⬇⟨at⟩	⬇			⬇
⬇⟨for⟩ ⬇⟨within⟩		⬇	⬇	
●⟨" r ≈ 13.926 "⟩ ●⟨" 14.5 ≤ r ≤ 24.5 "⟩ ●⟨strange ⌐variant set⟩ ●⟨" r = 24.5 "⟩	●	●	●	●
⬇⟨involved in⟩ ⬇⟨shrinking towards⟩		⬇		⬇
●⟨HOPF-bifurcation⟩ ●⟨" $C_1 \vee C_2$ "⟩		●		●
Semantic-Aspects, HOPF-Bifurcation				

5.2.4. Preturbulent Behaviour.

For trajectories in the range of $r \leq 24.74$ a phenomenon can be observed which is called pre–turbulence or meta–stable chaos. Trajectories may wander chaotically near the strange invariant set for a very long time before spiralling into $C_1 \vee C_2$. It directly leads to the first strange attractor of the dynamical information–structure. The proper development may shortly be sketched as follows.

●⟨trajectories⟩	●	●		●			●
⬇⟨for⟩	⬇	⬇		⬇			
●⟨" r ≈ 22.4 "⟩	●	●					
●⟨" r ≈ 24.06 "⟩ ●⟨" r < 24.06 "⟩				●			●
⬇⟨may wander chaotically near⟩ ⬇⟨⌐ show⟩	⬇						⬇
⬇⟨show⟩		⬇		⬇			
●⟨strange ⌐variant set⟩	●				●	●	
●⟨average preturbulence- time⟩				●			
●⟨preturbulent behaviour⟩		●	●				●
⬇⟨before spiralling into⟩ ⬇⟨interpreted as⟩ ⬇⟨tends towards⟩	⬇		⬇	⬇			
⬇⟨mapped into⟩ ⬇⟨leading to⟩ ⬇⟨when starting near⟩					⬇	⬇	⬇
●⟨" $C_1 \vee C_2$ "⟩ ●⟨meta-stable chaos⟩ ●⟨⌐finity⟩ ●⟨itself⟩ ●⟨strange attractor⟩ ●⟨" (x, y, z) = 0 "⟩	●		●	●	●	●	●
Semantic-Aspects, from Preturbulence to strange Attractor							

5.2.5. Stable and non–stable Orbits involved in specific Bifurcations.

Periodic orbits can be observed for $1 < r < \infty$, but stable orbits only will exist for $r > 28$. Stable or non–stable orbits with or without symmetry are involved in three types of bifurcations responsible for destructions and/or further generation of orbits presumably with properties different from the initial ones.

●⟨stable period orbits⟩	●											
●⟨period orbits⟩		●	●	●								
⬇⟨⌐ found for⟩ ⬇⟨involved in⟩	⬇			⬇								
⬇⟨found for⟩		⬇	⬇									
●⟨" r ≤ 28 "⟩	●											
●⟨" r ≳ 100 "⟩		●	●									
		∧	∧									

●⟨" r ≳ 150 "⟩		●	●									
		∧	∧									
●⟨" 200 < r < ∞ "⟩		●	●									
●⟨saddle-node-bifurcation⟩				●	●	●						
				∧								
●⟨(symmetric saddle-node ∨ symmetry-breaking)-bifurcation⟩				●			●	●	●			
				∧								
●⟨period-doubling-bifurcation⟩				●						●	●	●
⬇⟨coalesces⟩					⬇		⬇	⬇				
⬇⟨may occur between⟩ ⬇⟨may disturb⟩						⬇			⬇			
⬇⟨makes⟩										⬇	⬇	
●⟨stable periodic orbit⟩					●					●		
●⟨symmetric orbits⟩ ●⟨symmetry⟩						●			●			
					∧	∨						
●⟨¬stable periodic orbit⟩					●						●	
●⟨¬symmetric orbits⟩						●						
●⟨2 stable ¬symmetric orbits⟩ ●⟨2 ¬stable ¬symmetric orbits⟩							●	●				
							∧	∧				
●⟨¬stable symmetric orbit⟩ ●⟨stable symmetric orbit⟩							●	●				
⬇⟨to create⟩							⬇	⬇				
⬇⟨to cause⟩ ⬇⟨can only occur in⟩									⬇			⬇
⬇⟨to become⟩										⬇	⬇	
●⟨stable symmetric orbit⟩ ●⟨¬stable symmetric orbit⟩							●	●				
●⟨saddle-node-bifurcation⟩ ●⟨¬symmetric orbits⟩									●			●
●⟨¬stable periodic orbit⟩ ●⟨stable periodic orbit⟩										●	●	
⬇⟨creating⟩										⬇	⬇	
●⟨stable periodic orbit of double period⟩										●		
●⟨¬stable periodic orbit of double period⟩											●	

Semantic-Aspects, Stable periodic orbits involved in Bifurcations

5.2.6. Generation and Annihilation of Orbits in Period–Doubling– and Saddle–Node–Bifurcations.

Orbits are generated in cascades of period–doubling–windows, may change their stabilities/non–stabilities, will possibly coalesce with ancient orbits in order to annihilate each other in final saddle–node–bifurcations. In the following this kind of processing shall be demonstrated by a few selected examples.

5.2.6.1. The Cascade of ($R^2L \wedge L^2R$)–Period–Doubling Windows.

On base of the periodic orbits $R^2L \wedge L^2R$ an infinite series of succeeding $(R^2L)^{p\to\infty} \wedge (L^2R)^{p\to\infty}$ period–doubling–bifurcations with a permanently increasing density is presented. The period–doubling–cascade resides in the range $99.98 < r < 100.795$. An infinite collection of stable periodic orbits left over from infinite number period–doubling–bifurcations finally lost their stability.

●⟨($R^2L \wedge L^2R$)-period-doubling bifurcation⟩ ●⟨universal property⟩			●					●			
●⟨(($R^2L)^2$)-period-doubling bifurcation⟩ ●⟨(($L^2R)^2$)-period-doubling bifurcation⟩				●	●						
●⟨¬finite number of (($R^2L)^{[n-1]}$)-period-doubling-bifurcations⟩						●					
●⟨¬finite number of (($L^2R)^{[n-1]}$)-period-doubling-bifurcations⟩							●				
●⟨symmetric pair of ¬symmetric periodic ($R^2L \wedge L^2R$)-orbits⟩										●	
●⟨¬finite collection of ¬stable periodic orbits⟩											●
⬇⟨between⟩				⬇	⬇						
⬇⟨with⟩						⬇	⬇				
⬇⟨associated with⟩ ⬇⟨existing for⟩ ⬇⟨left over from⟩								⬇		⬇	⬇
●⟨stable periodic (R^2L)-orbit⟩ ●⟨¬finite number of period-doubling-bifurcations⟩	●										●
	∧										
●⟨stable periodic (L^2R)-orbit⟩ ●⟨¬finite sequence of bifurcations⟩	●							●			
●⟨stable periodic (($R^2L)^2$)-orbit⟩		●		●							
		∧		∧							
●⟨stable periodic (($L^2R)^2$)-orbit⟩		●			●						
●⟨stable periodic ((($R^2L)^2)^2$)-orbit⟩				●							

					∧						
●⟨stable periodic $(((L^2R)^2)^2)$-orbit⟩					●						
●⟨stable periodic $((R^2L)^{[p-1]})$-orbit⟩ ●⟨stable periodic $((L^2R)^{[p-1]})$-orbit⟩						●	●				
						∧	∧				
●⟨stable periodic $((R^2L)^{[p]})$-orbit⟩ ●⟨stable periodic $((L^2R)^{[p]})$-orbit⟩						●	●				
⬇⟨exist for⟩	⬇	⬇									
⬇⟨happened in⟩			⬇	⬇	⬇	⬇	⬇				
⬇⟨through⟩ ⬇⟨lost⟩								⬇			⬇
●⟨" $r > 99.98$ "⟩ ●⟨" $r < 99.98$ "⟩ ●⟨" $r \lesssim 99.98$ "⟩ ●⟨" $r < 100.795$ "⟩	●	●	●							●	
●⟨" $99.547 < r < 99.629$ "⟩				●	●						
●⟨" $99.98 < r < 100.795$ "⟩						●	●				
⬇⟨defining⟩						⬇	⬇				
●⟨(R^2L)-period-doubling window⟩ ●⟨(L^2R)-period-doubling window⟩						●	●				
●⟨limit of ratio " $(r_{q-1}-r_q)/(r_q-r_{q+1})$ "⟩								●	●		
⬇⟨equal to⟩ ⬇⟨with⟩ ⬇⟨disappearing in⟩								⬇	⬇	⬇	
●⟨FEIGENBAUM-constant " 4.669201... "⟩ ●⟨stability⟩								●			●
●⟨" r_q " = value of q-th doubling-bifurcation⟩ ●⟨simultaneous saddle-node bifurcation⟩									●	●	
⬇⟨at⟩										⬇	⬇
●⟨" $r > 100.795$ "⟩ ●⟨" $r < 99.524$ "⟩										●	●
Semantic-Aspects, $(R^2L \wedge L^2R)$–Period-Doubling-Cascade											

5.2.6.2. Change of Orbit–Stability and Saddle–Node–Bifurcation in (R^2L^2)–Period–Doubling–Window.

In the example of (R^2L^2)–period–doubling–window a stable symmetric orbit is subjected to a symmetry–breaking saddle–node–bifurcation, loses its stability and additionally a pair of non–symmetric stable orbits is created. The orbit–pair remains stable for some time and finally undergoes permanently simultaneous period–doubling–bifurcations.

●⟨stable symmetric periodic (R^2L^2)-orbit⟩	●		●				
●⟨symmetry breaking saddle-node bifurcation⟩ ●⟨⌐stable symmetric periodic (R^2L^2)-orbit⟩		●			●		
●⟨limiting-point for period-doubling-bifurcations⟩							●
⬇⟨stable for⟩ ⬇⟨happens at⟩ ⬇⟨loses⟩ ⬇⟨still exists below⟩ ⬇⟨exists at⟩	⬇	⬇	⬇		⬇		⬇
●⟨" $154.4 < r < 166.07$ "⟩ ●⟨stability⟩ ●⟨" $r \approx 145$ "⟩	●		●				●
●⟨" $r < 154.4$ "⟩		●			●		
⬇⟨in favour of⟩			⬇				
●⟨pair of ⌐symmetric periodic (R^2L^2)-orbits⟩			●	●		●	
⬇⟨stable for⟩ ⬇⟨at⟩				⬇		⬇	
●⟨" $148.2 < r < 154.4$ "⟩ ●⟨" $r < 148.2$ "⟩				●		●	
⬇⟨undergo permanently⟩						⬇	
●⟨simultaneous period-doubling bifurcations⟩						●	
Semantic-Aspects, (R^2L^2)–Period-Doubling-Window							

5.2.6.3. Final (RL)–Period–Doubling–Window.

This doubling window involves the stable symmetric RL–orbit which does not suffer annihilation in a saddle–node–bifurcation. The window is not associated with intermitted chaos. The window is exactly like the (R^2L^2)–window except that the final stable (RL)–orbit which it produces does not suffer annihilation in a saddle–node–bifurcation and exist for all $r > 313$. The specific property of semi–periodicity (in essence depends on the specification of an orbit's period) can be observed in connection with some sequences of bifurcations. Semi–periodicity can be observed at the lower end of the infinite sequence of period–doubling–bifurcations for any period–doubling–window.

●⟨final RL-period-doubling-window⟩	●			●					
●⟨⌐finite sequence of period-doubling-bifurcations⟩ ●⟨system-flow⟩			●					●	
●⟨behaviour of trajectories⟩ ●⟨specific flow-properties⟩					●	●			
⬇⟨involves⟩ ⬇⟨accumulates at⟩ ⬇⟨at ∧ below⟩ ⬇⟨considered for⟩	⬇		⬇		⬇	⬇			
●⟨stable symmetric RL-periodic-orbit⟩	●	●							
⬇⟨⌐ suffering⟩ ⬇⟨exists for⟩ ⬇⟨⌐ associated with⟩	⬇	⬇		⬇					
●⟨annihilation in saddle-node bifurcation⟩ ●⟨sequence of bifurcations⟩	●					●			

●⟨" r > 313 "⟩ ●⟨" r ≈ 214.364 "⟩ ●⟨intermittent chaos⟩		●	●	●					
↓⟨will show⟩ ↓⟨becomes semi-periodic below⟩						↓		↓	
●⟨semi-periodicity⟩						●	●		●
↓⟨below⟩ ↓⟨means⟩ ↓⟨has to be considered below⟩						↓	↓		↓
●⟨limit of ⌐-finite sequence of period-doubling bifurcations⟩					●	●		●	
↓⟨borders⟩ ↓⟨in⟩ ↓⟨with⟩					↓	↓		↓	
●⟨number of ⌐-stable periodic orbits⟩ ●⟨" 197.6 < r < 215.364 "⟩ ●⟨period⟩					●	●	●		
↓⟨left over from⟩ ↓⟨is⟩					↓		↓		
●⟨period-doubling-bifurcations⟩ ●⟨number of intersections with appropriate plane in $\mathbb{R}^3$⟩					●		●		
↓⟨rather than⟩							↓		
●⟨turn-around time⟩ ●⟨period " 2^n, n = large "⟩ ●⟨any period-doubling window⟩							●	●	●

Semantic-Aspects, Final RL-Period-Doubling-Window of 197.6 < r < ∞

5.2.7. Interactions between Period–Doubling–Bifurcations and homoclinic Explosions.

Quasi on a higher level within semantic aspects it is interesting to observe that interactions take place between period–doubling–bifurcations and homoclinic explosions. It is a complicated way by which period–doubling–windows and homoclinic explosions complement each other. Each homoclinic explosion may produce orbits for several different period–doubling–windows and each period–doubling–window involves periodic orbits produced in several different explosions.

There is a first homoclinic explosion producing the original strange invariant set. This set is initially non–stable. At a certain r–value the original invariant set becomes attracting, the R– and L–orbit go off to HOPF–bifurcation and an infinite sequence of homoclinic explosions begins. In an initial phase homoclinic explosions remove original periodic orbits from the non–wandering set. Later on hooks appear in the return–maps and at least some of the homoclinic explosions add new periodic orbits to the non–wandering set. In this phase of the development homoclinic explosions also remove original periodic orbits from the non–wandering set. They will do this in order to provide all the periodic orbits needed for a period–doubling window, which ends with an original periodic orbit being annihilated in a saddle–node–bifurcation. In addition, homoclinic explosions produce all the periodic orbits needed for the final RL–period–doubling–window which ends with the original symmetric RL–orbit after having obtained stable status.

●⟨original (R^2L)-orbit⟩ ●⟨(" R ∧ L ")-orbits⟩	●										●				
●⟨homoclinic RL-explosion⟩ ●⟨hooks⟩		●													●
●⟨⌐-finite sequence of homoclinic explosions⟩												●			
↓⟨born in⟩ ↓⟨go into⟩ ↓⟨remove⟩ ↓⟨appear on⟩	↓										↓	↓			↓
●⟨first homoclinic-explosion⟩	●				●					●					
●⟨HOPF-bifurcation⟩ ●⟨return-plane in $\mathbb{R}^3$⟩											●				●
↓⟨at⟩	↓	↓													↓
●⟨" r = 13.929 "⟩ ●⟨" r = 100.795 "⟩ ●⟨" r > 30.1 "⟩	●	●													●
↓⟨becomes⟩	↓														
↓⟨produces⟩		↓			↓					↓					
●⟨⌐-stable partner⟩ ●⟨orbits⟩	●				●										
●⟨RL-generated strange ⌐-variant set⟩		●													
●⟨original ⌐-stable strange ⌐-variant set⟩										●					
↓⟨in⟩ ↓⟨with⟩ ↓⟨for⟩ ↓⟨becomes attracting for⟩	↓	↓			↓					↓					
●⟨saddle-node-bifurcation⟩	●			●					●						
●⟨pair of ⌐-symmetric (" RL ∧ LR ")-orbits⟩		●													
●⟨" r > 24.6 "⟩					●					●					
●⟨period-doubling-window⟩						●	●								
↓⟨specifying⟩ ↓⟨used for⟩	↓	↓													
↓⟨involves⟩						↓	↓								
●⟨high-end of (RL)-period-doubling-window⟩	●														
↓⟨at⟩	↓			↓											
●⟨final RL-period-doubling-window⟩		●	●												
●⟨high-end of (R^2L^2)-period-doubling-window⟩				●											
●⟨periodic orbits⟩						●							●		
●⟨original periodic orbits⟩							●	●				●		●	
↓⟨produces⟩ ↓⟨produced in⟩ ↓⟨disappear in⟩			↓			↓		↗							
↓⟨added by⟩ ↓⟨removed by⟩													↓	↓	
●⟨⌐-stable symmetric (R^2L^2)-orbit⟩			●												
↓⟨involved in⟩ ↓⟨being transformed to⟩ ↓⟨from⟩			↗				↓					↓			

●⟨homoclinic explosions⟩						●							●	●	
↓⟨to⟩ ↓⟨from⟩													↓	↓	
●⟨¬wandering set⟩												●	●	●	
↓⟨in⟩												↓			
●⟨" r = 54.6 "⟩ ●⟨stable orbits⟩ ●⟨" 24.06 < r < 30.1 "⟩	●						●					●			
Pragmatic-Aspects, Interactions between Period-Doubling-Bifurcations and homoclinic Explosions															

5.2.8. Intermittent Chaos.

Near the ends of period–doubling–windows the phenomenon of intermittency can be observed. Intermittency or intermittent chaos starts from a laminar or periodic flow–behaviour with short bursts of chaos interrupted by laminar or periodic phases. Finally the flow behaviour will become laminar again.

●⟨intermittent chaos⟩	●	●						●	
●⟨trajectories⟩ ●⟨laminar intervals⟩ ●⟨chaos⟩			●	●			●		
●⟨periods between laminar intervals⟩					●	●			
↓⟨can be observed just outside of⟩	↓							↓	
↓⟨causes⟩ ↓⟨moving near to⟩ ↓⟨increase with⟩ ↓⟨decrease with⟩ ↓⟨near to⟩ ↓⟨finally returns to⟩		↓	↓	↓	↓	↓	↓		
●⟨(R^2L^2)-period-doubling-window⟩ ●⟨(R^2L)-period-doubling-window⟩	●							●	
●⟨increase of " r "⟩				●	●				
↓⟨at⟩ ↓⟨while executing⟩	↓							↓	
●⟨" r ≥ 166.07 "⟩ ●⟨short chaotic burst⟩	●	●							
●⟨saddle-node bifurcation⟩								●	●
↓⟨by disappearing⟩ ↓⟨interrupted by⟩ ↓⟨at⟩ ↓⟨involving⟩	↓	↓						↓	↓
●⟨stable symmetric (R^2L^2)-periodic orbit⟩ ●⟨laminar behaviour⟩	●	●							
●⟨" r = 100.795 "⟩ ●⟨" $R^2L \wedge L^2R$ "⟩-orbits								●	●
↓⟨located at⟩ ↓⟨in⟩	↓	↓							
●⟨intermittent threshold⟩	●		●			●			
↓⟨wander off and behave chaotically for⟩			↓						
●⟨random sequence⟩ ●⟨some time-interval⟩		●	●						
↓⟨before returning to⟩ ↓⟨are proportional to⟩			↓			↓			
●⟨periodic ∨ laminar behaviour⟩			●				●		
●⟨" $(r-166.07)^{-1/2}$ "⟩						●			
Semantic-Aspects, Intermittency									

5.3. Pragmatic Aspects.

From the information founded and dynamically extended in the LORENZ–system's self–organization syntactical, parts of semantic aspects have been considered so far. The syntactical aspects (consisting of fundamental entities with their interrelationships) could mainly be derived from characteristics of the DGs–system. Semantic aspects in essence are meaningful amalgamations in the generated information–flow and comprehended sets of entities with their relationships limited appropriately by the actual context. Essential highlights in a pragmatic sense which happen in the permanently developing information–structure are comprehended under pragmatic aspects and are directly or indirectly depended on semantic aspects.

5.3.1. Strange Attractor.

One of these essential highlights in the LORENZ–system's process of self–organization is the original strange attractor emerging at $28 < r < 30.2$. Because no stable periodic orbits can be found for $r < 28$, all distances among orbits on an appropriate return–plane become stretched due to the current properties of the actual return–map and thus orbits are forced permanently to diverge with increasing numbers of revolutions (evolution of orbits is sensitive on initial conditions), no strange attractor can be found in this region.

As soon as $r > 28$ stable periodic orbits will come up and the distances among orbits begin to shrink under the attracting property of the actual return–map. Orbits will intersect an appropriate plane in $\mathbb{R}^3$ with a CANTOR–

set of arcs, the attractor itself is formed by a CANTOR–set of sheets which intersect the return–plane through the CANTOR–set of arcs and radiate out from a spine; spine and CANTOR–set of sheet will finally give to the attractor the structure of CANTOR–book.

The strange attractor lacks orbits removed by HOPF–bifurcation, those with a period > 25 of consecutive $R \vee L$ and those removed by the original homoclinic explosion in comparison with the original strange invariant set.

●⟨strange attractor⟩	●										●	●	●		●	●	●	●	●
●⟨⌐stable periodic orbits⟩		●																	
●⟨stable manifold of " (x, y, z) = 0 "⟩			●																
●⟨distances⟩							●		●										
↓⟨lacks⟩																	↓	↓	↓
●⟨orbits⟩				●	●	●				●							●	●	●
↓⟨emerges at⟩ ↓⟨for⟩ ↓⟨intersects⟩ ↓⟨draw⟩	↓	↓	↓			↓													
↓⟨normal to⟩							↓		↓										
↓⟨contains⟩											↓	↓	↓		↓	↓			
●⟨general attractor-points⟩												●							
●⟨specific attractor-points⟩													●						
●⟨countable infinity⟩ ●⟨⌐countable infinity⟩															●	●			
↓⟨located on⟩												↓	↓						
↓⟨of⟩															↓	↓			
●⟨CANTOR-set of sheets⟩											●	●		●					
↓⟨starting on⟩				↓	↓														
●⟨" 28 < r < 30.2 "⟩ ●⟨" r ≤ 28 "⟩	●	●																	
●⟨CANTOR-set of convex arcs⟩						●													
↓⟨on⟩ ↓⟨forced by⟩ ↓⟨radiates out from⟩						↓				↓				↓					
●⟨appropriate return-plane in $\mathbb{R}^3$⟩			●	●	●	●													
↓⟨in⟩ ↓⟨left of⟩ ↓⟨right of⟩ ↓⟨normal to⟩			↓	↓	↓	↓													
●⟨line " AD " through " (x,y,z) = 0 "⟩			●	●	●	●	●		●										
↓⟨are attracted by⟩				↓	↓														
↓⟨initially effected by⟩ ↓⟨finally effected by⟩							↓		↓										
↓⟨symmetrical with respect to⟩						↓													
●⟨saddle-point " C_2 "⟩ ●⟨saddle-point " C_1 "⟩				●	●														
●⟨stretching⟩							●	●											
●⟨attraction⟩ ●⟨stable periodic orbits⟩									●						●				
●⟨" (x,y,z) = 0 "⟩ ●⟨⌐stable periodic orbits⟩						●										●			
																∧			
●⟨spine of a CANTOR-book⟩													●	●					
●⟨one-ways⟩																●			
↓⟨for⟩							↓		↓										
●⟨" r ≤ 28 "⟩ ●⟨" 28 < r < 30.2 "⟩							●		●										
↓⟨influenced by⟩				↓	↓				↓										
↓⟨under⟩ ↓⟨discloses⟩ ↓⟨intersecting⟩							↓	↓			↓								
↓⟨to form⟩														↓					
↓⟨removed by⟩																	↓		↓
●⟨⌐stable manifold of " C_2 "⟩				●															
●⟨⌐stable manifold of " C_1 "⟩					●														
●⟨sensitivity on initial conditions⟩								●											
●⟨rising stability⟩ ●⟨HOPF-bifurcation⟩									●								●		
●⟨application of return-map⟩							●			●									
↓⟨returning back to⟩				↓	↓														
↓⟨demonstrated by⟩ ↓⟨of⟩ ↓⟨to intersect⟩								↓	↓	↓									
●⟨return-plane⟩				●	●					●	●								
↓⟨to be intersected with⟩ ↓⟨through⟩										↓	↓								
↓⟨compared with⟩																	↓	↓	
●⟨diverging of orbit-pairs⟩								●											
●⟨original homoclinic explosion⟩																			●
●⟨" ≥ 25 " consecutive " R ∨ L "⟩																		●	
●⟨original strange ⌐variant set⟩																	●		
●⟨periodic orbits⟩ ●⟨CANTOR-book⟩									●					●					
●⟨CANTOR-set of arcs⟩										●	●								

Pragmatic-Aspects, Original strange Attractor

The size of strange attractor can be measured by the maximum number of revolutions which may happen right ∨ left of line AD. The size of strange attractor may decrease or increase within various $r-$intervals.

●⟨attractor-size⟩	●	●	●	●		●	●	●	
●⟨strange attractor⟩					●				
↓⟨specified by⟩ ↓⟨decreases for⟩ ↓⟨increases for⟩ ↓⟨reaches⟩ ↓⟨contains⟩ ↓⟨increases by⟩	↓	↓	↓	↓	↓			↓	
↓⟨decreases to⟩						↓	↓		
●⟨maximum-number of revolutions⟩ ●⟨" 33 "⟩ ●⟨" 2 "⟩ ●⟨" 1 "⟩	●			●		●	●		
●⟨homoclinic explosions⟩								●	●
↓⟨for⟩	↓							↓	
↓⟨at⟩				↓		↓	↓		
↓⟨reinstall⟩									↓
●⟨" right ∨ left " of " AD "⟩ ●⟨some r-intervals⟩ ●⟨alternate r-intervals⟩	●	●	●						
●⟨" r = 30.2 "⟩ ●⟨" r = 47.5 "⟩ ●⟨" r = 54.6 "⟩ ●⟨" r < 54.6 "⟩				●		●	●	●	
●⟨trajectories⟩					●				●
↓⟨with up to⟩					↓				
●⟨" 33 " consecutive " R ∨ L "⟩					●				
Pragmatic-Aspects, Size of strange Attractor									

5.3.2. Cumulative Effect on Number and Types of periodic Orbits.

One can derive rules on sequences $k(re)$ which describe the behaviour of orbits influence by the unstable manifold of $(x,y,z) = 0$. They will change as soon as r becomes a parameter–value of an homoclinic orbit. The rules specify restrictions on sequences of explosions. For instance if r signals the existing of homoclinic explosion at some r this may happen in consequence of another explosion at an alternate $\boldsymbol{r}$ or on a so–called destructive sequence of homoclinic explosions (when $k(re) = RRRRRR\ldots$ changes to $k(re) = RLRLRL\ldots$). The destructive sequence adds periodic $(R \vee L)-$orbits of right numbers and types appropriate for an infinite number of period–doubling–windows terminating in saddle–node–bifurcations and thereby leaving stable periodic $RL-$orbits. Destructive sequence of homoclinic explosions enables non–homoclinic explosions too.

●⟨rules on symbol sequence k(re)⟩	●	●	●								
●⟨⌐destructive sequence of homoclinic explosions⟩					●	●				●	●
↓⟨describe⟩ ↓⟨change with⟩ ↓⟨place⟩ ↓⟨attended with adding of⟩ ↓⟨⌐destroys⟩	↓	↓	↓			↓				↓	
●⟨behaviour of right-hand branches⟩	●	●									
●⟨combinatorial restrictions⟩			●	●							
●⟨periodic orbits⟩						●	●	●			
↓⟨of⟩	↓	↓									
↓⟨on⟩ ↓⟨signals⟩ ↓⟨changes⟩ ↓⟨are⟩ ↓⟨enables⟩			↓	↓	↓		↓				↓
●⟨⌐stable manifold of " (x, y, z) = 0) "⟩	●	●									
●⟨sequences of explosions⟩ ●⟨k(re) = " RRRR... "⟩ ●⟨⌐homoclinic explosions⟩			●		●						●
●⟨existence of homoclinic explosion at some " r "⟩ ●⟨(R ∧ L)-orbits⟩				●			●				
↓⟨producing⟩											↓
●⟨⌐finity of periodic orbits⟩										●	●
↓⟨passes⟩ ↓⟨according to⟩ ↓⟨implies⟩ ↓⟨to⟩ ↓⟨with⟩ ↓⟨⌐produced by⟩		↓	↓	↓	↓			↓		↓	
●⟨" r "of homoclinic orbit⟩ ●⟨probable existence of explosion at alternate " r "⟩		●		●							
●⟨increase of " r "⟩ ●⟨k(r) = " RLRL... "⟩●⟨homoclinic explosions from sequence⟩			●		●					●	
●⟨right number and types⟩								●	●		
↓⟨appropriate for⟩								↓	↓		
●⟨⌐finite number of period-doubling-windows⟩ ●⟨period-doubling-windows⟩								●	●		
↓⟨terminating in⟩ ↓⟨leaving⟩ ↓⟨put together into⟩								↓	↓		↓
●⟨saddle-node-bifurcation⟩ ●⟨stable symmetric periodic RL-orbits⟩								●	●		
●⟨strange ⌐variant set⟩											●
↓⟨suitable for⟩											↓
●⟨destruction in homoclinic bifurcation⟩											●
Pragmatic-Aspects, Rules on homoclinic Explosions and involved Orbits											

5.3.3. Extra Period–Doubling–Windows.

There exists an infinite number of period–doubling–windows which do not involve original periodic orbits. These start at $r = 30.1$ (as the windows do which involve original periodic orbits) and continue up to $r \approx 500$. These extra–period–doubling–windows happen in predictable sequence, they will not fit into the general sequence of period–doubling–windows which involve original orbits. One or more extra–period–doubling–windows may occur concurrently with one another or with a period–doubling window which involves an original orbit. But these windows will not occur at r–values which are occupied by windows involving original orbits.

Period–doubling–windows can be divided into 2 kinds, those that involve periodic orbits that existed in the original invariant set and those that do not.

6. Conclusion.

Beyond information introduced by SHANNON and WARVER as a matter of statistics only, without any attempt to give an interpretation of what one has been informed about, these discussions shall direct the view on information as meaning being the important part in extending knowledge, meaning as outcome from the dynamics of a self–organizing system. Self–organizing systems can be found e.g. in physics, chemistry or biology, acting far from thermo–dynamical equilibrium with respect to pseudo–stable internal states. These systems most often can be described in a mathematical form with DG's acting on variables representing physical entities modified by parameters representing the influence of the outside world.

This kind of system accept initial conditions as stimuli for its internal dynamics which takes place as integration–steps on system–variables modified by environmental parameters. A self–organizing system takes the stimuli as its input, reflects (on base of its internal algorithm) about its actual situation by having its total history in mind and finally comes up with an appropriate answer. Any time it reports about its actual situation and generates hereby – in the fullest sense of the word – new information. In every evolution–step the system is creating something completely new on a regular base, nothing what was known before or earlier prepared. The answer thus becomes as outcome a lawful addendum to an (empty or regular) information–structure of the proper self–organizing system. This information–structure consists of 3 levels in hierarchical order, syntactical aspects on lowest level, semantic on top of it and pragmatic on top semantic aspects.

The type of self–organizing systems considered above, are mathematically described by n differential–equations of first order in time with n time–dependent variables representing physical entities. The variables are coupled and modified by $0 < p \leq n$ parameters appropriate for a simulation of environmental influences acting on the system. From this class of systems the LORENZ–system – first considered by E. N. LORENZ [5] in 1963 – was selected because of the extensive numerical investigations done by C. SPARROW [8] with its special focus on the system's data–structure. LORENZ–system describes a fluid–cell warmed up from below and cooled down from above mathematically represented by 3 DG's of a kind just mentioned in $\mathbb{R}^3$ (scaled by a rectangular coordinate–system) with 3 variables (representing warm–air–properties), each of them is increasing/decreasing into one of the coordinate–directions. The variables are modified by proportions $\sigma \wedge r$ of the PRANDTL– and RAYLEIGH–values (respectively) and physical proportions b of the considered region. The system's data–structure – as mentioned above – has to be understood as information–structure, whose syntactical aspects can be obtained on base of system's mathematical characteristics by theoretical considerations only. To explain semantic and pragmatic aspects of the LORENZ–information–structure, SPARROW's investigations [8] have to be inspected but are not required in their full contents. Parts for $\sigma = 10$, $b = 8/3$ and $1 \leq r < \infty$ – LORENZ himself had this parameter–range considered in 1963 already – are sufficient enough to show the essentials.

Semantic aspects like:

– Residence of structure–elements and system–immanent dynamic properties,
– Stability of stationary points, original homoclinic orbits and explosion,
– HOPF–bifurcation,
– Preturbulent behaviour,
– Stable and non–stable orbits involved in specific bifurcations,
– Generation and annihilation of orbits in period–doubling– and saddle–node–bifurcations,
– Interactions between period–doubling–bifurcations and homoclinic explosions or
– Intermittent chaos

arise from syntactical entities by the dynamics of the self–organizing system. During these processes appropriate entities are grasped up and extended in regard to their properties suitable to form a significant and meaning kind of amalgamations.

Pragmatic aspects like:

– Strange attractor,
– Cumulative effect on numbers and types of periodic orbits or
– Extra period–doubling–windows

will be directly or indirectly delivered from semantic aspects as outstanding highlights in the view of an actual analysis versus this kind of self–organization – therefore they are called pragmatic ones –. In this sense the strange attractor e.g. has to be understood as such an outstanding highlight in N. MCBRIDE's analysis [6].

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