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Unity of the Sciences

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# Evolving Physics
# and the Problem of Reduction

DISCUSSION PAPER

by

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on

Roman Sexl's

Order and Chaos

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To the retrospective view the historical development of physics exhibits periods of closedness and unification, alternating with phases of diversification, which arise from either new empirical facts or new theoretical aspects.

For the first part of his paper R. Sexl delineates (guided by the aspects of determinacy, predictability, regularity) a pathway of the development of physics which leads from the mechanistic description of Newton's world and Laplace's Demon with its rigid order to the chaotic systems, the synergetic view and the soft order behind the chaos.

This is a partial view of physics, of course, following the topic of the paper; some of his conclusions, however, seem to me to incline to a too pessimistic situation of physics, which I would like to comment.

When we are discussing about reduction to physics this is - irrespective of its justification otherwise— not independent of the "state of art" of physics; our answer cannot be a definitive one. It sounds trivial to say that the feasibility of the reduction of a chaotic-like biological phenomenon to physics depends on our knowledge about chaotic physical systems. R. Sexl's paper elucidate's the impetuous development of this domain of physics.

Last, but not least, the semantics of reduction appears to be open among philosophers of science and those who are practicing it.

Predictability and Regularity as Exception

A naive reader, after having read the paper of R. Sexl only once, could have the impression that physics as a (so called exact) natural science could merely exist, or at least in exceptions.

Our real experience contradicts, and after the second reading we see that this is not Sexl's opinion. The situation reminds me to mathematical lectures which I attended as a young student. We always had to treat pathological functions, and in physics we met the more normal ones.

We know, after Siegel, about the strong restrictions existing for the predictability and regularity of physical Hamiltonian systems; "almost all", that means " all without a finite number of exceptions" (the harmonic oscillator for instance) are not predictable; this finite number is of first interest to us.

We know that the inaccuracy of a variable of the initial state of a classical mechanical system at time $t_o$ increases with time, and after a certain time $t_1$ reórders it indetermined: the inaccuracy of an angular variable for example becoming $> 2\pi$.

This is valid for separable systems as the central motion of a planet, the more for nonseparable systems. On the other hand, do we request to predict for infinity?[2] We have to restrict the prediction to times $t < t_1$, which in some cases may be very short. Being aware of the limits—Sexl meritoriously hints to them--we are able to handle these systems, also with inaccurately known initial variables.

We know also about the problems which arise already for the solution of the 3-body problem in classical mechanics: The stability of the planetary system as a problem of the dynamics of a manybody system, known since , was once copying many famous mathematicians like Laplace, Langrange, Poisson, Poisscare (who won the award written out for its solution by King Oscar of Sweden). Siegel Kolmogorov and recently (in 1960) two young scientists, Arnold (Moscow) and Moser (Goettingen) who made decisive contributions.

Computers will help us to treat such problems with increasing efficiency and to learn about the instabilities, which they exhibit and which probably are their most interesting features.

It was fortunate, meritorious and of essential importance for the development of physics and for the methodology--of other natural sciences too--that the observation (Galileo may stand paradigmatically for it) and the mathematical description (Newton as example) were attempted at systems: free fall and planetary motion which represented a rather good idealization of a classical system being closed and only weakly disturbed 2-body systems. This way only, allowed to recognize fundamental relations: "laws" such as Newton's law of gravitation. Regularity was the essential presupposition.

In this case the frog's view did not limit the vision, it opened the eye for the lawfulness behind.

The foundation of the statistical thermodynamics by Boltzmann in the last century is another example for finding the relevant (regular) in the apparent irregular motion of the molecules of a gas: the temperature and the distribution function of the momenta.

Apparent irregularities have been encountered by physics with stochastic phenomena like the radioactive decay, characterized by the Poisson distribution of the decay rates.

The irregular of a quite new dimension comes out with chaotic systems, nonlinear and mostly open systems.

Though some empirical facts like the instability-behaviour of the double pendulum in mechanics or the Benard phenomenon or hydro dynamical instabilities are known since half a century and more, the recent approach by Haken's Synergetics, by Prigogine with his work on thermodynamics far from equilibrium and Eigen's and Schuster's approach to order from chaos in biological systems have opened a new dimension of vision, beginning with physics. These phenomena are described and elucidated in Sexl's paper so clearly that I have nothing to add.

The problem of reduction finds new interest in this context.

## The Problem of Reduction

Sexl's paper has a precautious, sometimes refusing, tenor against "reduction."

We are observing uncertainties in the semantics of reduction which--among other reasons--arise from the different weight of the aspects with the philosophers of science and with the practicing scientists of the various disciplines.

We could try to change--temporarily--the name, and speak of a "projection" of--for instance--an ensemble of chemical empirical facts and relations onto the notation of quantum theory.

It will then be a matter of trial whether, if it works sufficiently, it remains a methodological (formal) reduction or also an ontological. The latter would increase our understanding by connecting physical phenomena which occur also in other domains of the reality with those hitherto expressed in the language of the discipline of chemistry.

(It will evidently be easier to connect chemistry with physics than other disciplines of higher complexity.)

This weak* reduction should not act as unification by complete integration, but work like Esperanto besides national languages.

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*In this context the contribution of Percy Loewenhardt: Mind and Brain, Reduction or Correlation, to this Conference offers very interesting arguments.