8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

MATHEMATICAL AND PRACTICAL ASPECTS OF ADVANCED COMPUTATIONAL METHODS IN COMPLEX SYSTEMS

MARIO-CÉSAR SUÁREZ A.[*], JOCHEN BUNDSCHUH [†], FRANCISCO DOMINGUEZ M.[*] AND KARSTEN PRUESS[††]

[*] Faculty of Sciences, Michoacán University - UMSNH
Ed. B, Cd. Universitaria, 58060 Morelia, Mich. Mexico
msuarez@umich.mx , www.umich.mx

[†] Instituto Costarricense de Electricidad ICE,
International Tech. Co-operation Prog. CIM (GTZ/BA)
AP 10032, 1000 San José, Costa Rica
jochenbundschuh@yahoo.com

[††] Earth Sciences Division Lawrence Berkeley Nat. Lab.
1 Cyclotron Rd. MS 90-1116, Berkeley, CA 94720
k_pruess@lbl.gov , http://www-esd.lbl.gov/

Key words: Complex systems, Multiphysics Problems, Advanced Computing Methods.

ABSTRACT

Any arrangement of things composed, at least, by two interactive parts to form a whole unit, is a complex system. The parts of the unity interact with each other in such a way that the separated understanding of the functioning of each part does not guarantee the understanding of the entire system [2]. The complex system acts as a whole and is not possible to understand its global behavior without considering the interactions among all its parts. The solar set with the sun and its planets, the biological organisms or the geophysical processes are typical examples of natural complex systems. The human body and the planet Earth, as a geothermal entity, are highly complex systems. The geologic reservoirs containing water, energy, oil, gas or minerals are other concrete examples of complex systems. Examples of artificial complex systems are the contemporary civil engineering structures, mechanical vehicles, mechatronics, MEMS and NEMS devices. The paradoxical situation of this matter is that the scientific fundamental laws governing all those phenomena are represented by very simple equations. Everything seems to be simple, except the Universe[3]. At least in both primary sciences, Physics and Chemistry, all phenomena can seemingly be explained starting from some simple basic principles. Everything can be explained starting from the fundamental laws of Physics. This is Cartesian reductionism [1].

There are two principal aspects of complexity: *Some things are fundamentally simple but superficially complex. Some things are fundamentally complex but superficially simple*. One of the keys of complexity resides in understanding how the simplest elements and from the simplest relationships, nets of interactions are created reaching the astounding complexity of the world where we live.

There are radical differences between Reductionism and Complexity. These differences can be briefly exposed by showing, through some examples, that the first perspective dominates the roots of western science. When approaching the modeling and numerical simulation of natural systems complexity arises immediately. This fact emerges from the needfulness of understanding how the basic parts of an organic whole interact with each other. This deep comprehension is more important than the simple analysis of each subsystem. Recent ideas concerning the artificial creation of complexity will be discussed in this minisymposium. Several complex phenomena and complex processes will be described, using numerical modeling, software, computers and cellular automats. "*Unexpected results force a whole new way of looking at the operation of our universe*" [4].

REFERENCES

[1] R. Descartes (1977). "El Discurso del método". Ed. Espasa-Calpe, Mexico, (1977).

[2] N. Goldenfeld and L. Kadanoff "Simple Lessons from Complexity", *SCIENCE*, Vol. **284**, No. 5411, pp. 87-89. - American Association for the Advancement of Science. (1999).

[3] K. Mainzer, *Thinking in Complexity*. 4th Edition, Springer-Verlag, New York. (2004).

[4] S. Wolfram, *A New Kind of Science*. Wolfram Media, Inc. (2002).