Is it possible to describe solar system (planetary orbits) using self-organized criticality theory?

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Abstract

This article summarizes a discussion in researchgate.net. My hypothesis is that SOC can be used to explain the origin of the solar system too, especially planetary orbits, alas so far I do not find any equation yet which is based on SOC and can be used to derive numerical predictions of planetary orbit distances in solar systems. We know that planetary orbit distances in solar systems can be explained by many models such as Titius-Bode law, wave mechanics, wave equation and Lane-Emden equation.

Introduction

It is known that solar flares show power law characteristics, so it may also be related to critical self organization (see Guido Boffetta et al., PRL, 1999, http://personalpages.to.infn.it/~boffetta/Papers/bcgvv99.pdf). SOC is a concept introduced by Per Bak, Tang et al. (BTW) to explain complex dynamics of various phenomena, and this concept has been used to explain many phenomena like earthquakes, economic fluctuations, etc.

My hypothesis is that SOC can be used to explain the origin of the solar system too, especially planetary orbits, alas so far I do not find any equation yet which is based on SOC and can be used to derive numerical predictions of planetary orbit distances in solar systems. We know that planetary orbit distances in solar systems can be explained by many models such as Titius-Bode law, wave mechanics, wave equation and Lane-Emden equation.

Answers:

[1] **Carlos Eduardo Maldonado**

I like very much your question, Victor. I agree with you in that the solar system can be explained as a SOC. That, descriptively is in fact what happened early on n the history of our Galaxy.

As to the equation, right now I do not have the ingredients. Yet, as you know, being a SOC the solar system does exhibit a power law property. Hence...

[2] **Carlos Eduardo Maldonado**

I remember having read about in E. Chaisson's book "Cosmic Evolution".

Besides, as we know, the epistemological entailment of SOC is that we do not need "ad hoc" arguments any longer; f.i. external, superior, creationist, and the like.

The issue raised by your question can also be retailed to a twofold aspect, thus: on the one hand, the arrow of time, and correspondingly, the measure of the solar system (or the galaxy)'s complexity. Though and marvelous questions, as they are.

[3] **Victor Christianto**

Thank you, Carlos, for your answer. You made a sharp remark, which reminds me to another question: provided we can generalize SOC to the universe, does it mean that SOC excludes God as the Prime

Mover? What do you think? Thanks

[4] **Carlos Eduardo Maldonado**
SOC as well as self-organization are probably the most radical conceptual tools that do not need of causality. And yet, causality was a cornerstone in the entire history of mankind since the Greeks. This means that complexity science is a radical cultural and scientific shift, in that it does not work and is not based on causality - whatsoever.

In other words, the traditional stand between subject and object is not necessary in complexity theory, whence the autonomous and external assumption of a subject on and upon an object becomes groundless.

We are, it seems, in the midst of a conceptual and theoretical revolution, indeed.

[5] **Stam Nicolis**
One answer is No, because planetary orbits *do* have characteristic scales, so the notion of criticality in that context isn't appropriate. On the other hand, one may ask whether in the manifold of *initial conditions* the notion might be of some use, since planetary systems with more than two bodies are, generically, chaotic. However, once more, the issue is what concrete insight could one derive from such a statement, i.e. in a way that isn't tautological but could make some predictions, that could be checked by simulations. It isn't obvious.

[6] **Victor Christianto**
Dear Carlos, thank you for your answer. Perhaps you are right that the cause and effect arguments need revision, but if we compare with the original experiment, that is the sandpile, then one can ask: who will add more sands into the sandpile in order to trigger avalanches? So it seems to need a subject as Prime Mover. Best wishes

[7] **Stam Nicolis**
The problem is that planetary orbits, in the two-body approximation, are integrable, so the only way stochastic aspects *might* enter the description is in the case of chaotic dynamics.

[8] **Carlos Eduardo Maldonado**
Right Stam! I agree with you. The solar system and our galaxy, to take up Victor's comments and answers are chaotic systems; or rather, close to the edge of chaos. Entropy out there - especially in our galaxy as far it we know about it, largely reigns.

Now, @Victor: the idea of a Prime Mover sends us back to Aristotle and the Aristotelian tradition. Whence there is no room any longer, at all, for your question about SOC and power laws.

[9] **Victor Christianto**
Dear Carlos, thank you for your answer. Allow me to clarify what i meant before: is it possible to think of SOC as physical process underlying solar system, but at the same time still gives room for someone who triggered its creation at the beginning? Thanks

[10] **Carlos Eduardo Maldonado**
Dear Victor, I got your point the first time you ask it. Now you are kindly re-phrasing it.

SOC and self-organization - closely related to each other - have the merit that they provide new

insights and tools that enable us to think far beyond causality.

As we all know, causality only works as a scientific explanation:

a) Under controlled circumstance, and
b) At the local scale or level.

Complex systems are intrinsically not controlled and causality is extremely poor to explain complex behaviors. No matter how you think or conceive of causal explanations.

For the first time in history (since the ancient Greeks) we are liberated, to some extent, from having to think causally. Isn' t that great?

[11] **Victor Christianto**
@Carlos, with regards to this discussion on SOC, I just posted a different but related question concerning possible application of SOC in prediction of human behavior. Your comments are welcome. see the question at https://www.researchgate.net/post/Is_there_connection_between_Self-Organized_Criticality_and_Human_Cognition#share

[12] **David Horgan**
Hi victor, may I suggest that you have a look at : Chaos-assisted capture of irregular moons, Nature 423, 264-267 (15 May 2003).

In this article the authors show that, the capture of irregular moons with non-circular orbits--by giant planets occurs by a process in which they are first temporarily trapped by gravity inside the planet's Hill sphere. The capture of the moons is then made permanent by dissipative energy loss or planetary growth.They show that irregular satellites are captured in a thin spatial region where orbits are chaotic, and that the resulting orbit is either prograde or retrograde depending on the initial energy. Dissipation then switches these long-lived chaotic orbits into nearby regular or non-chaotic zones from which escape is impossible.

It seems to me that you ought to be able to adapt some of the theory and techniques described in this article - including for example monte carlo analysis to your analysis of planetary orbits in the solar system.

Concluding remarks
Based on this discussion, it appears that so far there is no specific method in SOC which is able to describe solar system's planetary orbits. However, this situation may change in the future.

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