Chaos and order

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In the one slide, we can see a picture of a random game on the left, such as monopoly. On the right, we can see a picture of the solar system.

Let me start with a question: What do you think is the difference between these two systems? Well, one difference is that one of them will most surely make you lose some friends. But also, there is indeed a fundamental difference: the one on the left is a random system, while the one on the right is a deterministic system. This means that the one on the right evolves according to a set of well defined rules, in this case, gravitational equations, and if we know the initial conditions of the system, we can predict its state after certain period of time. In practice, we can know where Mars is going to be the next week, relative to the Earth. On the other hand, a system such as the game on the left, has an intrinsic random component, in this case, throwing dice. This implies that we cannot predict with a 100% accuracy what is going to happen after the first round of the game. In practice, this makes predictions for the 10th round impossible, unless you are very bad at monopoly. But these two systems share a surprising property. Even though, we can predict the position of the planets for your next birthday, if we ask the same question but for the next several hundred thousand million years, the answer is not so clear. The solar system exhibits what we call a *chaotic* behavior. Edward Lorenz referred to this as *The Butterfly Effect*. Small errors on the measurements of the current positions of the planets become huge when we try to make predictions at a cosmic timescale. In this sense, the system is as unpredictable as the monopoly game. What I do in my work, is trying to measure, quantify the degree of chaos, of unpredictability in this kind of chaotic systems, and possibly understand why some systems are more predictable than others. We build mathematical models, abstract enough to be simple in form to study, and yet general enough to be applied in many different instances, such as traffic problems, wireless communication, weather prediction, or even understanding the spreading of diseases. So now, whenever there is an unexpected snow storm, do not blame the weatherman, but blame the mathematician trying to deal with such chaotic models.