Department of Mathematical Sciences
Colloquium

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EQUATIONS WITHOUT EQUATIONS: CHALLENGES ON A WAY TO A MORE ADEQUATE FORMALIZATION OF CAUSALITY REASONING IN PHYSICS

Our interest in causality reasoning in physics was enhanced by the need to formalize reasoning in physics. In medicine, geophysics, and in many other applications areas, expert systems use automated expert reasoning to help the users.

We expect that similar systems may be helpful in general theoretical physics as well. To design such systems, we must formalize physicists' reasoning inside an automated computer system. To do this, we must be able to describe physicists' reasoning in precise terms.

Physicists' reasoning has a clearly formalized part: indeed, physical theories are usually formulated in terms of differential equations (in general, partial differential equations) that describe how the corresponding fields (and/or physical quantities) x change with time t.

From the purely mathematical viewpoint, the situation seems to be straightforward:

* from the observations, we find the initial conditions $x(t_i)$ at some moment of time t_0;
* we then solve the differential equation and find the values $x(t)$ for all moments of time t.

The above description does not capture the known fact that not all solutions to the equation are physically meaningful. For example, when a cup breaks into pieces, the corresponding trajectories of molecules make physical sense.

If we now reverse all the velocities, we get pieces spontaneously assembling themselves into a cup. This reverse process is clearly physically impossible. However, since Newton's equations remain valid when we change the time, the reverse process also satisfies the Newton's equations.

To provide an adequate description of physicists' reasoning, we must be able to capture not only the equations, but also the fact that some solutions of these equations are not physical. A usual physical explanation of this fact is that, e.g., the "time-reversed" solution is non-physical because its initial conditions are "degenerate". Specifically, this means that if we modify the initial conditions even slightly, the pieces will no longer get together.

So, for a solution to be physically meaningful, not only the equations must be satisfied, but also the initial conditions must be ``non-degenerate".

It is known that the notion of non-degeneracy in physics can be adequately described by the use of Kolmogorov complexity and algorithmic randomness.

However, there is another important challenge that it not easy to resolve: that the separation between equations and initial conditions depends on the way equations are presented.

In this talk, we will illustrate this dependence on the example of simple physical equations.

Friday, September 4, 2009 at 1 pm in BUSN 321

The University of Texas at El Paso

Refreshments will be served in front of the colloquium room,

15 minutes before the start of the colloquium.

Please note the unusual time and place for the colloquium.