AbstractID: 8130 Title: Computer-Intensive Models for Causal Inference

Most physicists would concur that, *"The ability to infer causation is an essential survival trait"* (Rothman, 1988). Fewer are aware that, *"The final quarter of the twentieth century witnessed a burgeoning of formal methods for the analysis of causal effects"* (Greenland, 2000), a *"burgeoning"* wholly due to the development of powerful computers. We examine dual aspects of causal inference: (1) identifying the cause of an observed effect; (2) measuring the effect of a given cause. (1) is a non-statistical problem: It is a problem in evolving dynamical systems. It can only be solved by attaining a clear understanding of the mechanism by which causal processes operate. The observed *"effect"* is realistically described as a parameter-dependent transformation of attractor topology, e.g., a Hopf bifurcation, or *perestroika*, in the system state-space, e.g., limit point (equilibrium) to limit cycle (oscillation), for which the *"cause"* is an instability created by a change in a control parameter describing the coupling of the system to its environment. Thus, it requires computer-intensive solutions to the set of nonlinear differential/difference equations defining the dynamics of the considered biological, chemical, social, etc., system. (2) is a statistical problem: The *"effect"* is **defined** by the difference in response of the **same individual unit** to each of two different *"causes"*. Since each unit can be exposed to only one of two causes, it is fundamentally a *"missing data problem."* Realistic solutions can only be achieved by re-sampling or, preferably, by phenomenological Bayesian imputation methods. These methods are also computer-intensive. Examples are discussed.