How does science work?

Nonlinear fits to data: Sloppiness, differential geometry, and algorithms

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The microscopically complicated real world exhibits collective behavior that is comprehensible, yielding to simple yet accurate descriptions. Predictions are possible despite many unknown microscopic parameters both in physics (where microscopic details are compressed into a few governing parameters), and in multiparameter models from other areas of science (systems biology, climate science, macroeconomics, neural networks, accelerator design, and Big Bang theories).

These systems exhibit a condensation in model space, with collective behavior primarily dependent on only a few parameter combinations, and many models exhibiting the same 'universal' behavior. We shall explain this condensation using differential geometry, as a hierarchical hyperribbon structure in the space of model predictions. In the process, we shall engage in Bayesian analysis, Monte-Carlo sampling, new 'geodesic' methods for nonlinear optimization, and potential group projects modeling macroeconomics, climate, machine learning, accelerator injection systems, and the cosmic microwave background radiation.