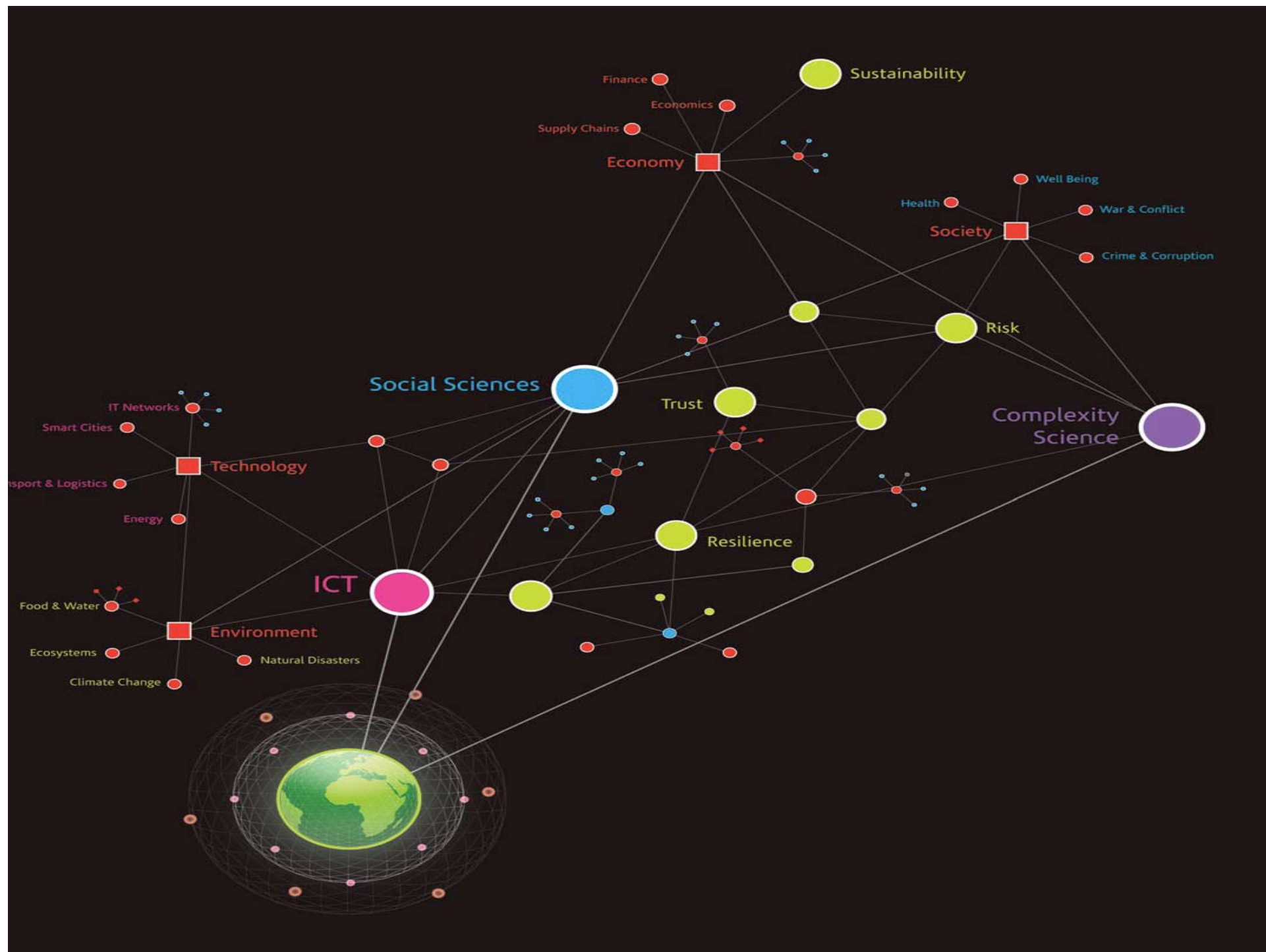


Complexity and Physics

- G. P. Tsironis (statistical, nonlinear systems)
- N. Lazarides (computations, theory)
- C. Athanasopoulos (Computations, business)
- G. Neofotistos (socio-economic agents, education, business links)
- S. Tzortzakis (experimental complexity)
- M. Mattheakis (PH. D. student, computations)
- K. Skoufaris (Diploma student, networks)



Complex = Nonlinear + Statistical + ...

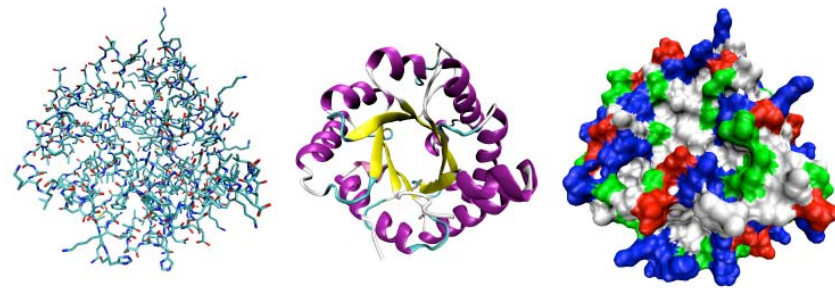
Nonlinear= Strongly interacting, chaotic, coherent,...

Statistical= Many elements, stochastic, disordered,...

Function and emergent properties



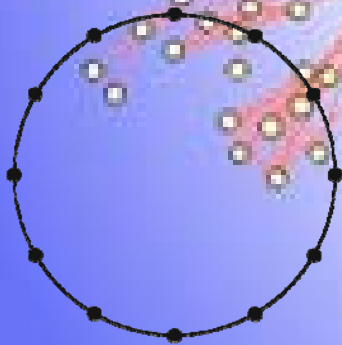
Metals



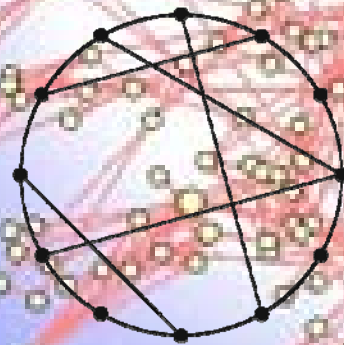
Proteins

Nonlinear Networks

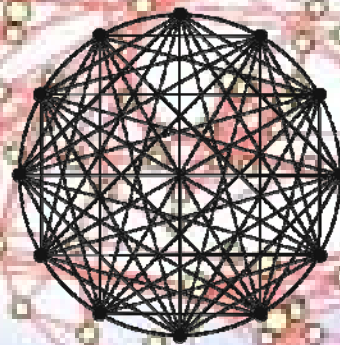
$$i \frac{d \psi_n}{dt} = \varepsilon_n \psi_n + V (\psi_{n+1} + \psi_{n-1}) - \chi |\psi_n|^2 \psi_n$$



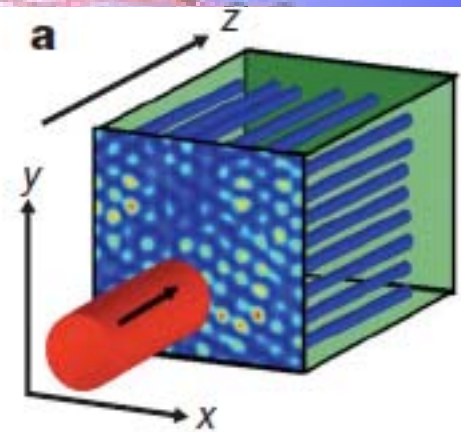
Nearest
neighbor
coupling



Small world
network



Fully coupled limit



Extreme events

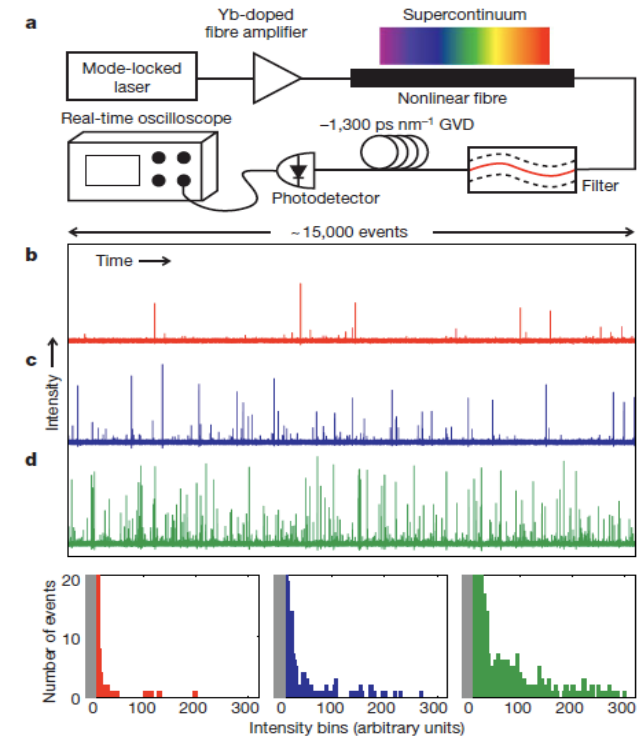


Figure 1 | Experimental observation of optical rogue waves. a, Schematic of

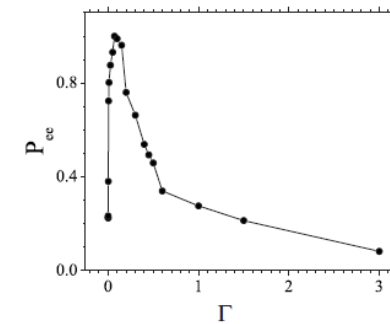
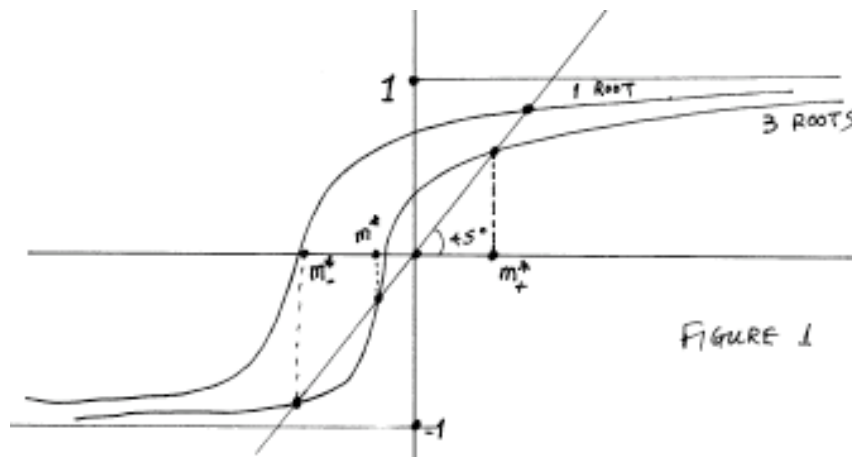


FIG. 3. The normalized probability $P_{ee} = P_h(h \geq h_{th})$ for the occurrence of extreme events as a function of the integrability parameter Γ . All data present averaged results of five numerical measurements differing in the initial conditions.

Economic agent models and spin glass theory

Agent models have used simple ferromagnetic-paramagnetic phase transitions in order to describe emergent behavior of social and economical groups (Brock, Durlauf, Ioannides)

More complex models involving statistically distributed (social) interactions may be utilized (spin glasses). This approach may capture in a more refined way the intricacies of societies of agents.



Discrete choice models: m is the agent's subjective expectation of the other agents' decision, β is a behavioral parameter, h a private utility component, and J describes the social interactions

$$m = \tanh(\beta h + \beta J m),$$

Solvable Model of a Spin-Glass

David Sherrington* and Scott Kirkpatrick

IBM Thomas J. Watson Research Center, Yorktown Heights, New York 10598

(Received 16 October 1975)

$$J_0 = \tilde{J}_0/N, \quad J = \tilde{J}/N^{1/2},$$

$$\mathcal{H} = -\frac{1}{2} \sum_{i \neq j} J_{ij} S_i S_j, \quad S_i = \pm 1,$$

$$p(J_{ij}) = [(2\pi)^{1/2} J]^{-1} \exp[-(J_{ij} - J_0)^2 / 2J^2],$$

$$m \equiv \langle \langle S_i \rangle \rangle_J,$$

$$q \equiv \langle \langle S_i \rangle^2 \rangle_J,$$

$$q = 1 - (2\pi)^{-1/2} \int dz \exp(-z^2/2) \operatorname{sech}^2[\tilde{J}q^{1/2}/kT z + \tilde{J}_0 m/kT],$$

$$m = (2\pi)^{-1/2} \int dz \exp(-z^2/2) \tanh[(\tilde{J}q^{1/2}/kT)z + \tilde{J}_0 m/kT].$$

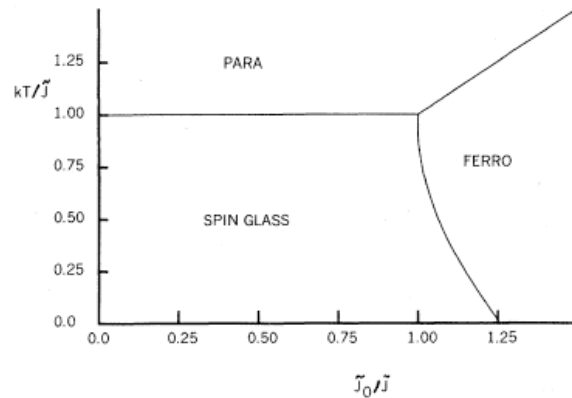


FIG. 1. Phase diagram of spin-glass ferromagnet.

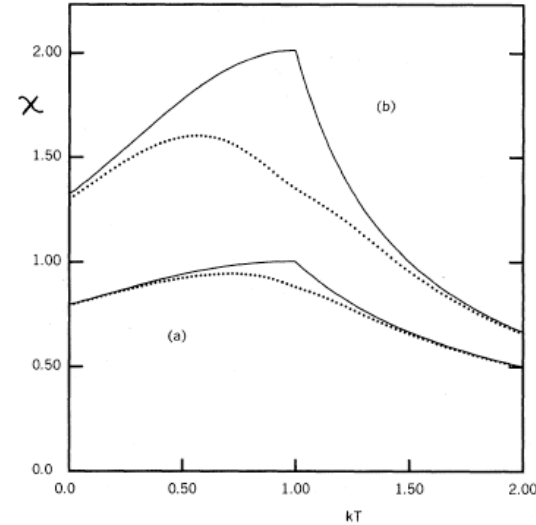


FIG. 3. Differential susceptibility without external field (solid lines) and with a field $H = 0.1\tilde{J}$ (dotted lines) for $\tilde{J}_0/\tilde{J} = 0$, curves *a*, and $\tilde{J}_0/\tilde{J} = 0.5$, curves *b*.

Economic and Social Systems Research (G. Neofotistos)

- **Complex network analysis**
 - quantitative study of the O*NET jobs-knowledge and jobs-skills networks (centralities, spanning trees)
 - identifying the most central skills and knowledge for the new-and-emerging green jobs (based on network analysis of the O*NET-SOC 2009 updated taxonomy)
- **Global climate change issues and climatic time series analysis**
 - the welfare effects of global coal taxes
 - using time-series models (the Campbell-Diebold model in particular) to estimate global warming trends
- **Dynamics of social excitations - Dynamics sales of digital products/services**
 - Build-up and decay of social excitations [currently: social excitations generated by “science” events (i.e. solar eclipses) in order to enhance “science & society” links]
 - Endogeneous v. exogeneous / critical v. subcritical shocks’ impact of digital goods sales
- **Quantifying web-usage patterns**
 - Currently: Quantifying and categorizing web-users behavior in online (e-learning) repositories)
- **Global trade simulations**, using the computational general equilibrium (CGE) GTAP model

Our FuturICT interests

- Define and solve complex models for social dynamics
- Explore the possible role of nonextensive entropies that appear to be appropriate for systems out of equilibrium
- Investigate the emergence of extreme socioeconomic events
- Link with (real time) data, produce predictions for specific instances and embed the code in the FuturICT accelerator
- Introduce real time statistical predictability
- Global climatic changes
- Networks and global trading
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