Universal Relaxation and Diffusion in Many-body Interacting Systems

I shall try to convince the audience that this is the most interesting and important discovery supported by basic physics and plenty of critical experiments in glass-forming, non-glass-forming, and even in crystalline materials.
Documented in "*Relaxation and Diffusion in Complex Systems*"
K. L. Ngai, Springer, New York 2011.

1. Theoretical Basis

a) Interaction potential determines dynamics. The potential is usually anharmonic and phase space is chaotic.
Consequences:
- Relaxation and diffusion governed by classical chaos (i.e. nonlinear Hamiltonian dynamics
- Emergence of fundamental laws of relaxation and diffusion
- Universal and general applied to all materials with interactions, independent of the nature of the interaction, inter-molecular, inter-onic, inter-particle, or inter-chain, and applicable to glass-forming systems, non-glass-forming systems, and even in crystalline systems
- 35 years of work collectively known as the Coupling Model

b) Too good to be true**!?**
- Takes 35 years of work in different research fields to test and confirm the fundamental laws
- Learn the different disciplines
- Collaborate with many researchers in different fields

2. Support from experiments and simulations in glass-forming systems

- Glass-forming systems offer the richest collection of experimental data and computer simulations to test the Coupling Model
- The Johari-Goldstein β-relaxation
- Introduction of pressure in addition to temperature opens up the field
- Thermodynamic factors including density and entropy do determine the dynamics, but separately, and certainly not totally.
- Origin of the $T\rho^{-\gamma}$-scaling of the dynamics.
- Pharmaceuticals
- Simulations
- Posson's ratio (Bulk metallic glasses)

3. Nanometer scale reduction in size

- Polymer thin films
- Nanoconfined glass-formers

- Nano-ionics

<u>4. Supports from experiments on glassy and non-glassforming systems</u>

- Dynamics of ions in glassy, molten, and crystalline systems
- Plastic crystals
- Supercooled and glassy water
- Carbohydrates
- Hydrated and solvated proteins
- Fuel cell materials

<u>5. Polymer dynamics and viscoelasticity</u>

- Rheology of entangled polymer sytems
- Explanation of the thermo-rheological complexity of amorphous polymers