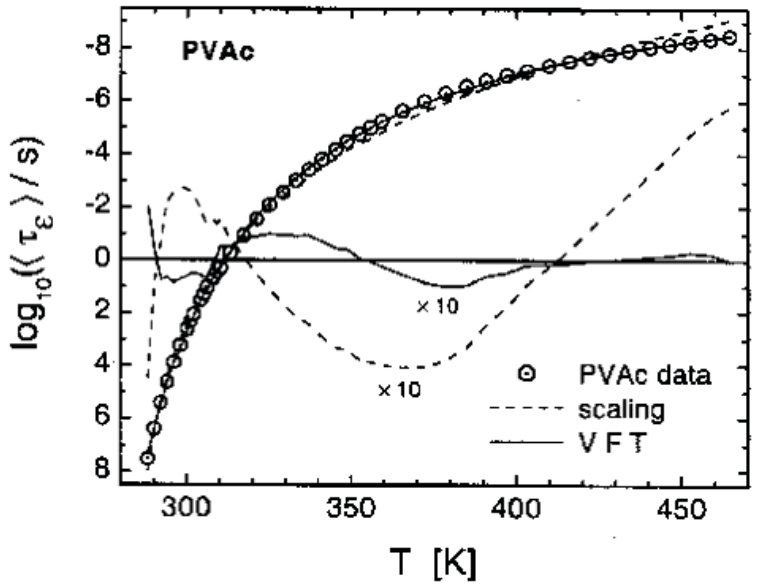
Experimental perspective on supercooled liquids and glasses (molecular and atomic systems)

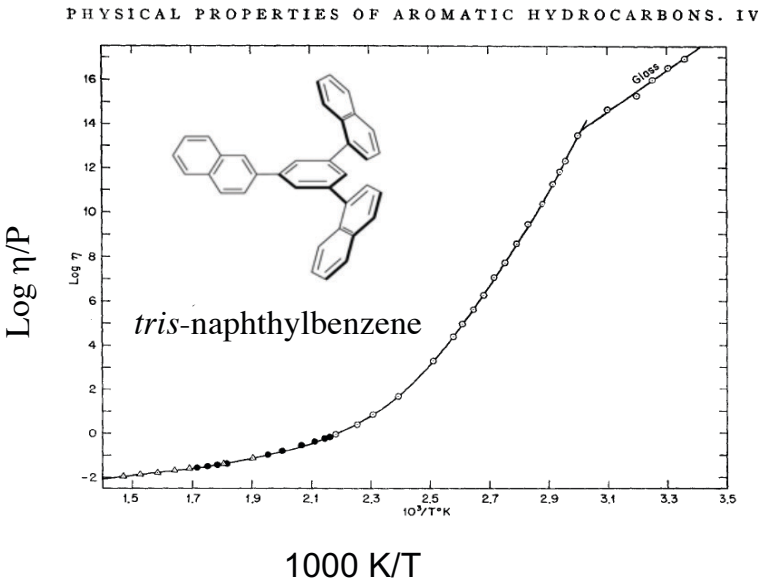
- Dynamics
- Thermodynamics
- Structure
- Glass properties
- Transformation kinetics
- Glasses near the bottom of the potential energy landscape (vapor-deposited glasses)

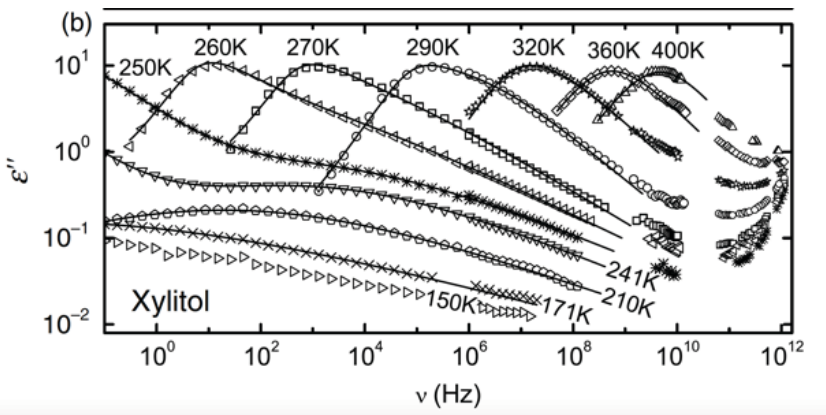
Dynamics in SCLs depend strongly on temperature

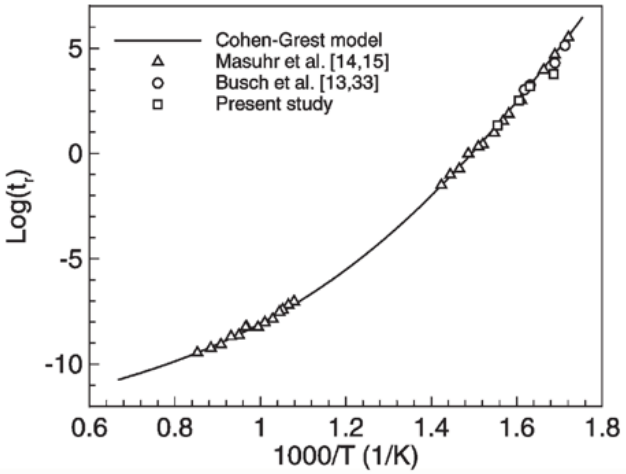
R. Richert / Physica A 287 (2000) 26–36



Plazek and Magill, J. Chem. Phys. 49, 3678 (1968)





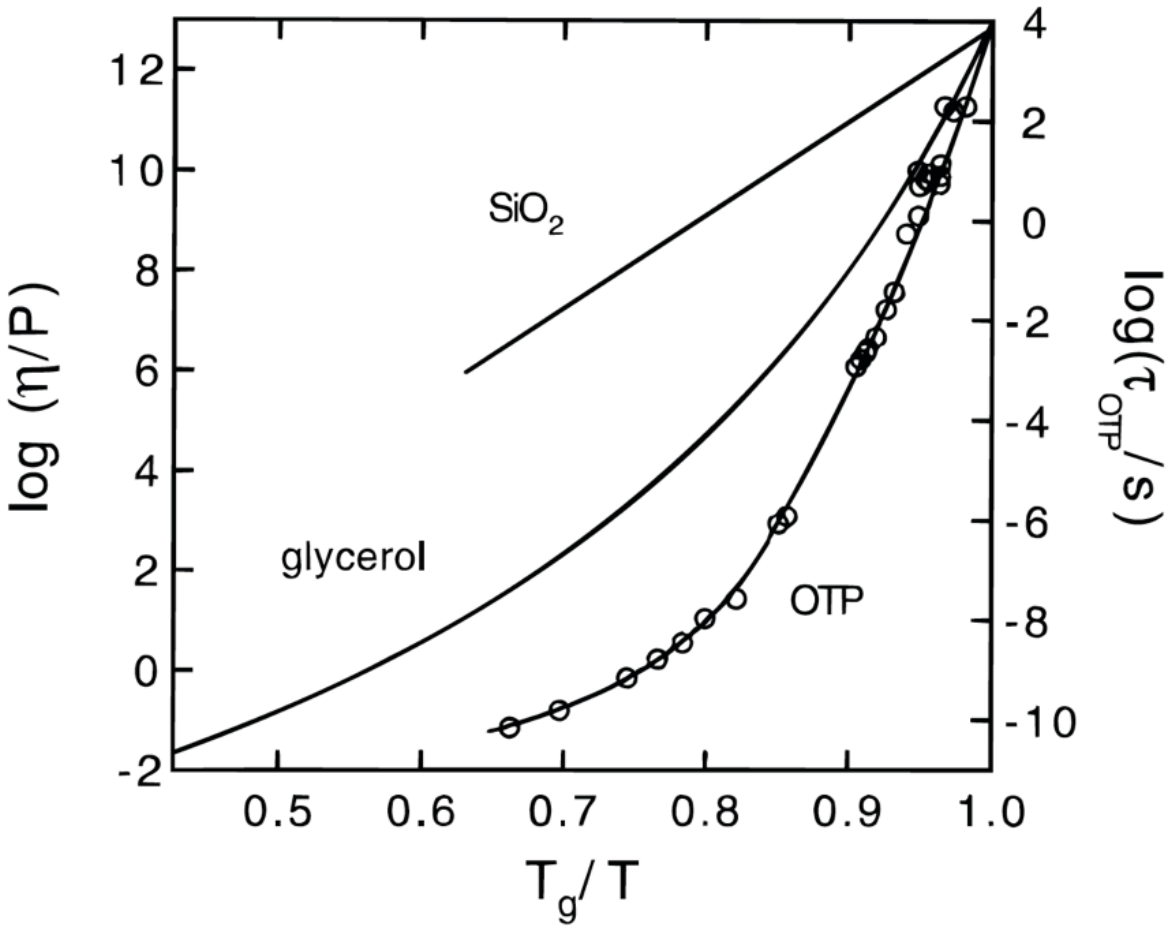


Lunkenheimer et al., in Structural Glasses and Supercooled Liquids: Edited by Peter G. Wolynes and Vassiliy Lubchenko. 2012

$Zr_{41.2}Ti_{13.8}Cu_{12.5}Ni_{10}Be_{22.5}$ (Vitreloy 1)
Lu et al. / Acta Materialia 51 (2003) 3429–3443

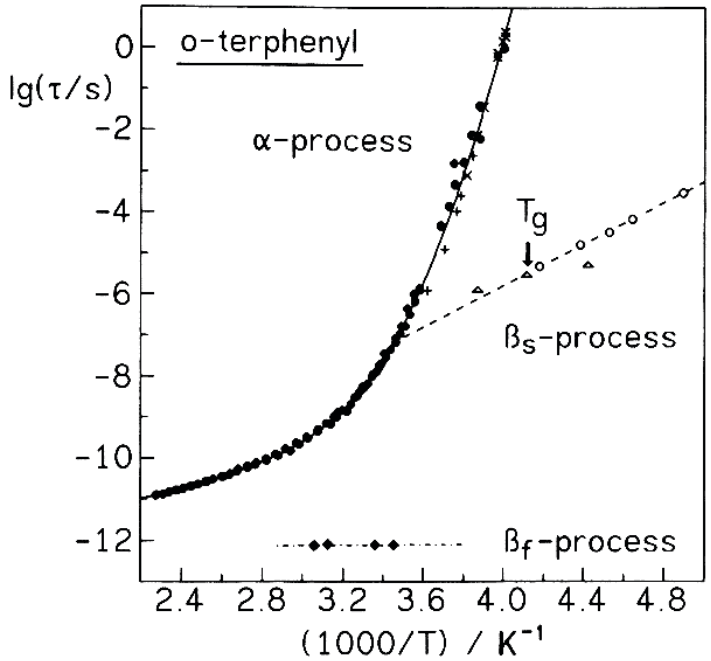
Strong and fragile glassformers

J. Phys. Chem., Vol. 100, No. 31, 1996 **13201**

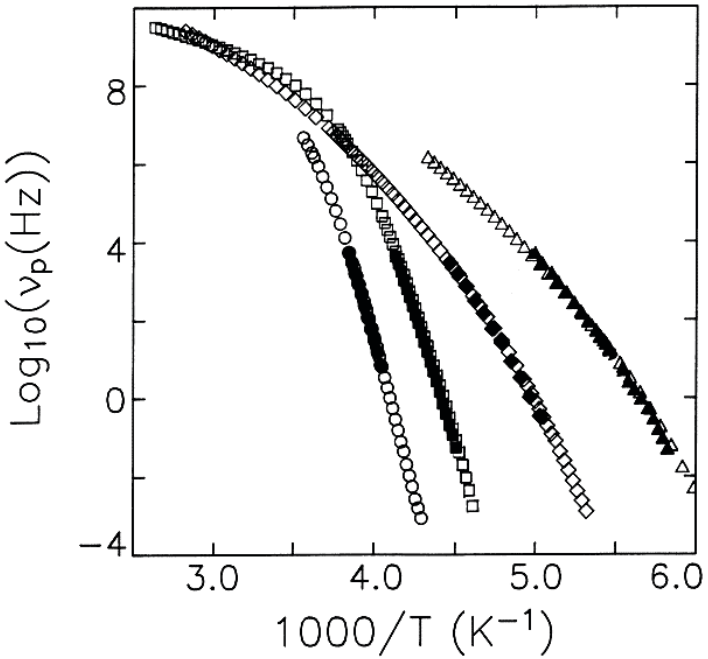


- Strong limit = Arrhenius
- Structure is strong or fragile (with respect to temperature)
- kinetic fragility “m”

Relaxation times from different techniques that measure SCL dynamics often show good agreement



Rossler, ...J. Non-Cryst. Solids 1994, 172-4, 113.

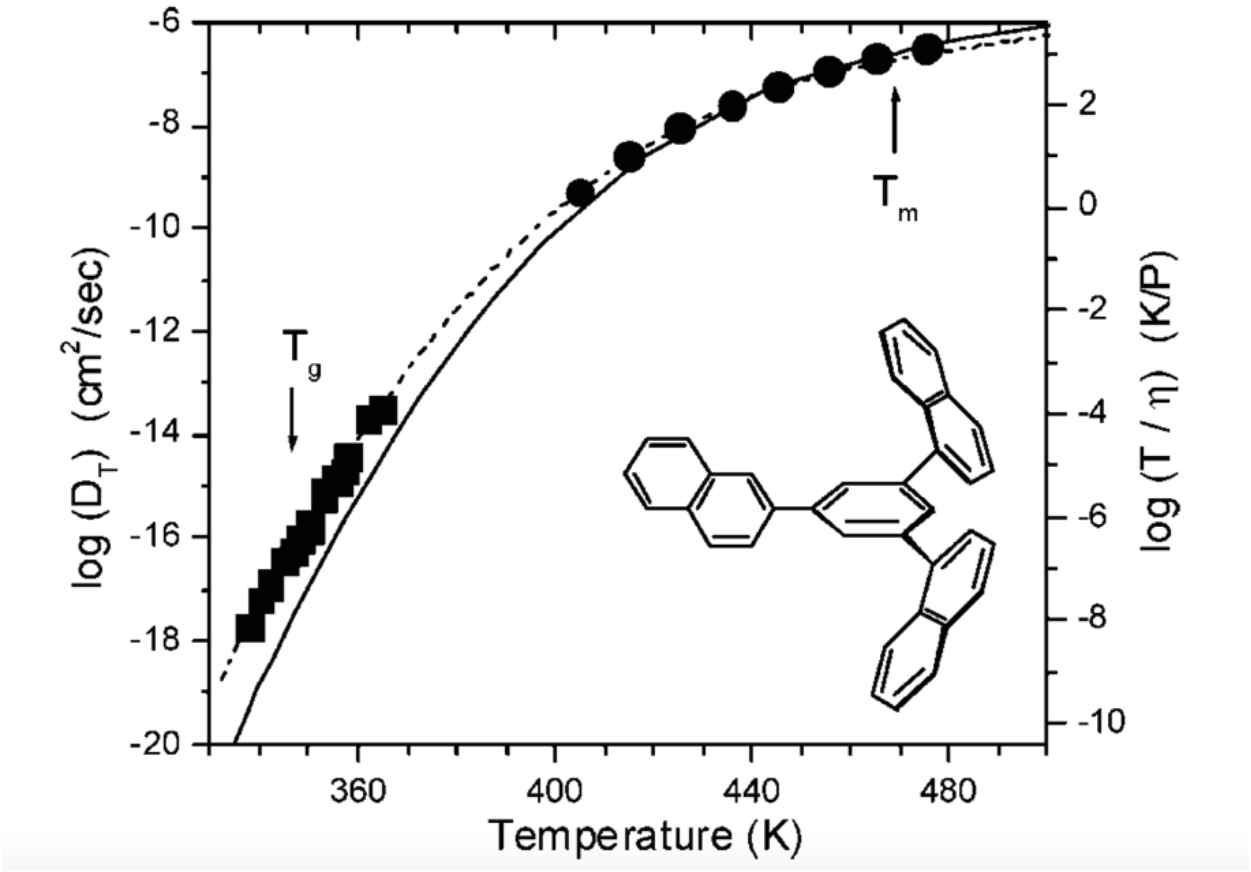


Wu, ...J. Non-Cryst. Solids 1991, 131-3, 32

- α relaxation: dielectric relaxation, dynamic Kerr effect, light scattering, NMR, probe rotation
- β relaxation: dielectric relaxation, partial probe reorientation

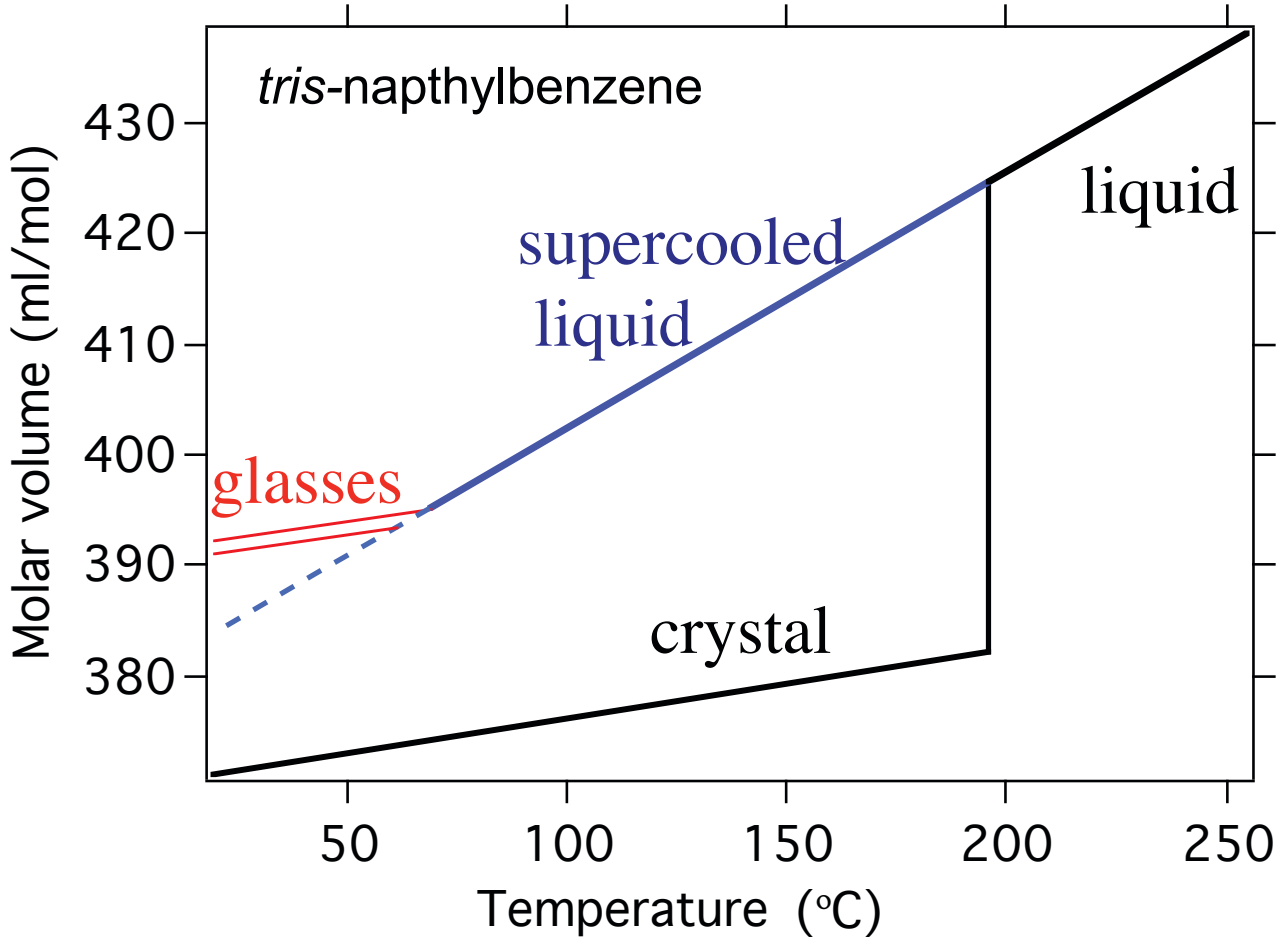
- α relaxation: Comparison of dielectric relaxation and heat capacity spectroscopy for glycerol, propylene glycol, salol, and o-terphenyl/o-phenylphenol

Dynamics in SCLs continued: Self-diffusion has a weaker temperature-dependence



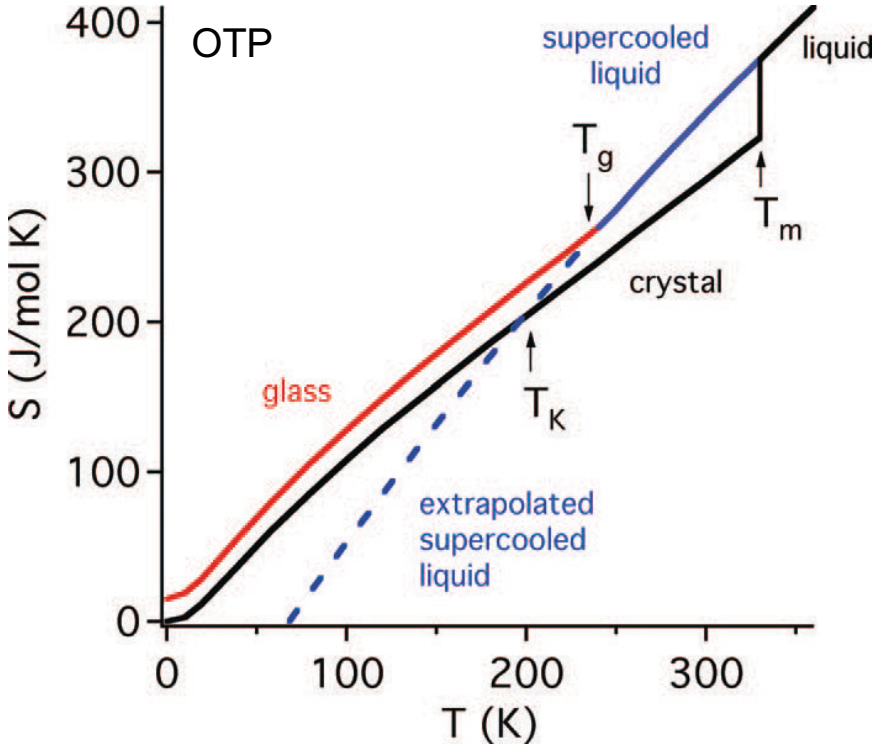
Swallen et al., J. Phys. Chem. B, (2009)

Thermodynamics

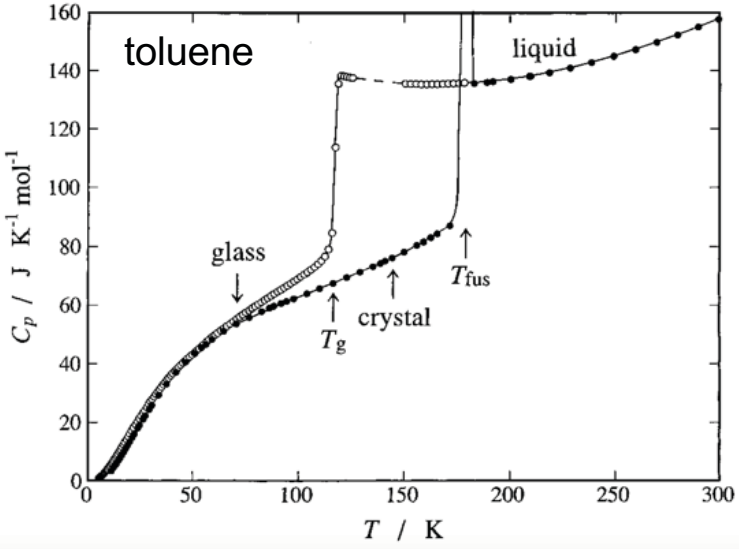


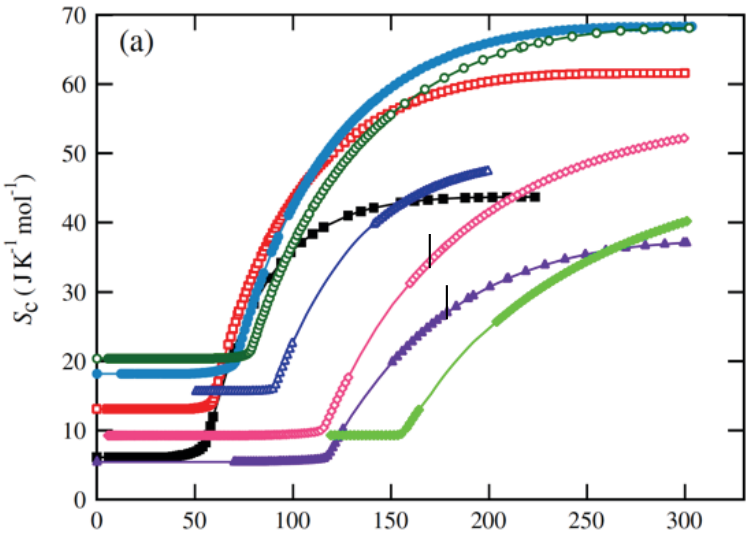
Molar volume data from Plazek and Magill, JCP 1966

Kauzmann entropy crisis



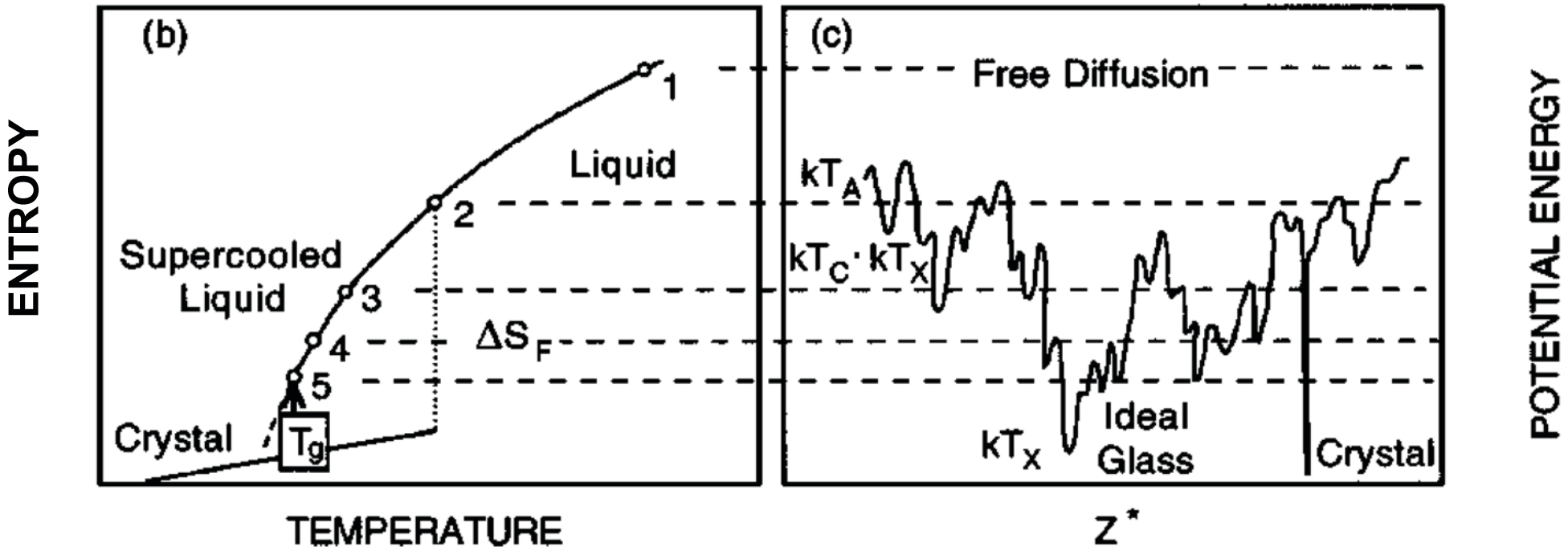
Ediger and Harrowell, JCP 137, 080901 (2012)





Yamamuro et al, J. Phys. Chem. B 1998, 102, 1605-1609
Tatsumi, et al. PRL 109, 045701 (2012);

Kauzmann entropy crisis and the potential energy landscape



Angell, et al., J. Appl. Physics (2002)

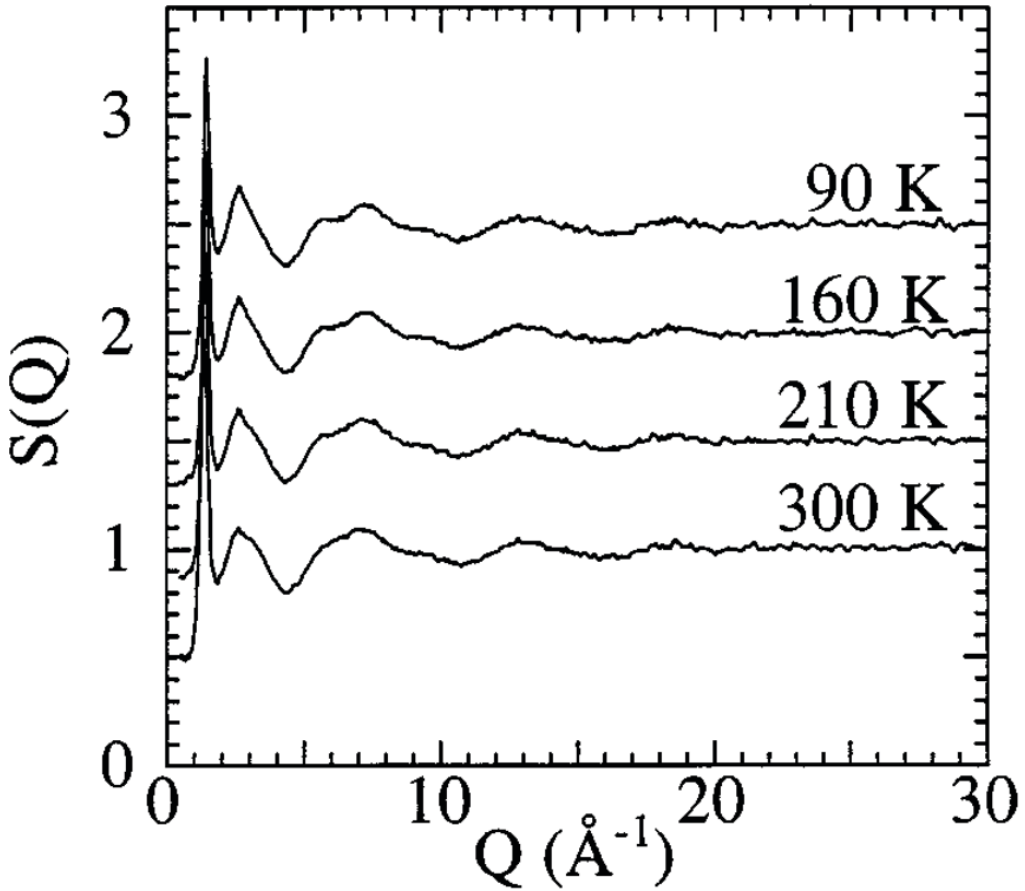
Are simulated systems good mimics of experimental glassformers?

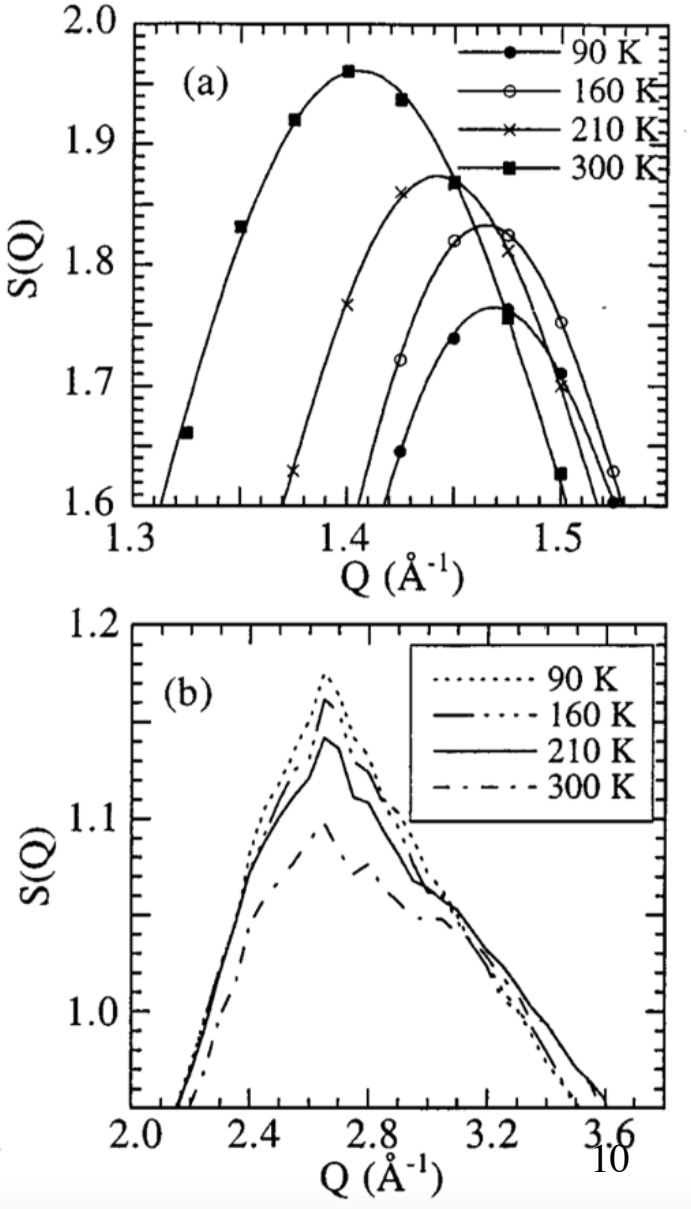
TABLE I. Parameters related to glass transitions.

	Propene	Butene	Pentene	3MP	MTHF	ETB	Toluene	PC
T_g (K)	56.0	60.0	71.7	79.0	93	115	119	158
T_K (K)	49.8	49.3	55.9	59.8	73	101	108	135
$T_g/T_K - 1$	0.12	0.22	0.28	0.32	0.27	0.14	0.10	0.17
$T_b/T_m - 1$	1.56	2.04	1.82	2.05	1.57	1.30	1.15	1.35
S_{res} (J K^{-1} mol^{-1})	6.09	13.1	18.1	20.4	15.6	9.25	5.43	9.29
$z^*(0)$	7.26	4.76	3.82	3.41	3.20	5.99	7.12	5.05

Tatsumi et al. PRL 109. 045701 (2012)

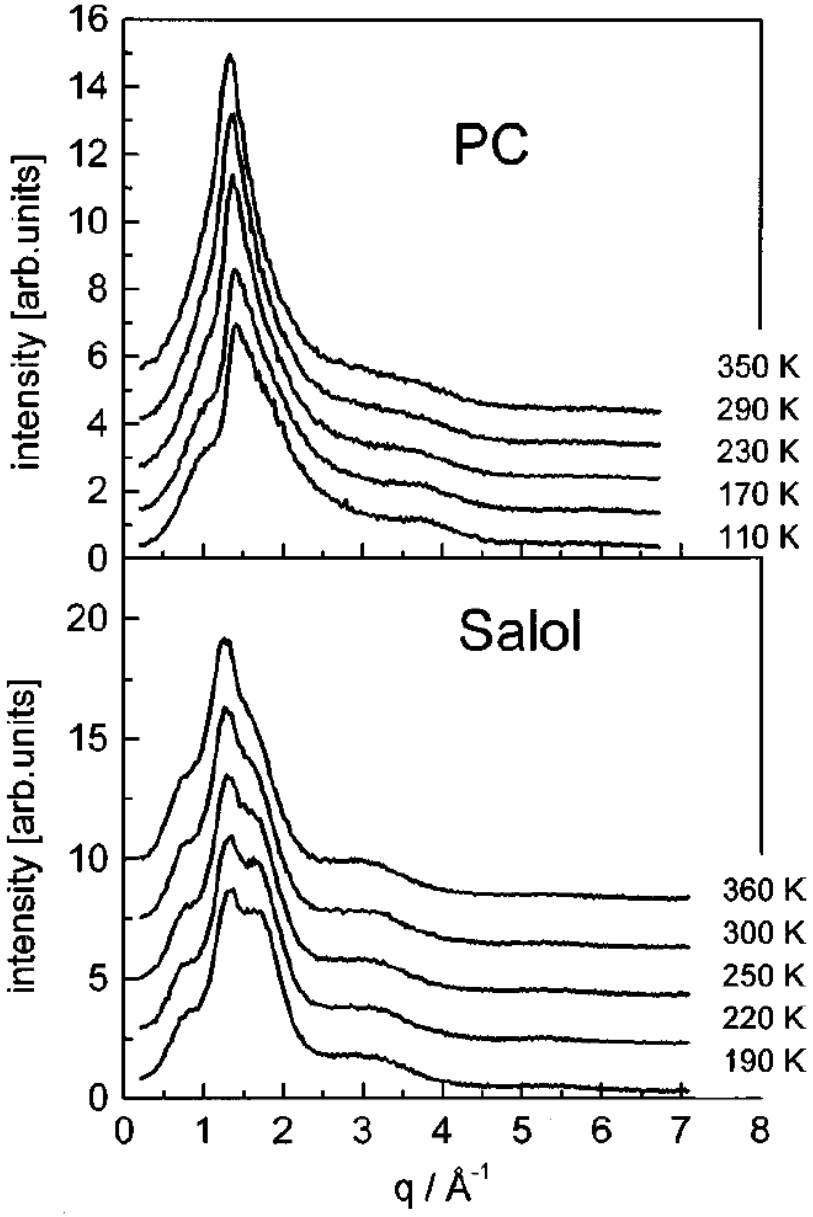
Structure of supercooled liquids and glasses: Can you find the origin of slow dynamics





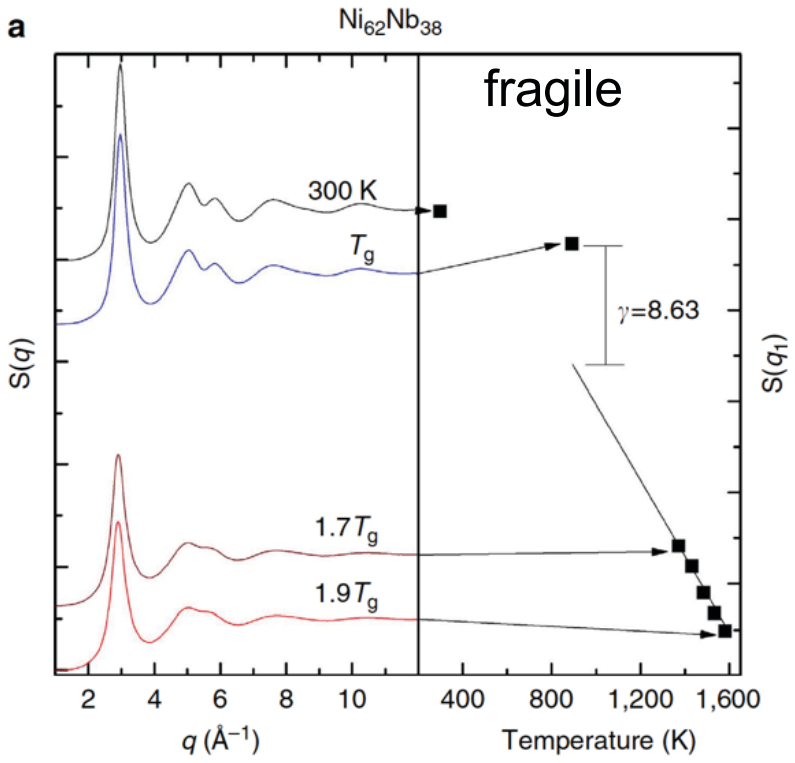
Propylene glycol
Leheny et al., JCP 1996

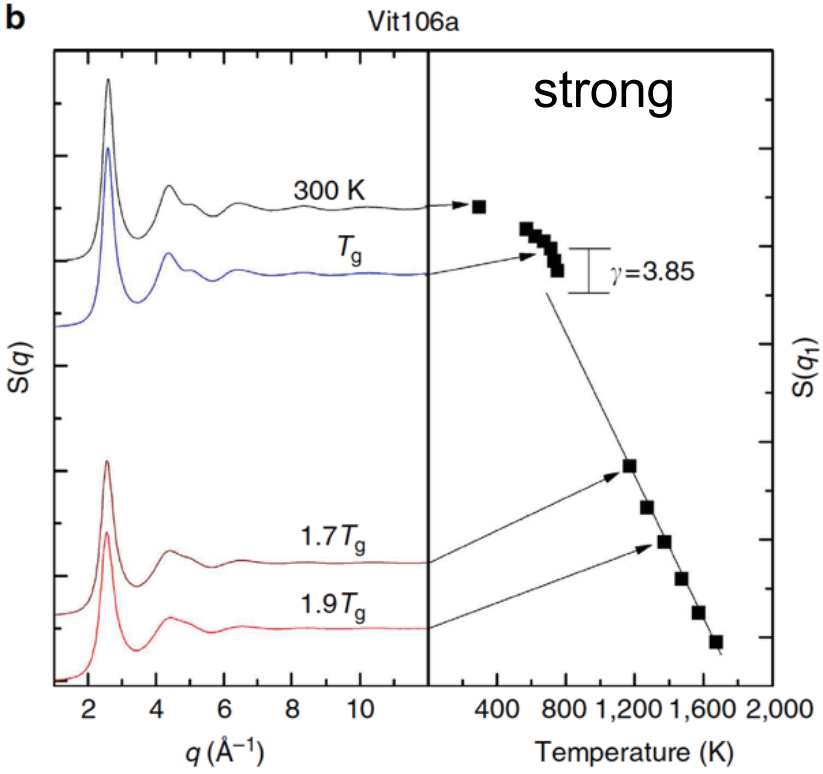
Structure of supercooled liquids and glasses: Can you find T_g?

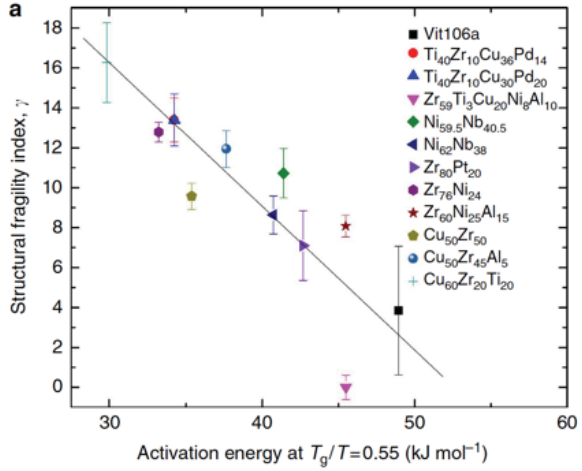


Eckstein, et al, JCP (2000)

Metallic glasses show correlation between temperature-dependent structural evolution and fragility

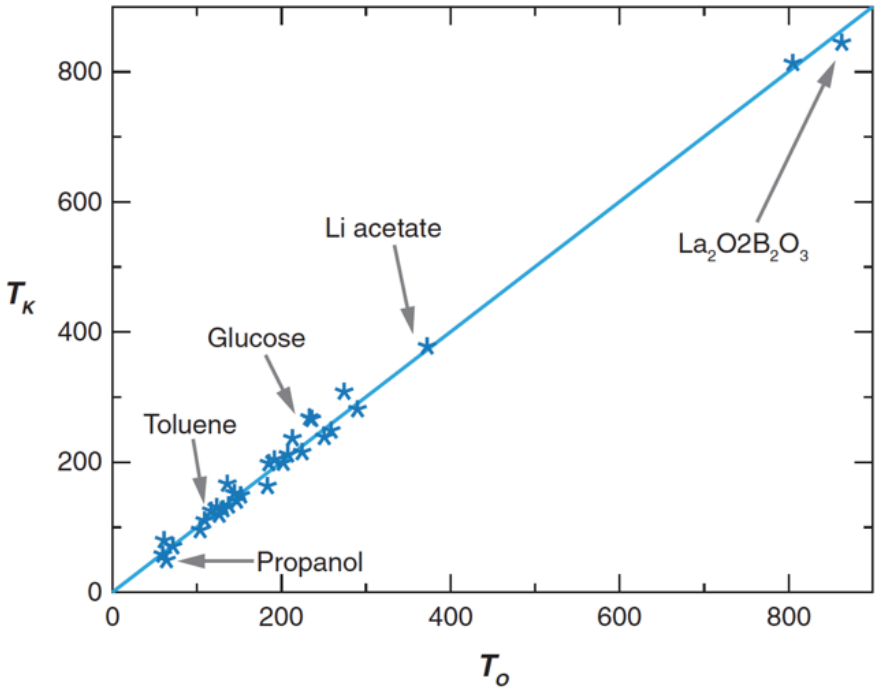


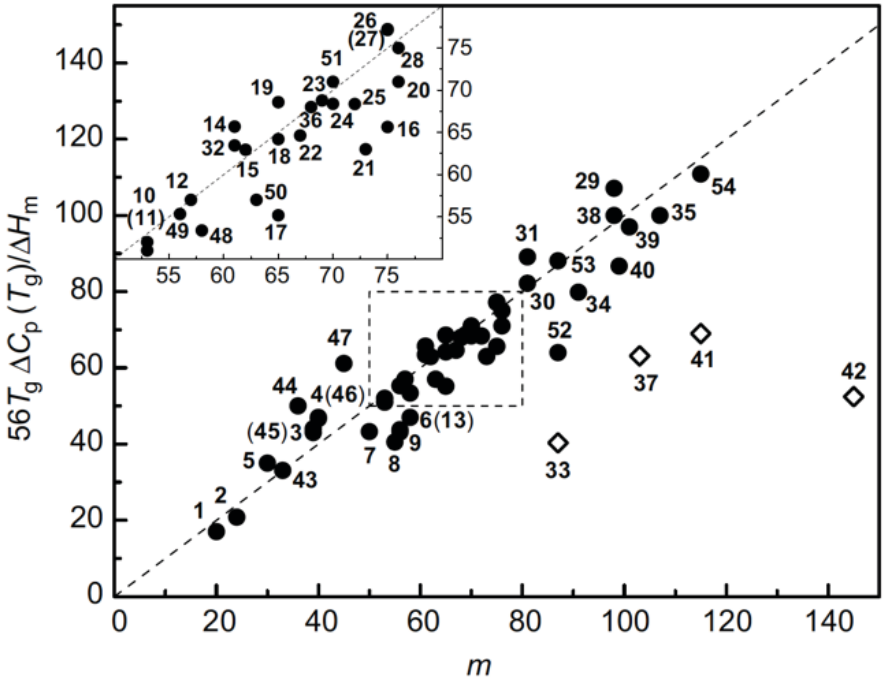




Mauro et al., Nature Comm. (2014)

Deep connections between thermodynamics and dynamics?





Richert in: Structural Glasses and Supercooled Liquids: Theory, Experiment, and Applications, First Edition. Edited by Peter G. Wolynes and Vassiliy Lubchenko. 2012 John Wiley & Sons, Inc.

Wolynes and Lubchenko, Annu. Rev. Phys. Chem. (2007)