Aging phenomena in magnetic systems

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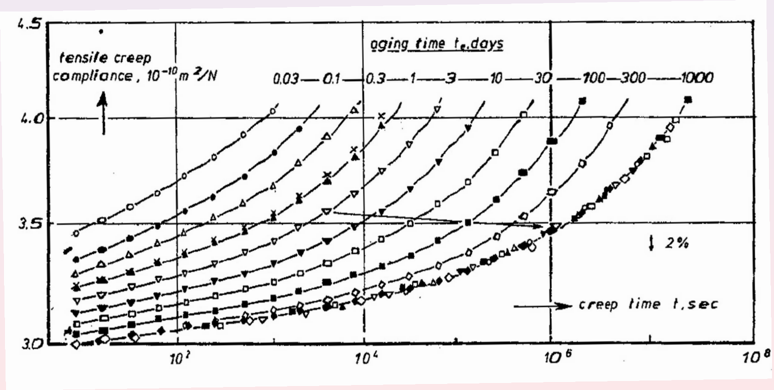
Content

Physical aging is known (and exploited) since prehistoric times

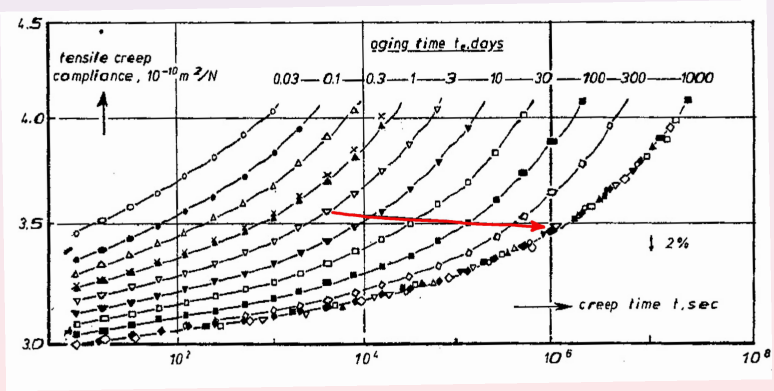
First systematic studies: glassy systems (Struik '78)



a priori behavior should depend on entire history of the sample

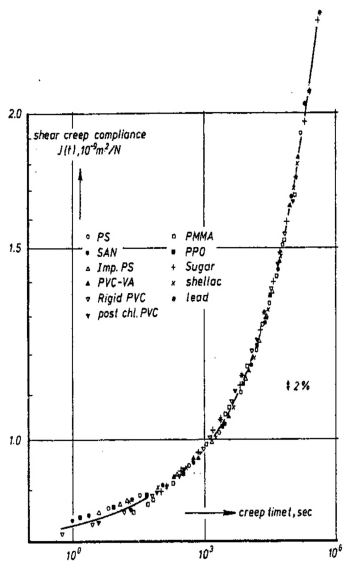
Physical aging is known (and exploited) since prehistoric times

First systematic studies: glassy systems (Struik '78)

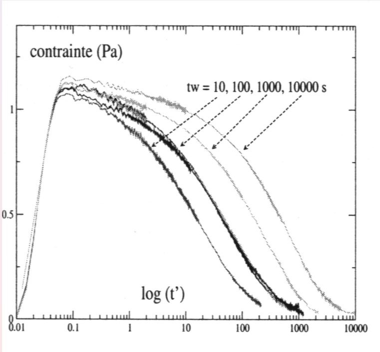


evidence for universal behavior

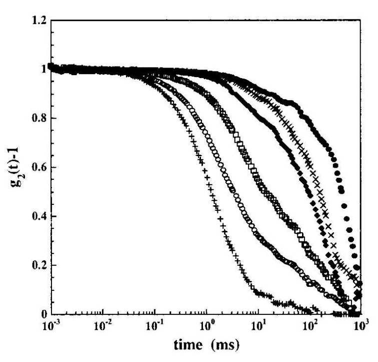
same universal curve for very different materials!



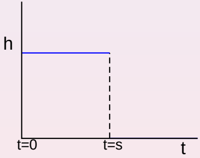
Colloids: relaxation after mechanical stress (Derec '95)

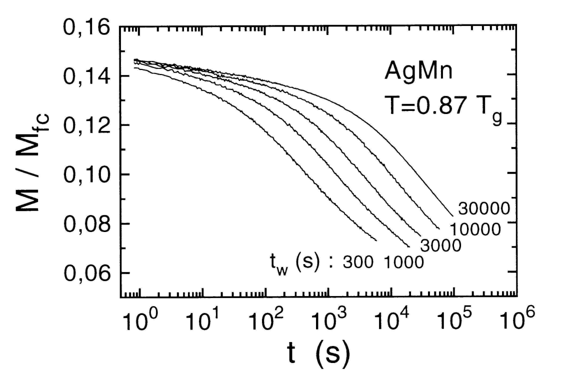


Colloids: two-time correlators (Bonn et al. '04)



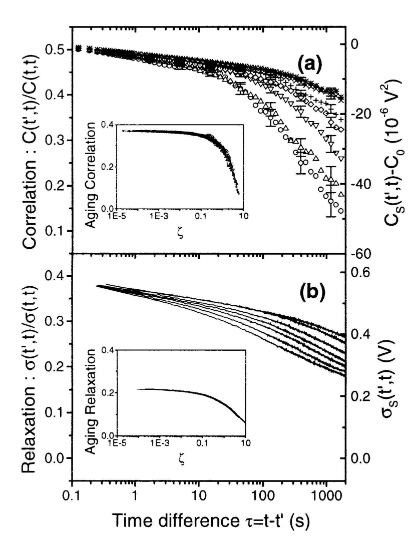
Spin glasses: thermoremanent magnetization (Vincent et al. '95)





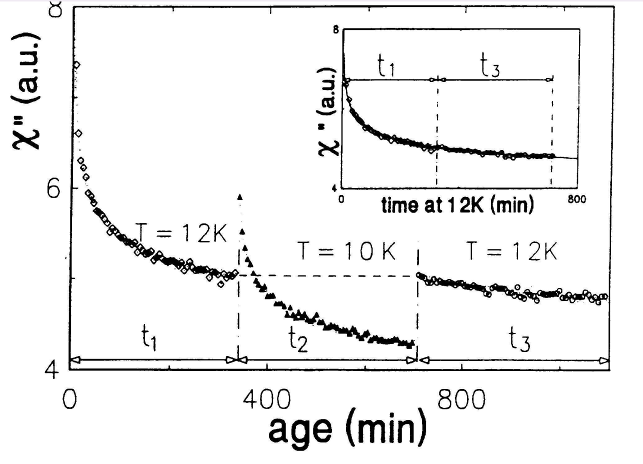
The answer of the system is slower for 'older' systems

$CdCr_{1.7}In_{0.3}S_4$
(Hérisson/Ocio '02)

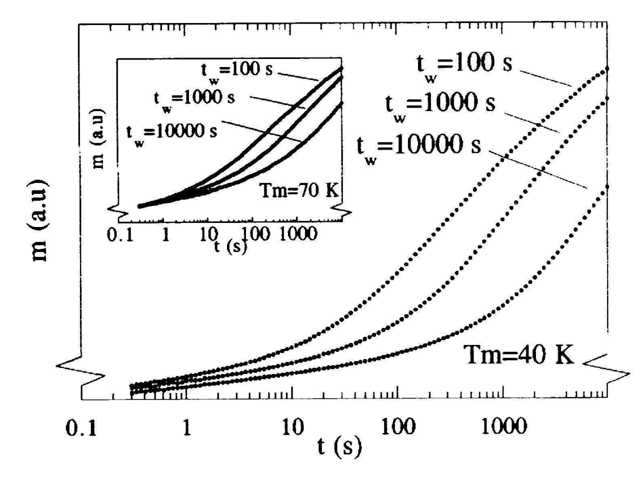


dynamical scaling!

Memory effects (Lefloch et al. '92)



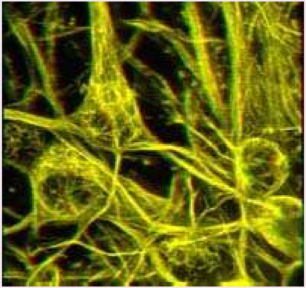
Diluted ferromagnets
$Fe_{0.20}Ni_{0.80})_{75}P_{16}B_6Al_3$ (Jonason et al. '96)



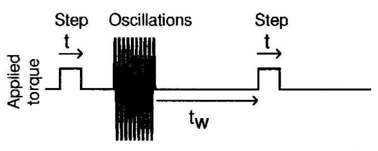
Bursac et al. '05: Aging phenomena are encountered in living cells

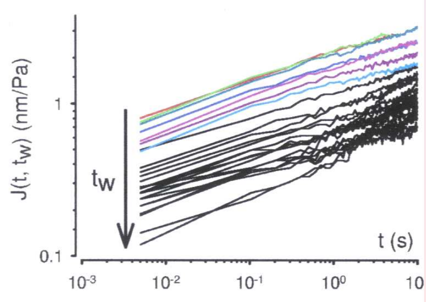
Cytoskeleton:

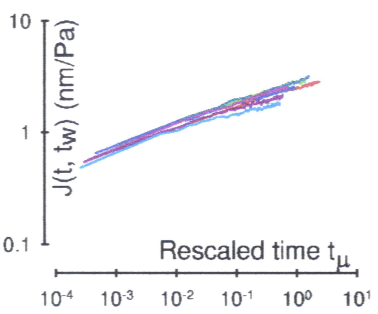
crowded nonequilibrium
network of structural proteins



cytoskeleton stabilizes cell shape and drives cell motion integrated response function

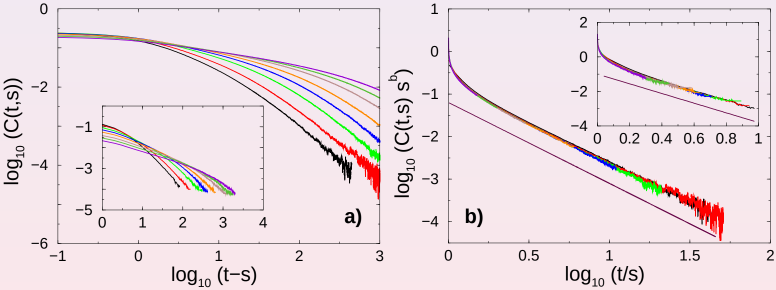






$t_\mu = t/t_W^\mu$ with $\mu = 0.4$

critical contact process: $A \xrightarrow{p} 0,\ A + 0 \xrightarrow{1-p} A + A$



Aging

Defining characteristics and symmetry properties of aging:

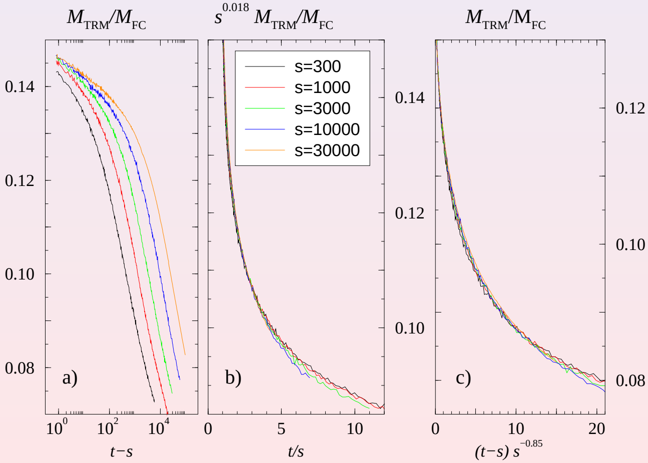
- slow dynamics (i.e. non-exponential relaxation)
- breaking of time-translation invariance
- dynamical scaling

Questions:

- why do materials 'look old' after some time?
- what (reversible) microscopic processes lead to such macroscopic behavior?

For better conceptual understanding:
study aging first in simpler systems

Aging in the spin glass $Ag_{0.933}Mn_{0.027}$ (Data courtesy M. Ocio, J. Hammann and E. Vincent)



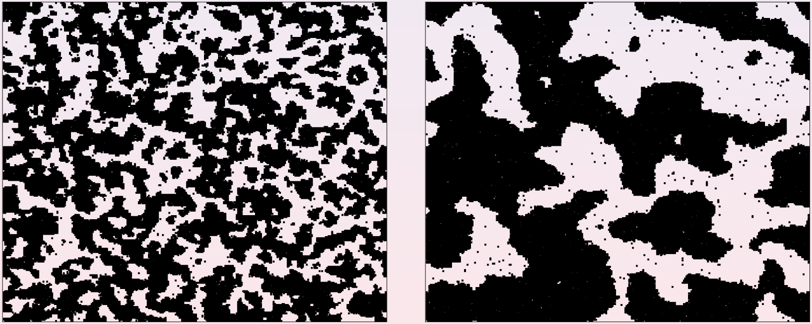
Measured values of the subaging exponent in some spin glasses

Material	μ	quantity
$Fe_{0.5}Mn_{0.5}TiO_3$	0.84	M_{TRM}
	~ 1	frequency-dependent susceptibility $\chi(t,\omega)$
$CdCr_{1.7}In_{0.3}S_4$	0.87	M_{TRM}
	0.87	autocorrelator
	~ 1	frequency-dependent susceptibility $\chi(t,\omega)$
$Au_{0.92}Fe_{0.08}$	0.91	M_{TRM}
$Ag_{0.933}Mn_{0.027}$	0.97	M_{TRM}
$Cu_{0.94}Mn_{0.06}$	0.999	M_{TRM}
$SrCr_{8.6}Ga_{3.4}O_{19}$	0.85	M_{TRM}

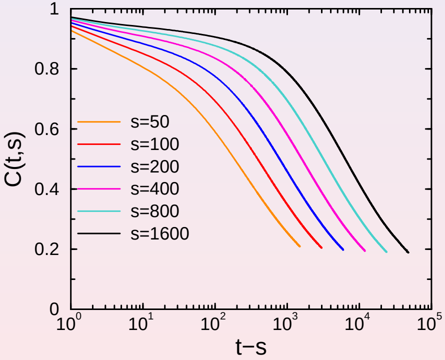
Measured values of the subaging exponent in some soft matter systems

Material	μ	quantity
cytoskeleton (human airway smooth muscle)	0.32	compliance
cytoskeleton (human muscle cell)	0.4	compliance
colloïdal glass (PMMA)	0.48(1) 0.48(1)	autocorrelator ZFC-response
polyelectrolyte microgel	~ 0.8	compliance
multilamellar vesicles	0.78(9) 0.77(4)	compliance intensity autocorrelation

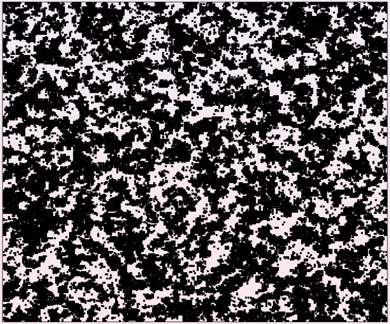
phase ordering

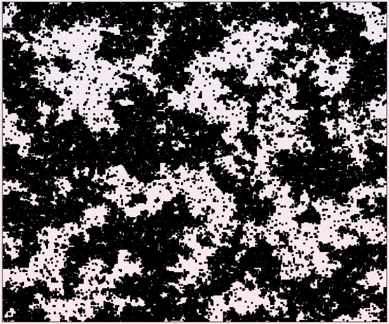


equilibrium is never reached in the infinite system aging in the $d = 2$ Ising model quenched below T_c

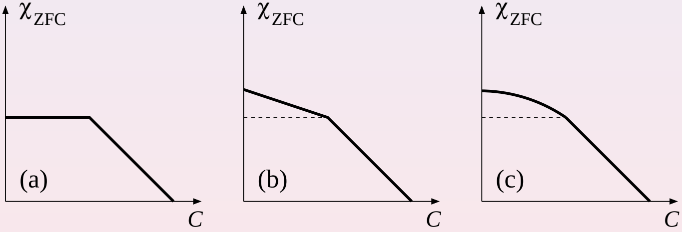


critical dynamics

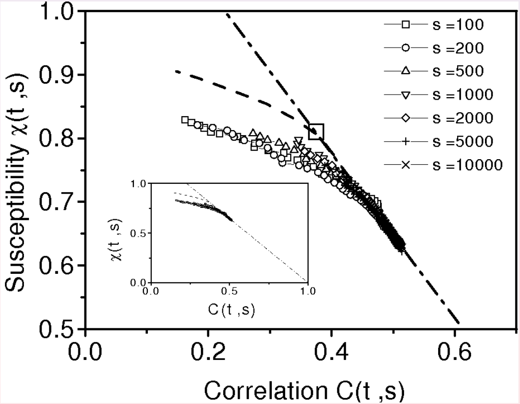




equilibrium is never reached in the infinite system fluctuation-dissipation ratio



phase ordering critical system spin glass experiment on the breaking of the fluctuation-dissipation theorem: spin glass $CdCr_{1.7}In_{0.3}S_4$



Friday, July 17, 1:45 pm

Monday, July 20, 10:45 am