Rheology of dry foams: a two-tensor model

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Dissipative Rheology of Foams

Trinity College Dublin, Ireland – Jan. 9-12

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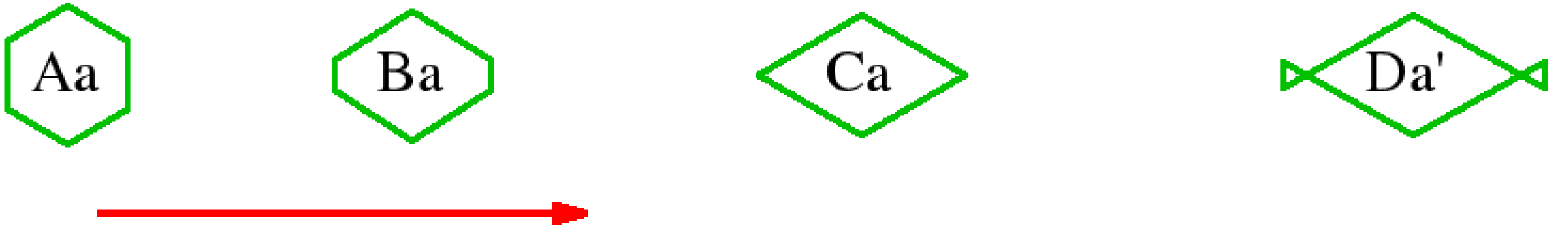
S at equilibrium

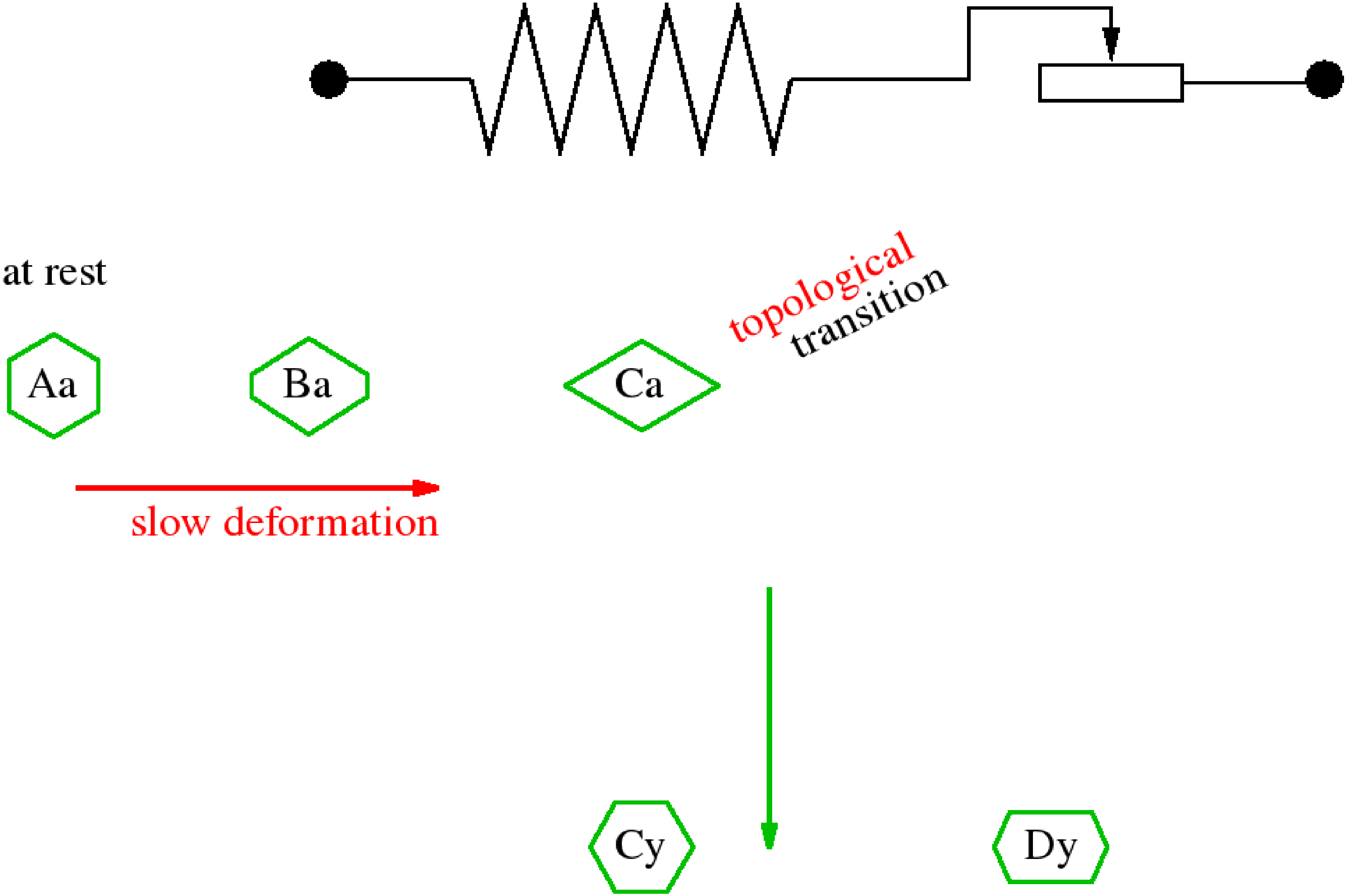


at rest

slow deformation

No internal timescale

S at equilibrium



at rest

Aa

Ba

Ca

topological transition

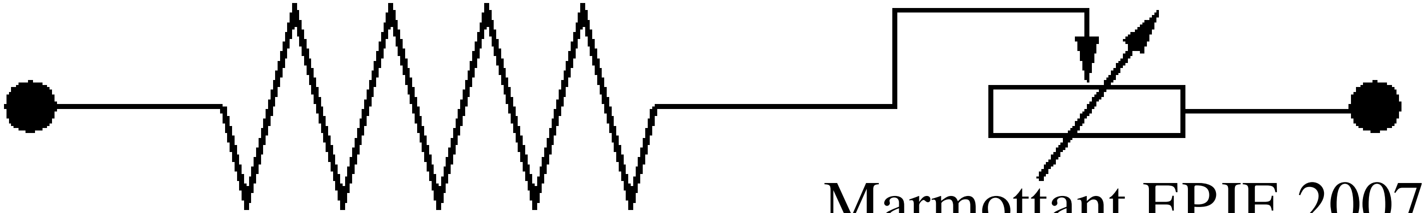
slow deformation

Cy

Dy

S at equilibrium

Progressive plasticity

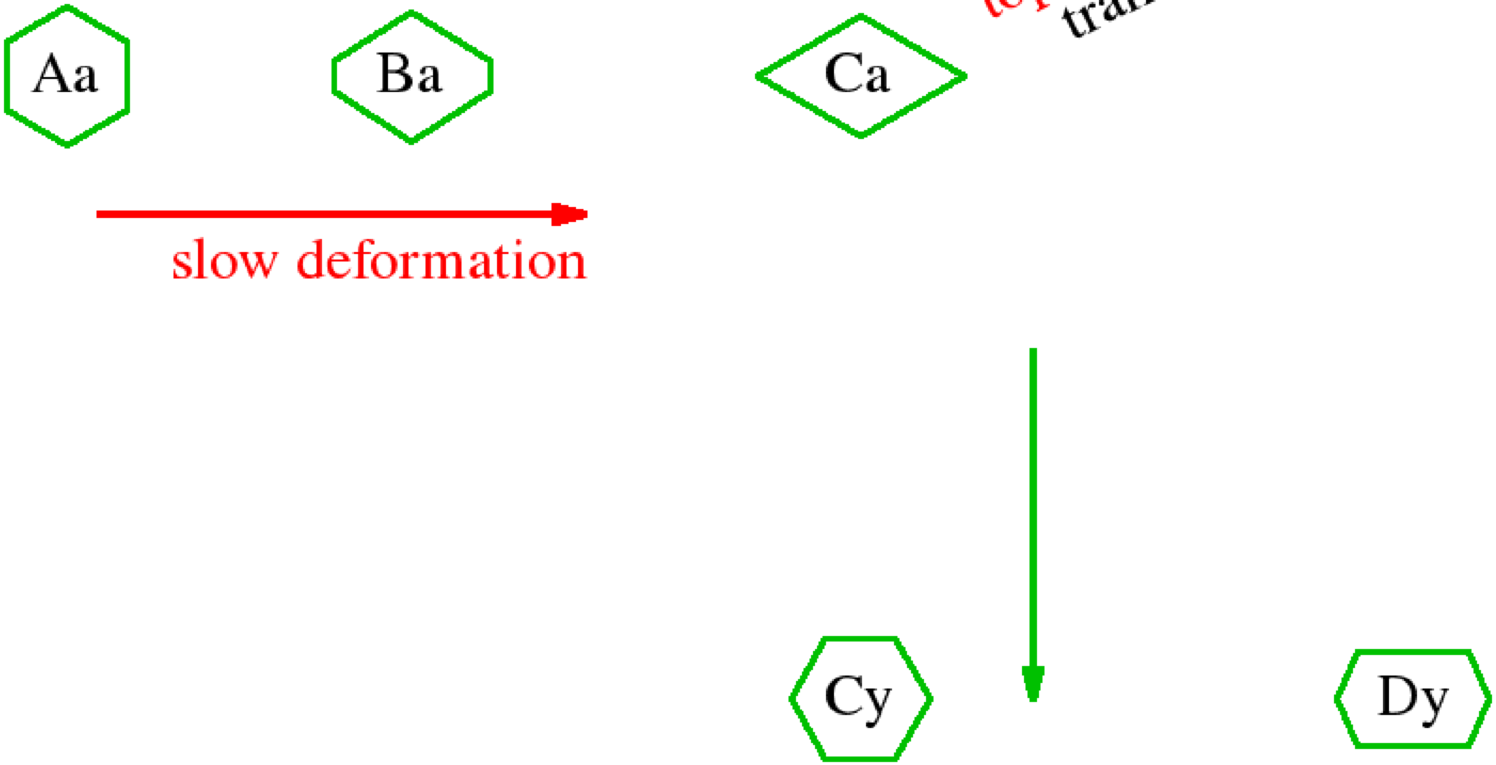


Marmottant EPJE 2007

Marmottant 2008

Raufaste PRE 2010

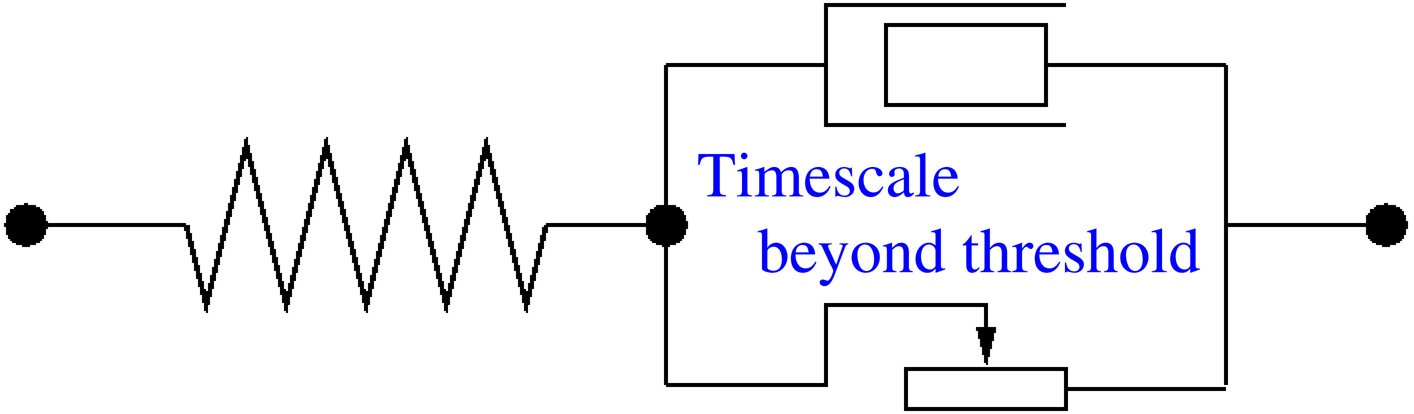
at rest



topological transition

slow deformation

S at equilibrium

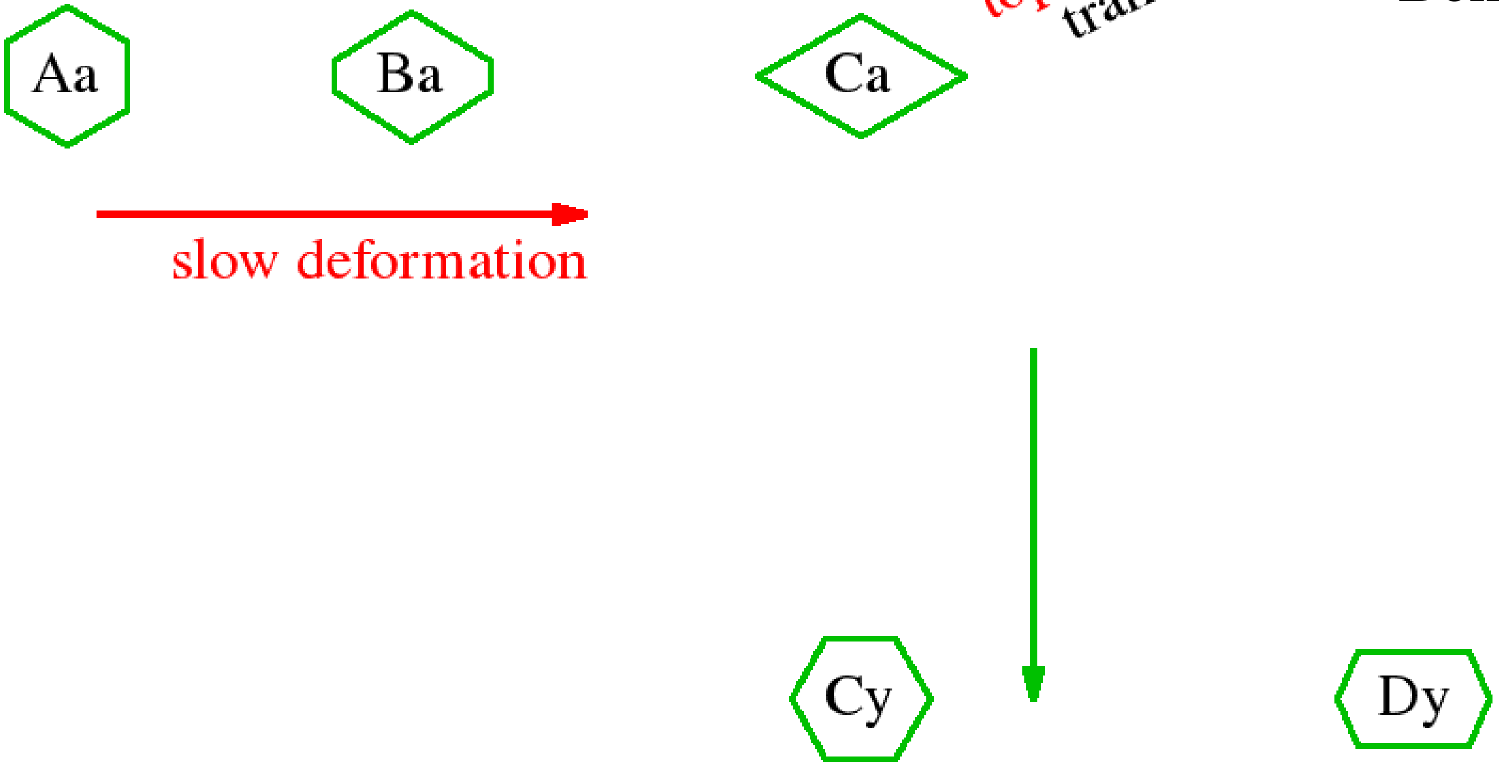


Timescale
beyond threshold

Saramito JNNFM 2007

Bénito EPJE 2008

at rest

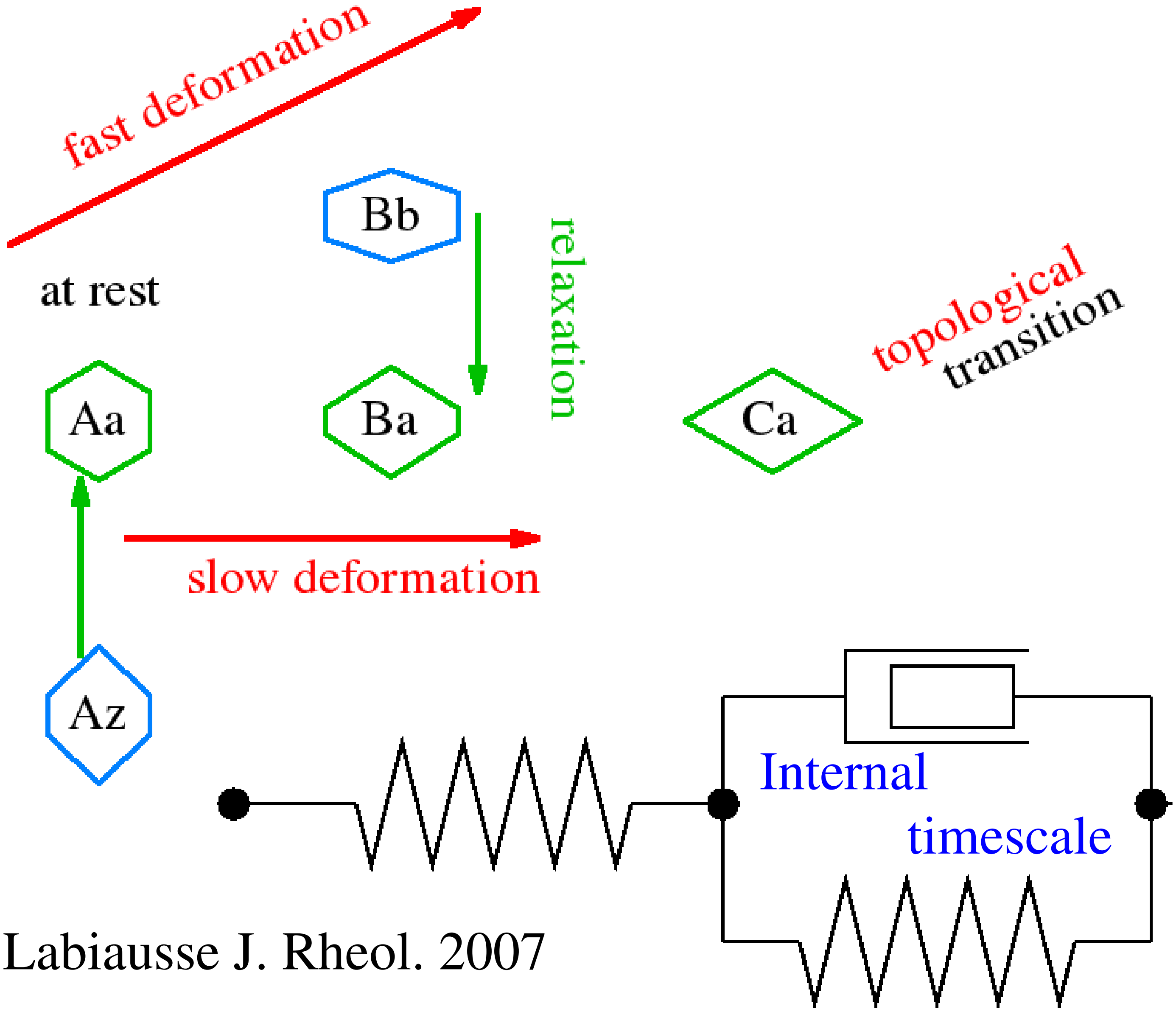


topological transition

slow deformation

S in transient configuration

S at equilibrium



fast deformation

at rest

Bb

relaxation

Aa

Ba

Ca

topological transition

slow deformation

Az

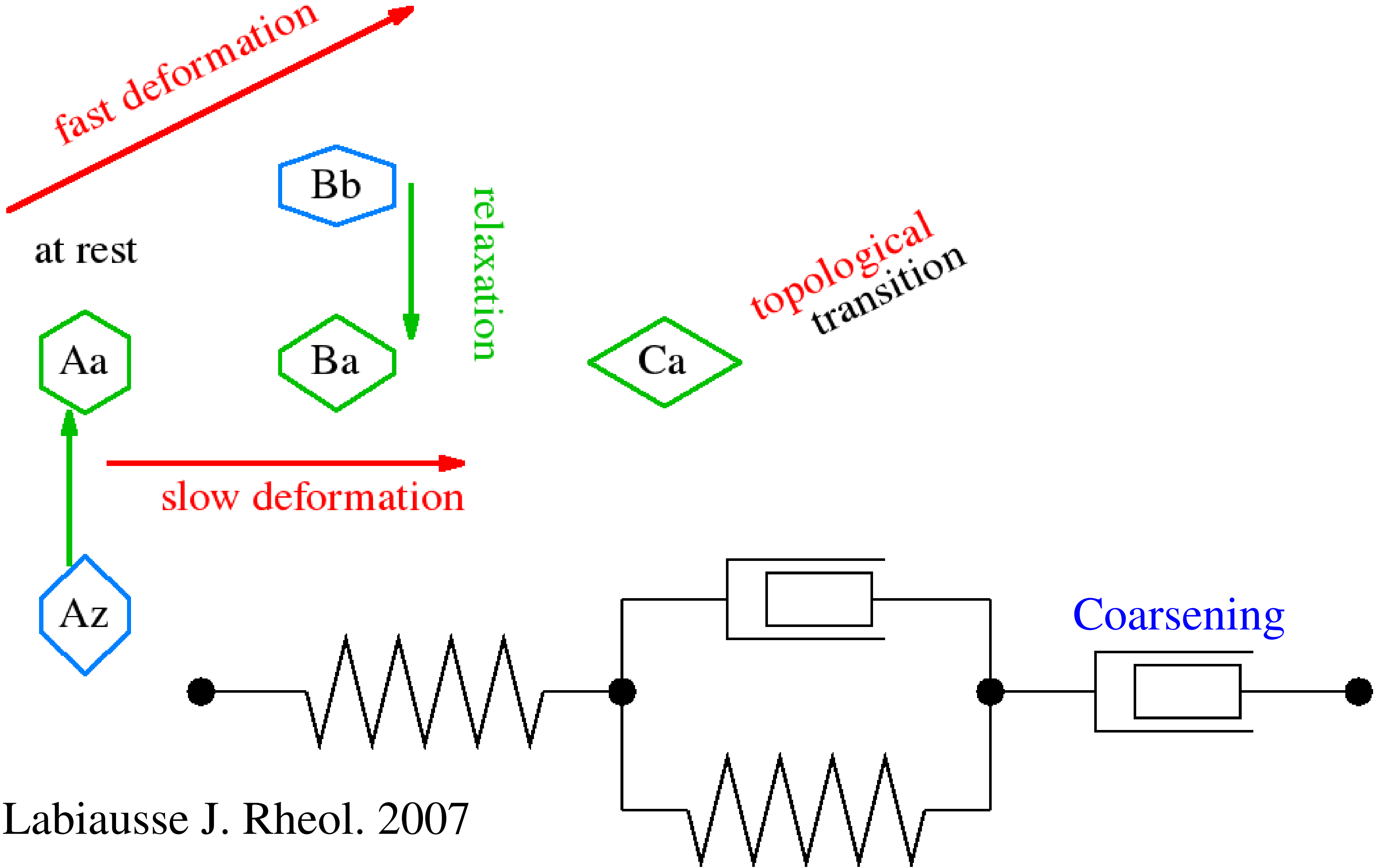
Internal timescale

Labiausse J. Rheol. 2007

Cohen-Addad PRL 2004

S in transient configuration

S at equilibrium



fast deformation

at rest

Bb

relaxation

Aa

Ba

Ca

topological transition

slow deformation

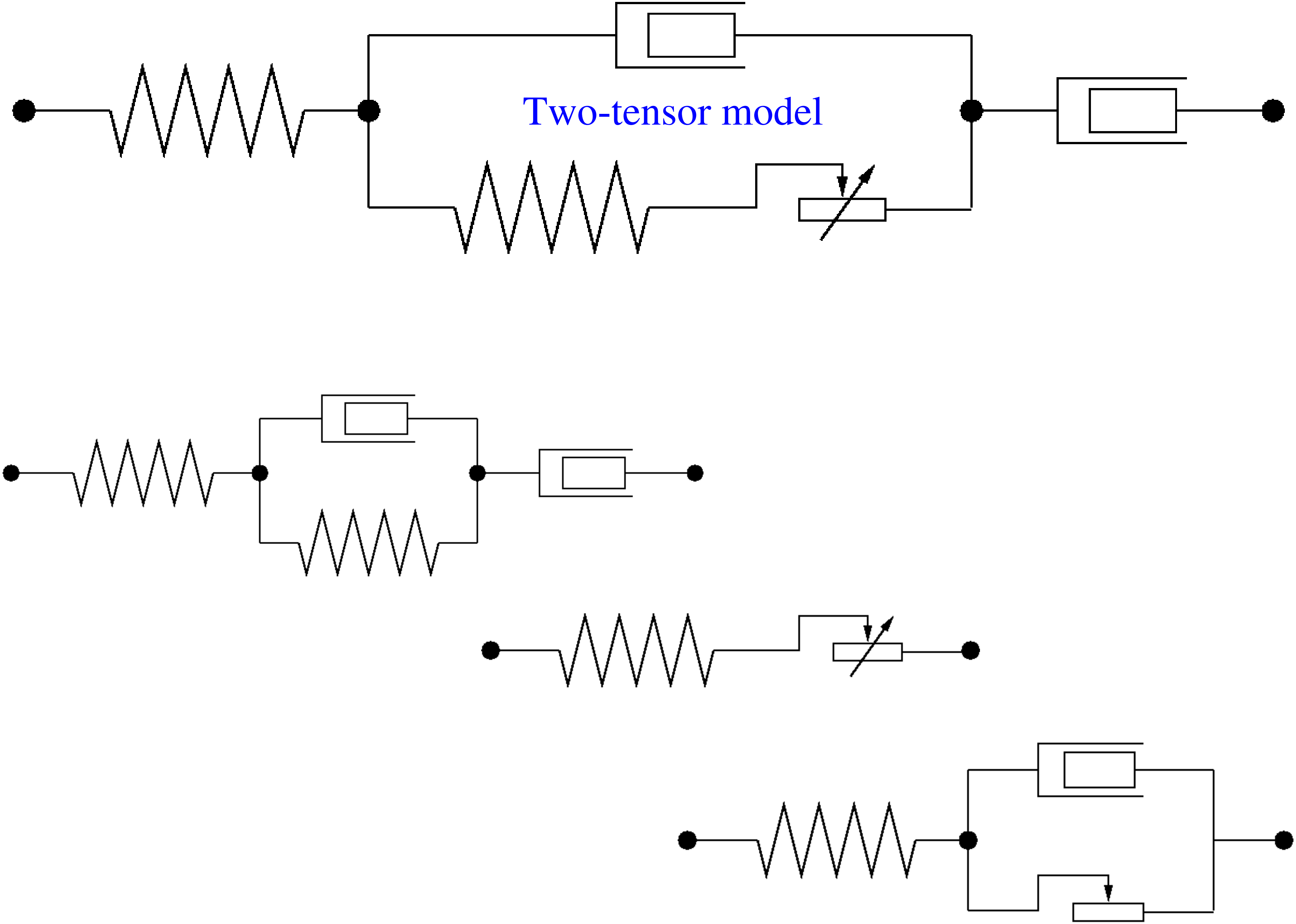
Az

Coarsening

Labiausse J. Rheol. 2007

Cohen-Addad PRL 2004

Two-tensor model



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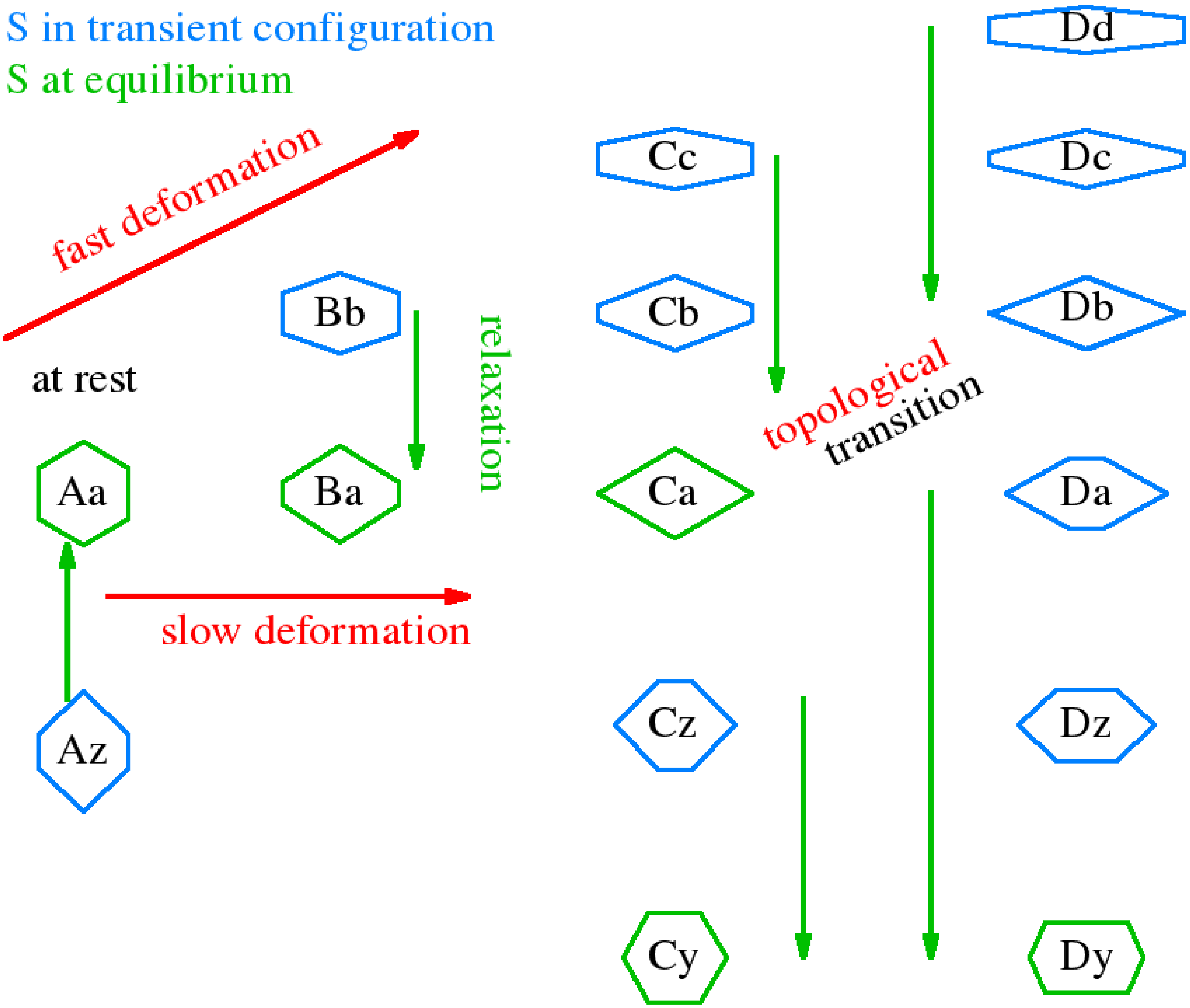
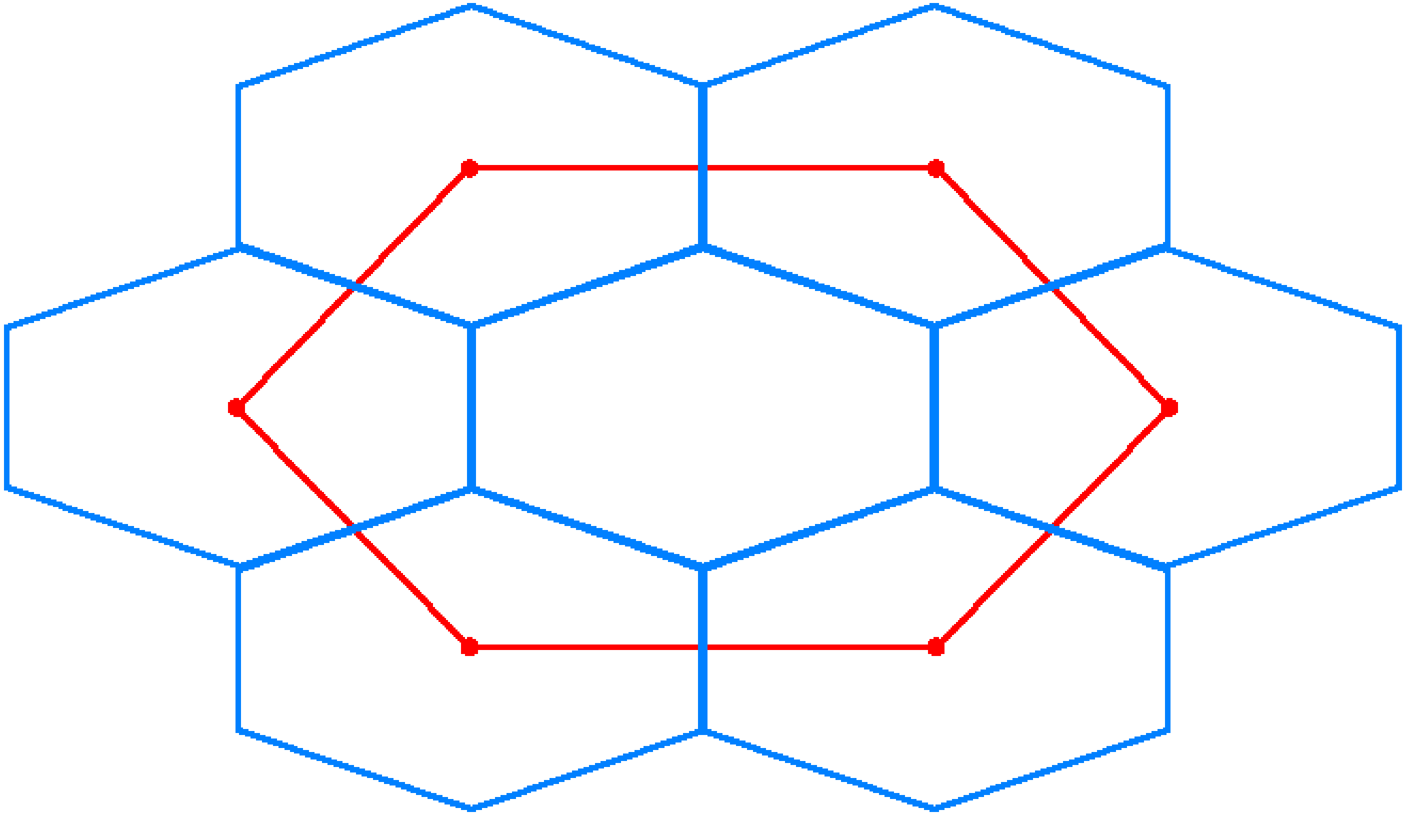
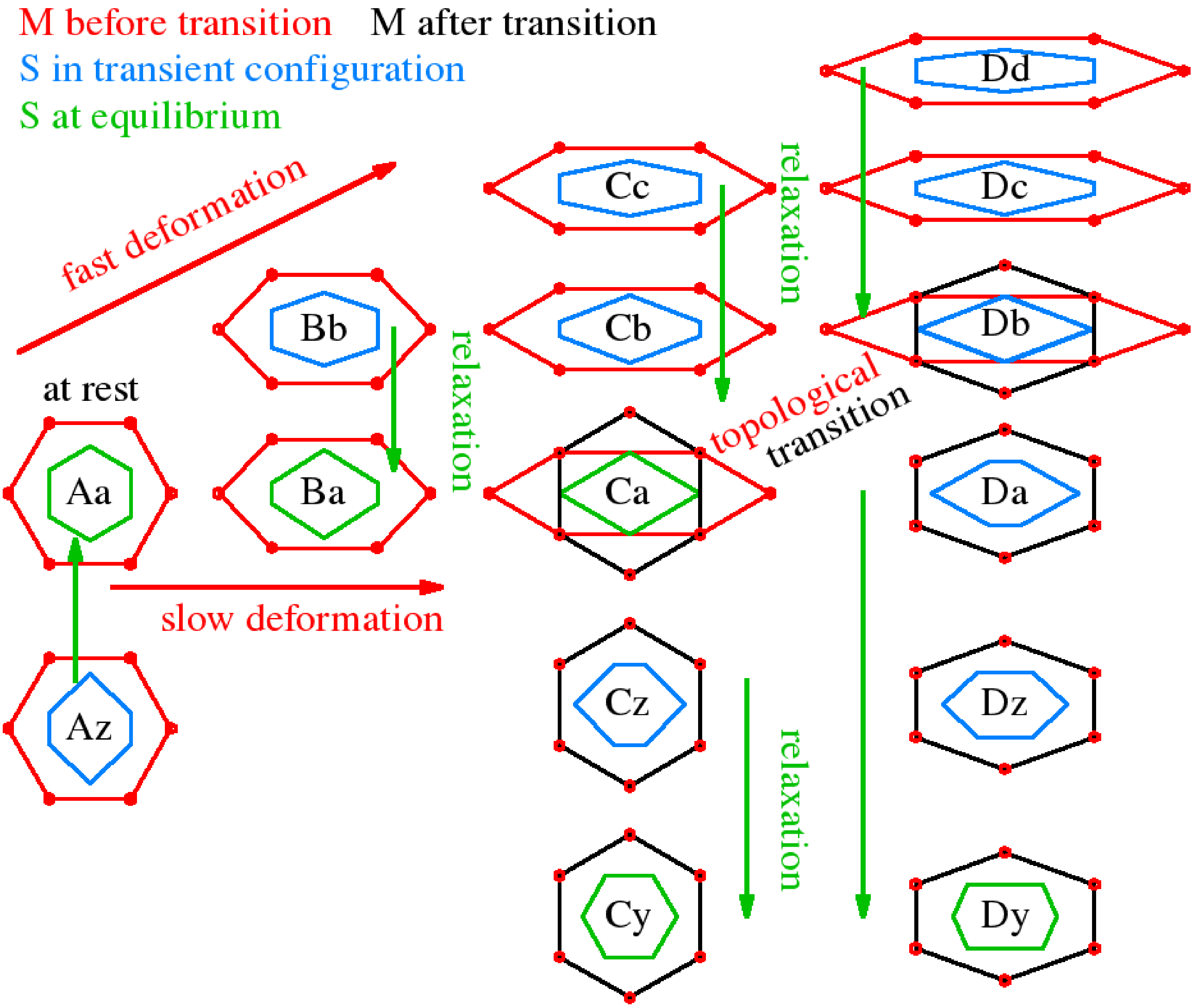
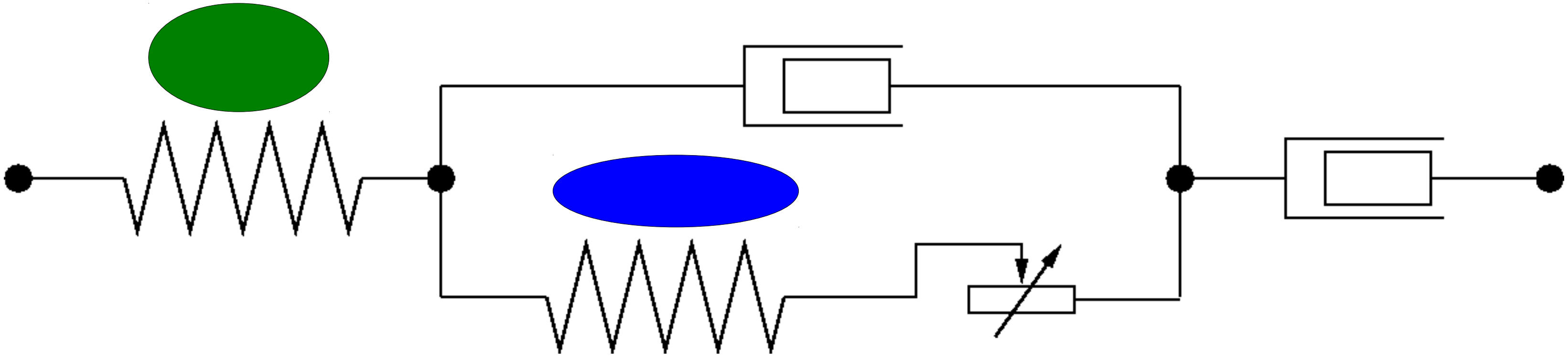

S in transient configuration
S at equilibrium
fast deformation
at rest
Bb
relaxation
Aa
Ba
Az
slow deformation
Cc
Cb
Ca
Cz
Cy
Dd
Dc
Db
Da
Dz
Dy
topological
transition




M before transition
M after transition
S in transient configuration
S at equilibrium
fast deformation
at rest
Aa
Az
Bb
Ba
relaxation
slow deformation
Cc
Cb
Ca
Cz
Cy
relaxation
topological transition
relaxation
Dd
Dc
Db
Da
Dz
Dy



$$\dot{M} = \dot{M}_{\mathrm{transport}} + \dot{M}_{\mathrm{T1}}(M,\ S,\ \nabla v)$$

$$\dot{S} = \dot{S}_{\mathrm{transport}} + \frac{S_{\mathrm{eq}}(M) - S}{\tau}$$

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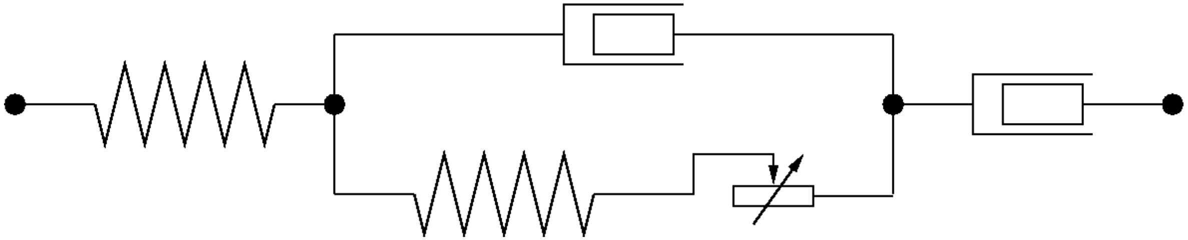
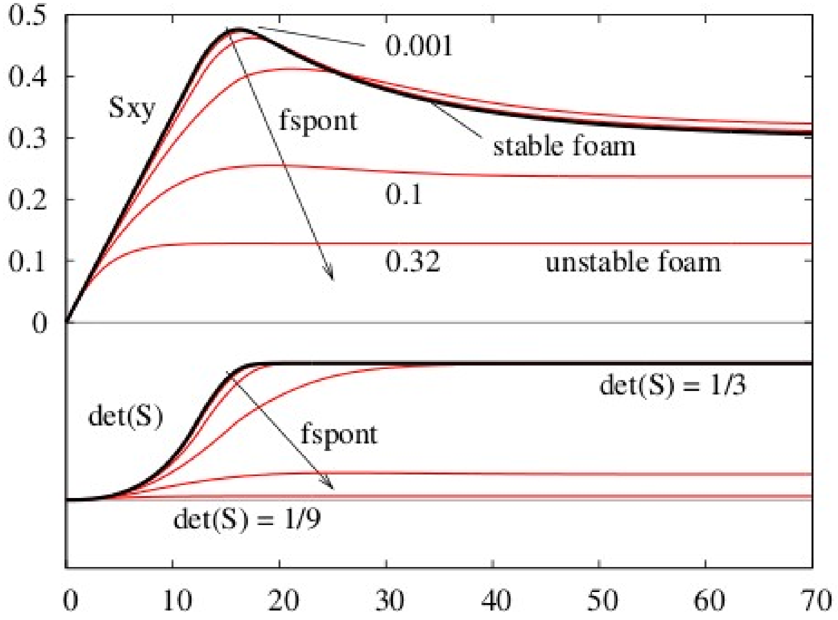
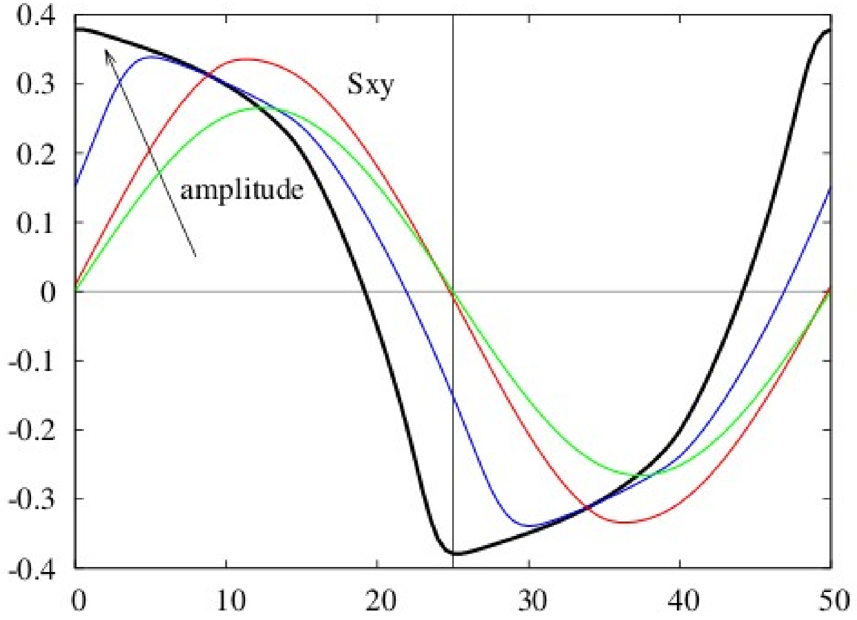
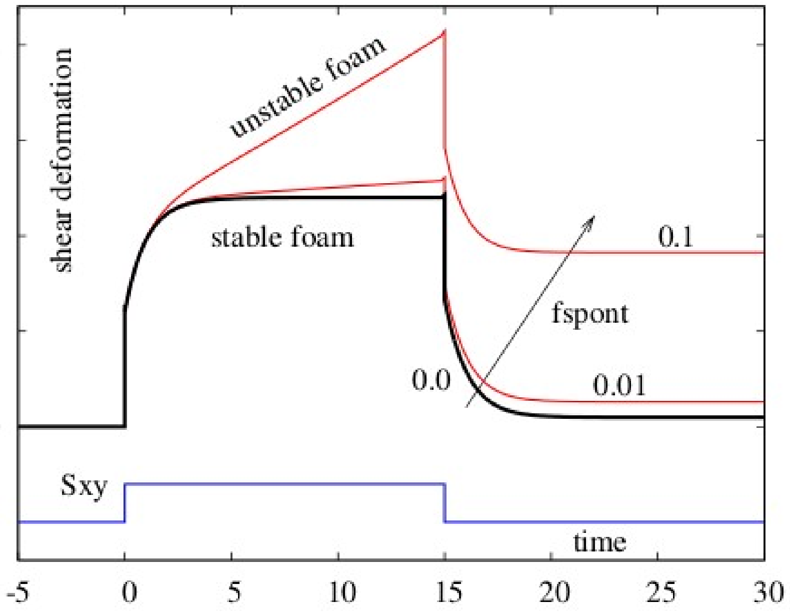




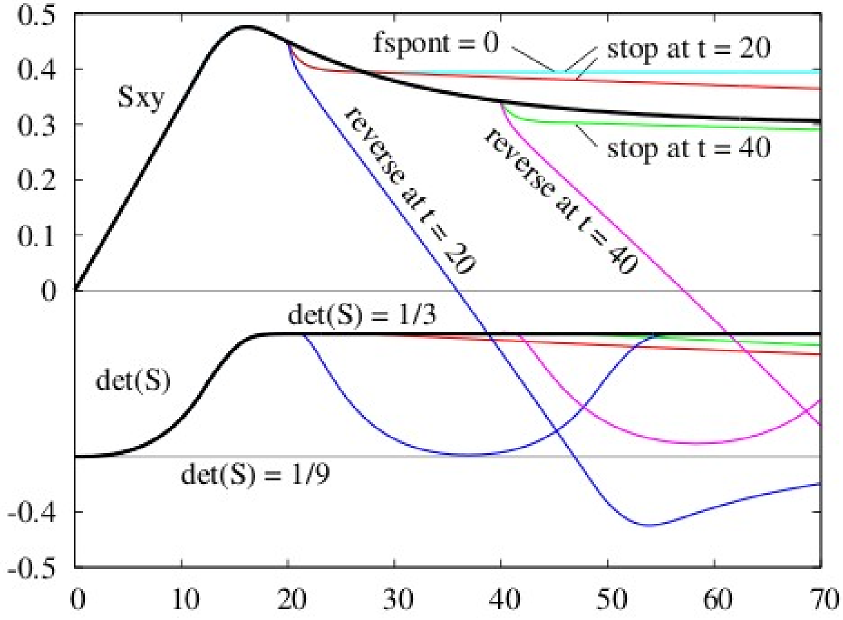
0.5
0.4
0.3
0.2
0.1
0
0.001
Sxy
fspont
stable foam
0.1
0.32
unstable foam
det(S)
fspont
det(S) = 1/3
det(S) = 1/9
0
10
20
30
40
50
60
70



0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
Sxy
amplitude
0
10
20
30
40
50



2
1.5
1
0.5
0
shear deformation
unstable foam
stable foam
0.1
fspont
0.0
0.01
Sxy
time
-5
0
5
10
15
20
25
30



0.5
0.4
0.3
0.2
0.1
0
-0.4
-0.5
fspont = 0
stop at t = 20
Sxy
reverse at t = 20
reverse at t = 40
stop at t = 40
det(S) = 1/3
det(S)
det(S) = 1/9
0
10
20
30
40
50
60
70