

# Spatial correlations and temporal heterogeneity of the slow dynamics of a colloidal fractal gel.

Agnes Duri, Luca Cipelletti

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## Experimental System

**Polystyrene colloids** ( $d = 20 \text{ nm}$ ) suspended in a buoyancy-matching  $\text{H}_2\text{O}/\text{D}_2\text{O}$  (45/55 vol/vol)  $\Leftrightarrow \phi_{\text{PS}} = 6 \cdot 10^{-4}$   
+  $\text{MgCl}_2 \Leftrightarrow C_{\text{MgCl}_2} = 10 \text{ mM} \Rightarrow$  **Fractal gel**

## Experimental Set Up

### “Multispeckle” Light Scattering experiments (Single Scattering)

- **N°1 Far field** – Several  $q$  ( $4337 \text{ cm}^{-1} < q < 52177 \text{ cm}^{-1}$ ) – **Time Resolved Dynamics** –  $V \Leftrightarrow$  All the scattering volume  $\Leftrightarrow$  All the speckled image
- **N°2 Imaging geometry** – Single  $q$  ( $q = 10^4 \text{ cm}^{-1}$ ) – **Time and Space Resolved Dynamics** –  $V \Leftrightarrow$  Portion of the scattering volume  $\Leftrightarrow$  Portion of the speckled image



### Time (N° 1) and Space (N° 2) Resolved Degree of Correlation :

$$c_i(t, \tau, \vec{r}) = \frac{\langle I_p(t) I_p(t + \tau) \rangle_{p \in V(\vec{r})}}{\langle I_p(t) \rangle_{p \in V(\vec{r})} \langle I_p(t + \tau) \rangle_{p \in V(\vec{r})}} - 1$$

$I_p(t)$ : intensity p-th pixel at time t

### Spatially Resolved Intensity Correlation Function (N°1):

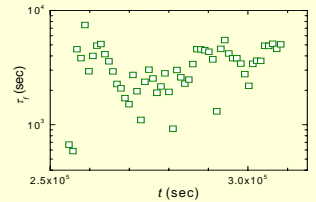
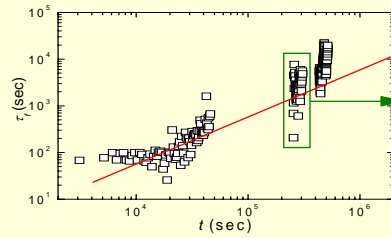
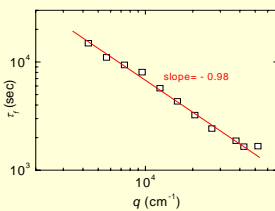
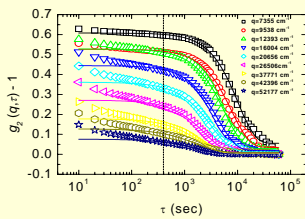
$$g_2(\tau, \vec{r}) - 1 = \langle c_i(t, \tau, \vec{r}) \rangle_t$$

### Spatial Correlation of the Dynamics (N° 2):

$$X_{ci}(\tau, \vec{r}) = \left\langle \frac{\langle [c_i(t, \tau, \vec{r}) - \langle c_i(t, \tau, \vec{r}) \rangle_t] [c_i(t, \tau, \vec{r} + \Delta \vec{r}) - \langle c_i(t, \tau, \vec{r} + \Delta \vec{r}) \rangle_t] \rangle_t}{\sqrt{\sigma_{ci}^2(t, \tau, \vec{r}) \sigma_{ci}^2(t, \tau, \vec{r} + \Delta \vec{r})}} \right\rangle_{\vec{r}}$$

## Experimental Results

### Average Dynamics :



Fit by a “compressed” exponential

$$g_2(q, \tau) - 1 \propto \exp[-(t/\tau_f)^{3/2}]$$

$\tau_f \propto q^{-1} \Rightarrow$  Drift motion

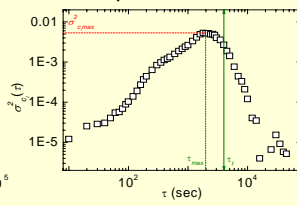
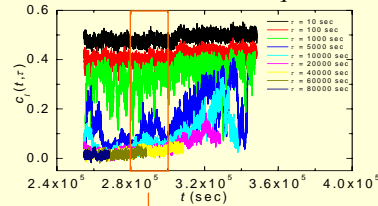
$\tau_f \rightarrow t \Rightarrow$  Aging behaviour

Large fluctuations of  $\tau_f$

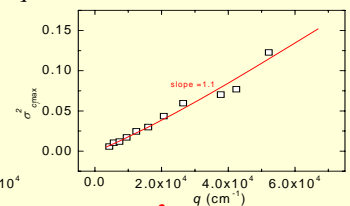
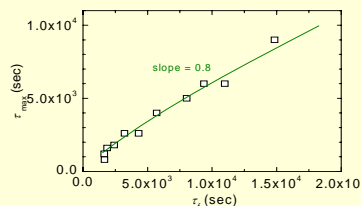
$\Downarrow$   
Heterogeneous dynamics

### Time Resolved Dynamics – Fluctuations Study:

$q = 20656 \text{ cm}^{-1} \Leftrightarrow 3 \mu\text{m}$



$4337 \text{ cm}^{-1} < q < 52177 \text{ cm}^{-1}$



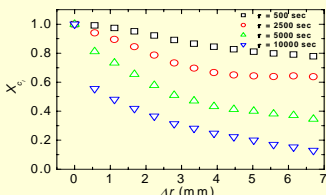
$\rightarrow$  Statistics treatment

$\tau_{\text{max}} \propto \tau_f$

$\sigma_{c, \text{max}}^2 \propto q$

$\Downarrow$   
Fluctuations max at large length scale

### Time and Space Resolved Dynamics – Local dynamics Study:



$\tau_f = 1000 \text{ sec}$

$\tau < \tau_f$  :  
Very long-ranged correlation  
 $\Rightarrow$  « solid-like » behavior

$\tau > \tau_f$  :  
Spatial correlation decay  
 $\Rightarrow$  « fluid-like » behavior

## References :

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