Light Propagation in Foams

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Multiple Scattering
Foams

Durian et. al., PRA 1991, 44, R7902

Physics of Foams, Weaire and Hutzler

wet foam
Gillette shaving cream
dry foam
Metallic Foams
• Drainage
  – gravity
  – pressure gradient

• Coarsening
  – diffusion of gas

Benjamin Dollet,¹,* Miguel Aubouy,² and François Graner¹

PRL 95, 168303 (2005)
• DWS (Diffusing Wave Spectroscopy)

![Diagram of DWS setup](image)

• In soft materials, the speckles fluctuate due to the microscopic motion in the media.
• Local dynamic properties can be studied by intensity autocorrelation function.

For Brownian particles

\[ g_{1,8}(\tau) \approx \exp[-2(6\tau/\tau_0)^{1/2}] \]

\[ \Gamma = \left( \frac{L}{l^*} \right)^2 \frac{1}{\tau_0} \]

\[ g_{1,7}(\tau) \approx \frac{\sqrt{6\Gamma \tau}}{\sinh(\sqrt{6\Gamma \tau})} \]
DWS results for foam


A) Transmitted light exponential in $t$
B) Backscattered light exponential in $\sqrt{t}$

• These shapes are identical to those obtained for diffusing Brownian particles, despite the absence of any such motion.
- coarsening
- capillary waves?
- Brownian motion of the bubbles?

\[ d \propto t^z \quad z = 0.45 \]

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rearrangement


\[ l^* \propto d \quad r \propto d \]

\[ t_0 \propto \frac{1}{Rr^3} \]

\[ R \propto \frac{1}{t_0 l^*^3} \]

\[ R \propto t^{-\gamma} \]

\[ \gamma = 2 \pm 0.1 \]
\( n = 1.34 \) (water)

\[
\begin{align*}
d/\lambda = 0.06 & \quad \text{(dashed line)} \\
d/\lambda = 0.37 & \quad \text{(dotted line)} \\
d/\lambda = 0.50 & \quad \text{(dashed-dotted line)} \\
d/\lambda = 0.60 & \quad \text{(dashed line)} \\
d/\lambda = 1.00 & \quad \text{(bold line)}
\end{align*}
\]
NEW!

4. MirFaez Miri, Ebrahim Madadi, and Holger Stark,
Fresnel's formula:

\[ r(i) = r_p r_p^* + \frac{(E \cdot b)(E^* \cdot b)}{E \cdot E^*} (r_s r_s^* - r_p r_p^*) \]
\[ \ell^* = \frac{\ell_s^*}{1 - \langle \cos \theta \rangle} \]

\[ \langle \cos \theta \rangle = \overline{r(i) \cos(\pi - 2i)} + \overline{t(i) \cos 0} \]

\[ f(i) = \sin 2i \]

\[ \ell_s^* = 0.7H \]

TOPOLOGY


OPTICS


