In Awe of Atoms:
The Lego Blocks of Stuff
Letzter Satz
der Neunten Symphonie mit dem Schlussschor
über Schiller's Ode „An die Freude“

Ludwig van Beethoven (1770-1827)
Opus 125

Klavierauszug von Richard Hofmann
Langevin dynamics (Models A through J):

\[
\frac{\partial \Psi_\mu(\vec{x}, t)}{\partial t} = \left\{ F, \Psi_\mu(\vec{x}, t) \right\}_{PB} - M_{\mu\nu} \frac{\partial F}{\partial \Psi_v} + \eta_\mu(\vec{x}, t)
\]

\[
= - \int \left\{ \Psi_\mu(\vec{x}, t), \Psi_v(\vec{x}', t') \right\}_{PB} \frac{\partial F}{\partial \Psi_v} d\vec{x}' - M_{\mu\nu} \frac{\partial F}{\partial \Psi_v} + \eta_\mu(\vec{x}, t)
\]

\[
= V_\mu(\vec{x}, t) - M_{\mu\nu} \frac{\partial F}{\partial \Psi_v} + \eta_\mu(\vec{x}, t)
\]

where

\[
\langle \eta_\mu(\vec{x}, t) \rangle = 0
\]

and (generalized Einstein-Stokes/fluctuation-dissipation)

\[
\langle \eta_\mu(\vec{x}, t) \eta_v(\vec{x}', t') \rangle = -2M_{\mu\nu}k_bT\delta(\vec{x} - \vec{x}')\delta(t - t')
\]

Au  
6.1 cm × 12.7 cm

Ag  
4.9 cm × 6.5 cm
Snowflakes

http://www.its.caltech.edu/~atomic/snowcrystals/class/class.htm
Figure 1 Sketch of a crystal, selected at random from an early mineralogy treatise. (Haüy.)

Figure 2 Relation of the external form of crystals to the form of the elementary building blocks. The building blocks are identical in (a) and (b), but different crystal faces are developed. (Haüy, from the atlas to the 1822 edition of his *Traité de cristallographie*.)
Figure 21a  A (110) plane of an fcc crystal structure, as built up from (100) layers. (This and the accompanying photographs are by J. F. Nicholas, *Atlas of models of crystal surfaces*, Gordon and Breach, 1965).

Figure 21b  A (111) plane of an fcc crystal structure, based on (100) layers.

Figure 21c  A (322) plane of an fcc crystal structure, based on (100) layers. The concentration of atoms tends to be lower in planes of high indices than in planes of low indices.
These shockwave and java animations show how:

Gases fill and conform to the shape of the container

Liquids do not fill, but conform to the shape of the container

Solids retain their shape, neither filling nor conforming to the container shape
Robert Brown (in 1827)
Albert Einstein (in 1905)
Constructive and destructive interference

(a) Amplitude

Wave amplitudes add

(b) Wave amplitudes cancel to give zero amplitude