NMR Diffusion Diffraction and Diffusion Interference from Cells

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Related posters

D2 Levitz, P. Intermittent Brownian dynamics over strands

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QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

East or West we are
all illuminated by science
don’t you agree!?

It says here that your
knowledge is *diffusing*
to the West!

Contents

- Red cells…motivation
- *q*-Space analysis
- Flow diffraction
- Octagon-star model

QuickTime™ and a
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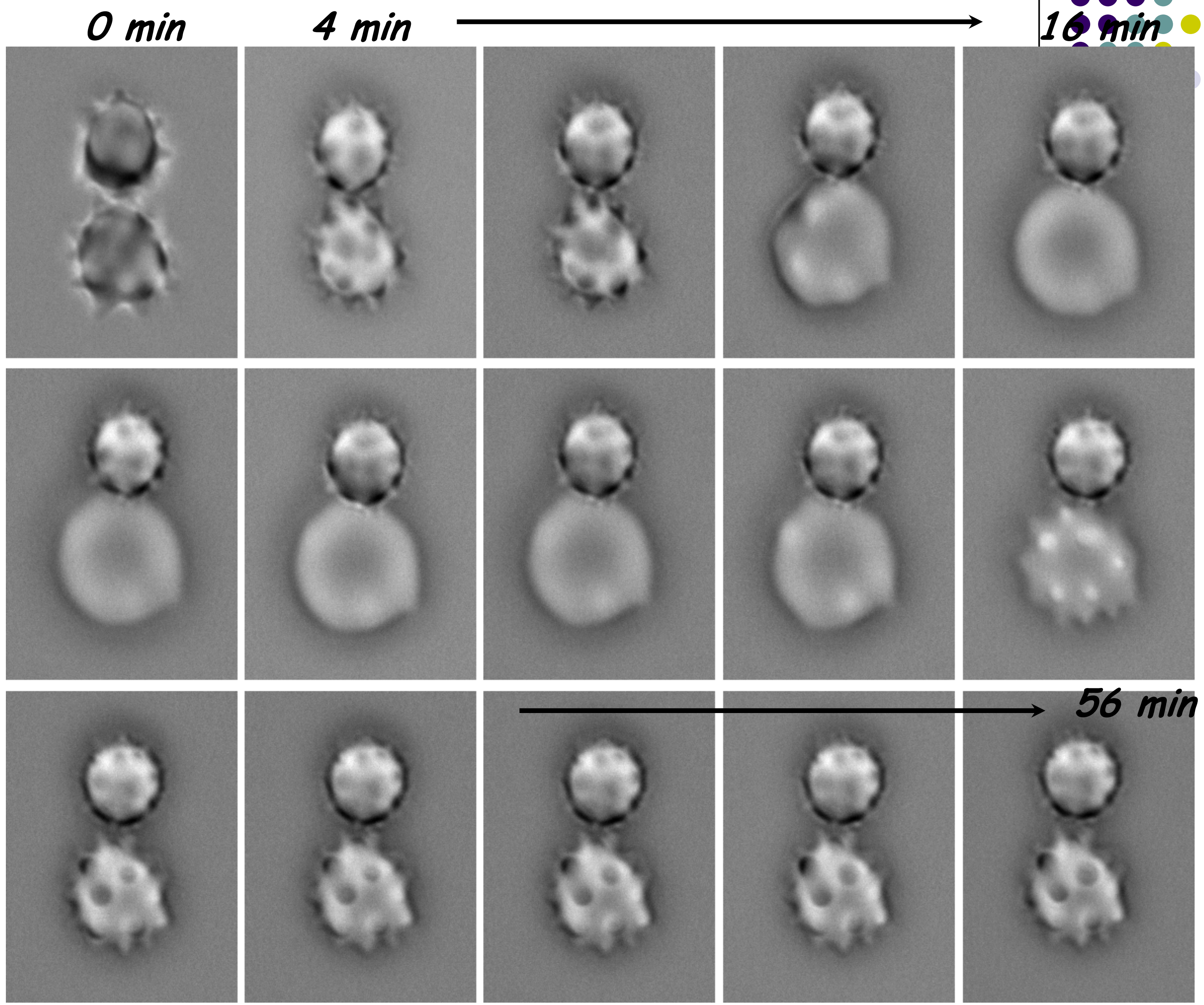
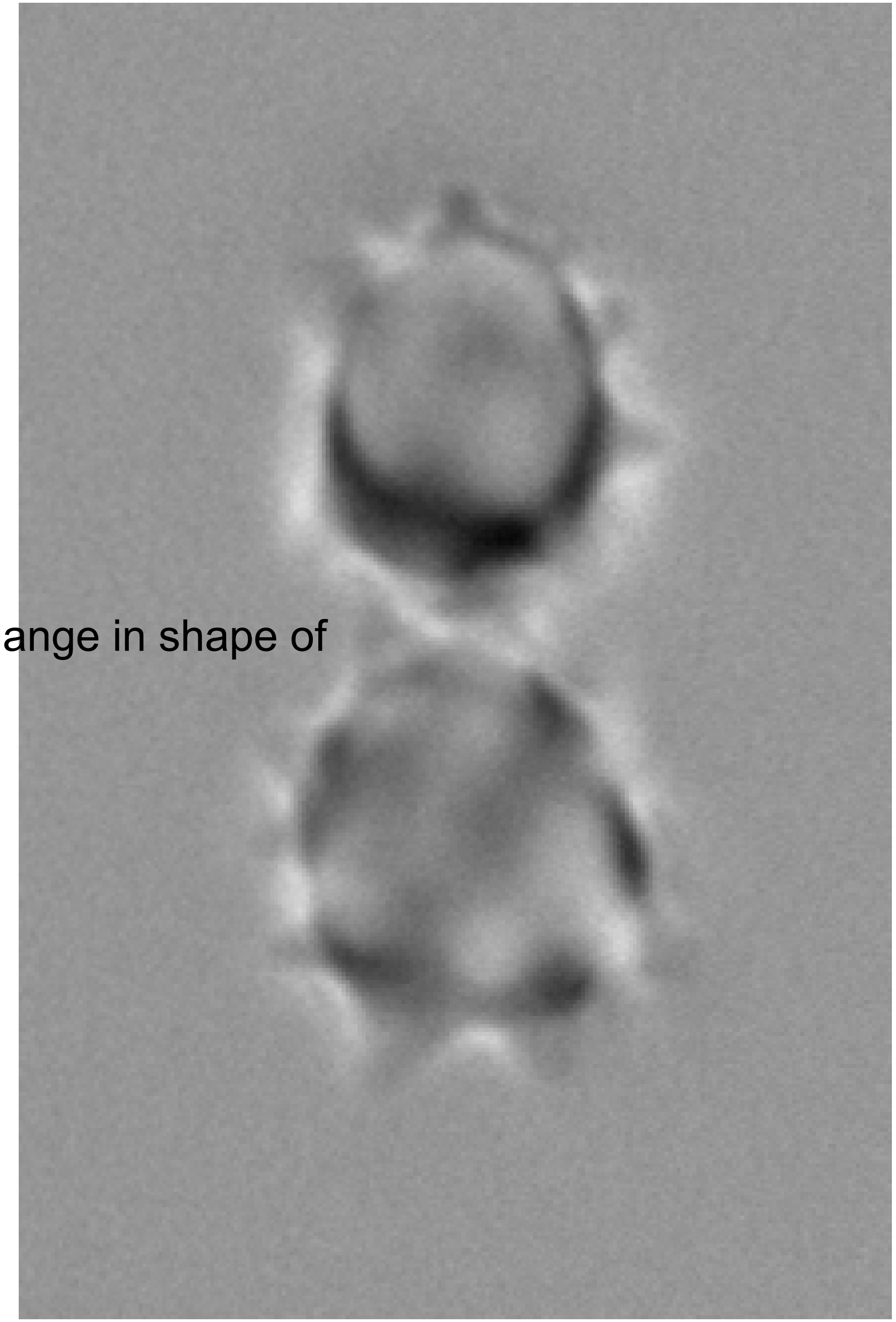
Echinocytes under DIC Microscopy

…showing echinocyte to discocyte reversion and back again



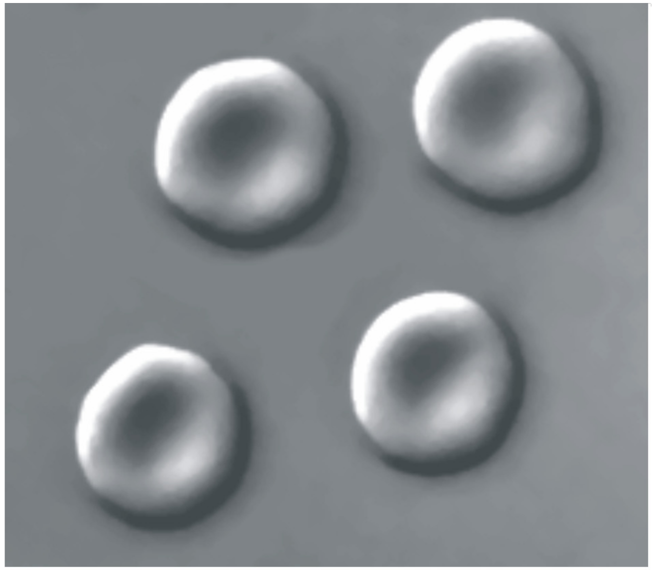
Echinocytes under DIC microscopy



Movie showing change in shape of red blood cell

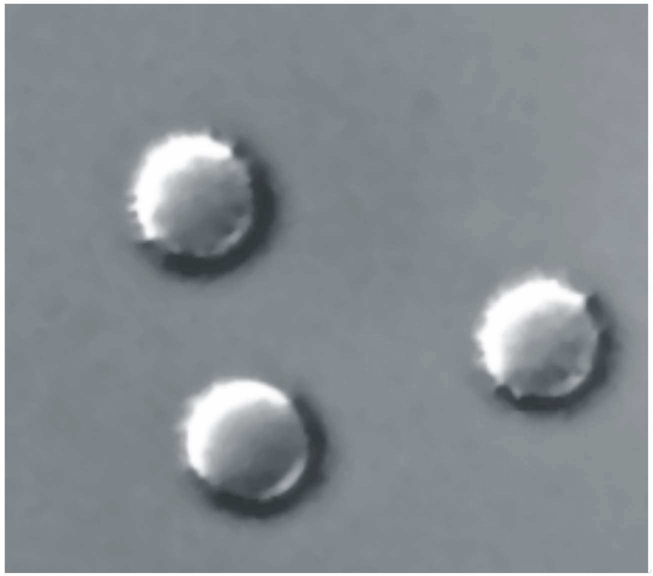
(a)

Discocytes

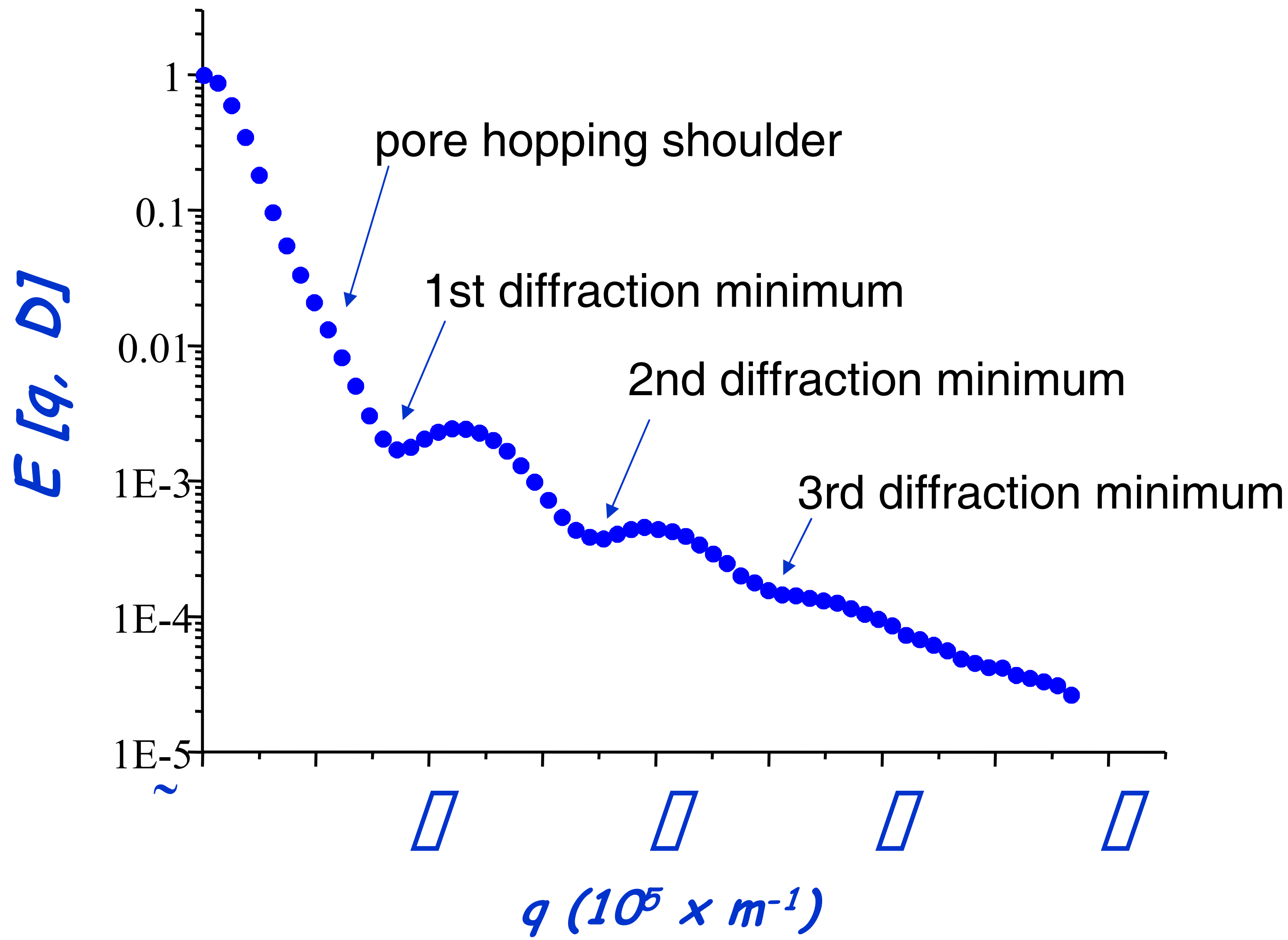


(b)

Spherocytes



Tracking red cell shape transformation in packed samples over time courses of minutes



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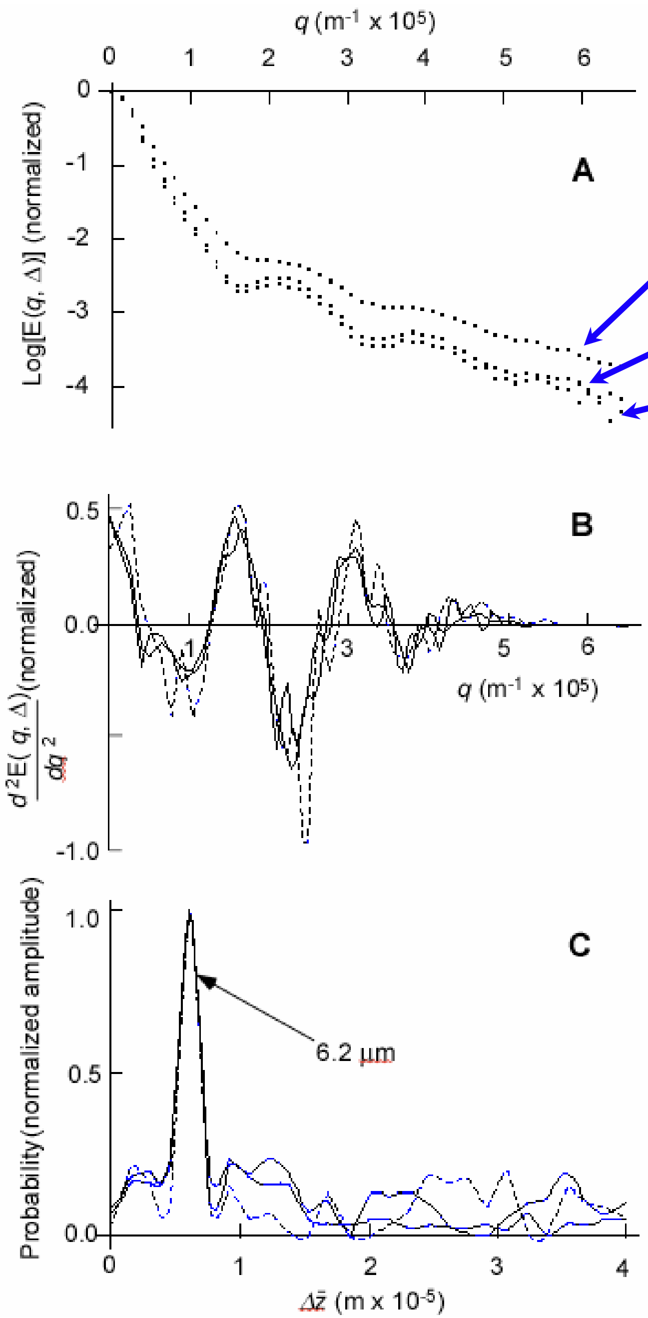


Ht = 58%

48%

41%

Second derivative

Fourier transform

Unbalanced bipolar pulses in STE…rapid signal acquisition

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Pelta et al. (2002) MRChem 40 S147

Movie showing change in shape of the q-space plot

QuickTime™ and a
decompressor
are needed to see this picture.

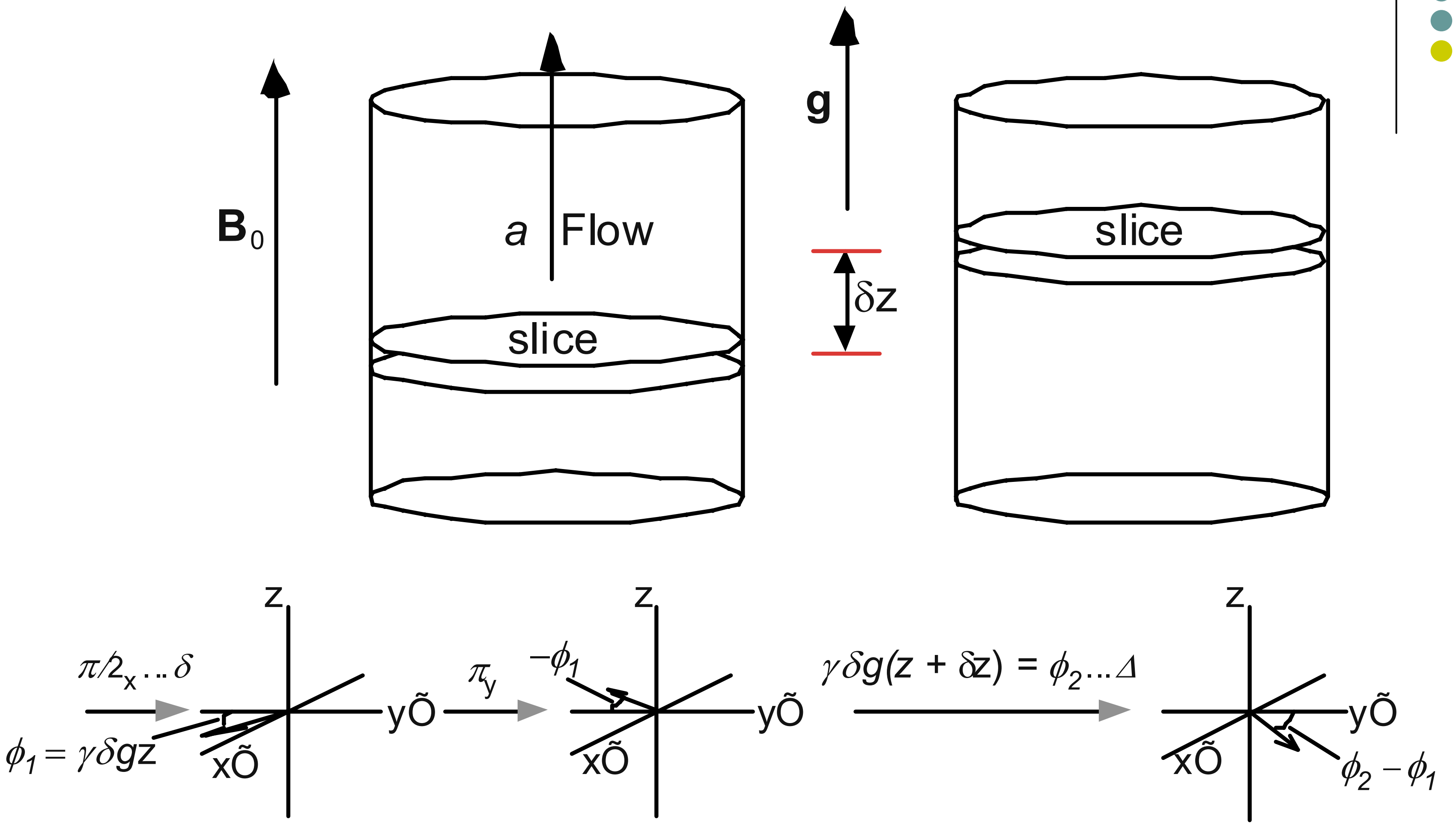
q

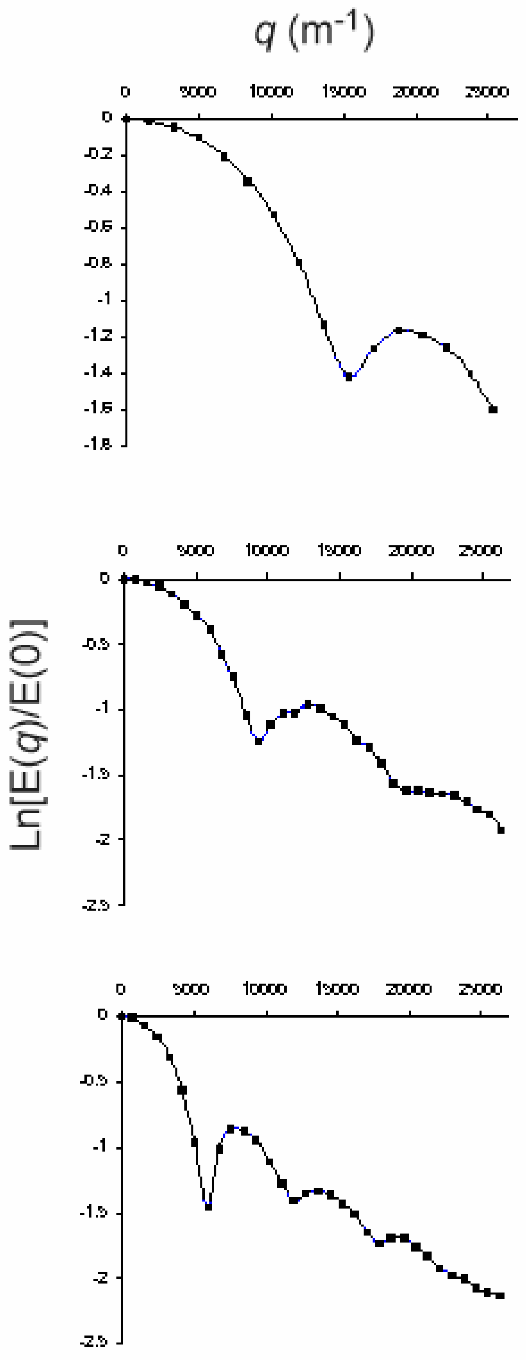
Movie showing change in shape of the mean cell diameter

QuickTime™ and a
decompressor
are needed to see this picture.

z (μm)

Flow diffraction


B0
a Flow
slice
g
δz
slice
z
π/2x … δ
φ1 = γδgz
xÕ
yÕ
πy
−φ1
z
xÕ
yÕ
γδg(z + δz) = φ2…Δ
z
xÕ
yÕ
φ2 − φ1



Flow rate = 0.834 mm s^{-1}

1.32 mm s^{-1}

2.15 mm s^{-1}

Since the uniform linear flow-velocity is a m s^{-1} then $a = \delta z/\Delta$; and by definition $\mathbf{q} = (1/2\pi)\,\gamma\,\delta\,\mathbf{g}$ so the change in phase angle brought about by flow is:

$$\Delta\phi = 2\,\pi\,q\,\delta z$$
$$= 2\,\pi\,q\,a\,\Delta$$

Hence, the normalized signal $S[q, \Delta]$ is proportional to,

$$S[q, \Delta] \propto \sin^2[2\,\pi\,q\,a\,\Delta]/(2\,\pi\,q\,a\,\Delta)^2$$

$$q_{\mathrm{min,n}} = n/(2\,a\,\Delta)$$

$$a = n/(2\,q_{\mathrm{min,n}}\,\Delta)$$

$$E[\mathbf{g}, \Delta] = \int \rho[\mathbf{r}][\mathbf{r}\,\Delta]\, exp[\mathrm{i}\ \delta\, \mathbf{g} \cdot (\mathbf{r} - \mathbf{r})]\ d\mathbf{r}\, d\mathbf{r}$$

$$E[\mathbf{q}, \Delta] = \iint \rho[\mathbf{r}_0]\ P[\mathbf{r}_0 \mid \mathbf{r}_0 + \mathbf{R}, \Delta]\ exp[\mathrm{i}\ 2\ \pi\ \mathbf{q} \cdot \mathbf{R}]\ d\mathbf{r}_0 d\mathbf{R}$$

$$\overline{P}[\mathbf{R}, \Delta] = \int \rho[\mathbf{r}_0]\ P[\mathbf{r}_0 \mid \mathbf{r}_0 + \mathbf{R}, \Delta]\, d\mathbf{r}_0$$

$$E[\mathbf{q}, \Delta] = \int \overline{P}[\mathbf{R}, \Delta]\ exp[\mathrm{i}\ 2\ \pi\ \mathbf{q} \cdot \mathbf{R}]\ d\mathbf{R}$$

$$\overline{P}[\mathbf{R}, \Delta] = \int E[\mathbf{q}, \Delta]\ exp[-\mathrm{i}\ 2\ \pi\ \mathbf{q} \cdot \mathbf{R}]\ d\mathbf{q}$$

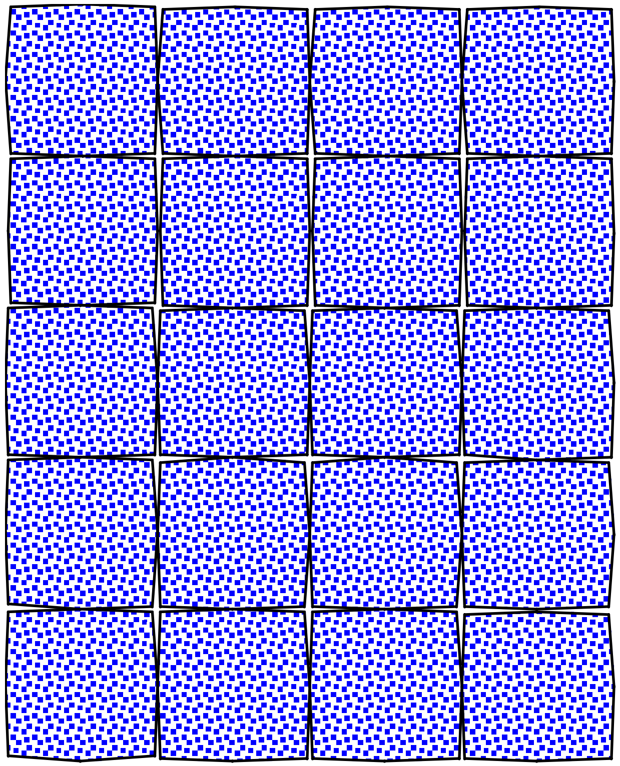
$$E[\mathbf{q}, \infty] = \int \rho[\mathbf{r}_0]\ exp[\mathrm{i}\ 2\ \pi\ \mathbf{q} \cdot \mathbf{r}_0]\ d\mathbf{r}_0 \int \rho[\mathbf{r}]\ exp[\mathrm{i}\ 2\ \pi\ \mathbf{q} \cdot \mathbf{r}]\ d\mathbf{r}$$

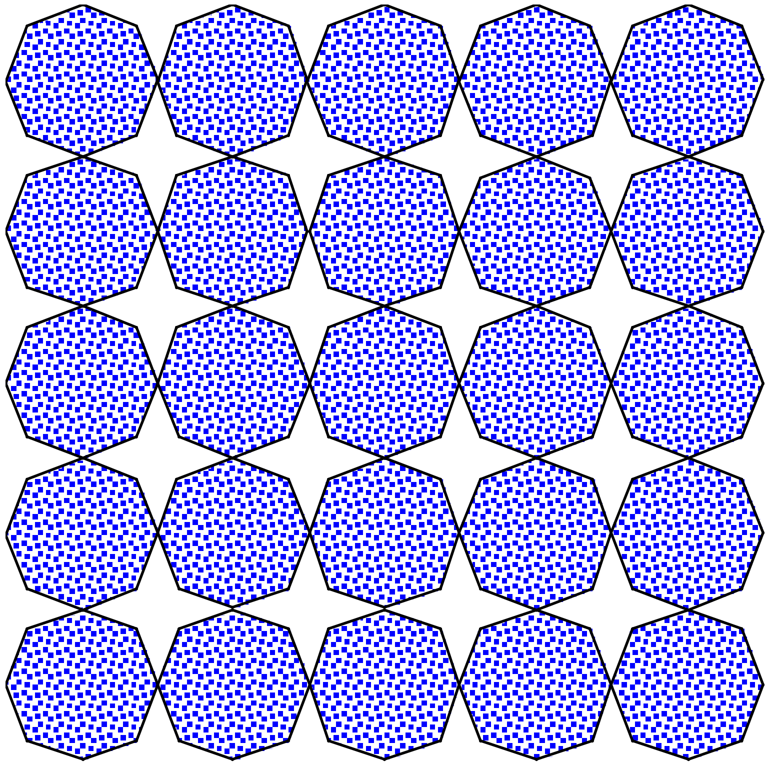
$$E[\mathbf{q}, \infty] = S^*[\mathbf{q}]\ S[\mathbf{q}] = |\, S[\mathbf{q}]\, |^2$$

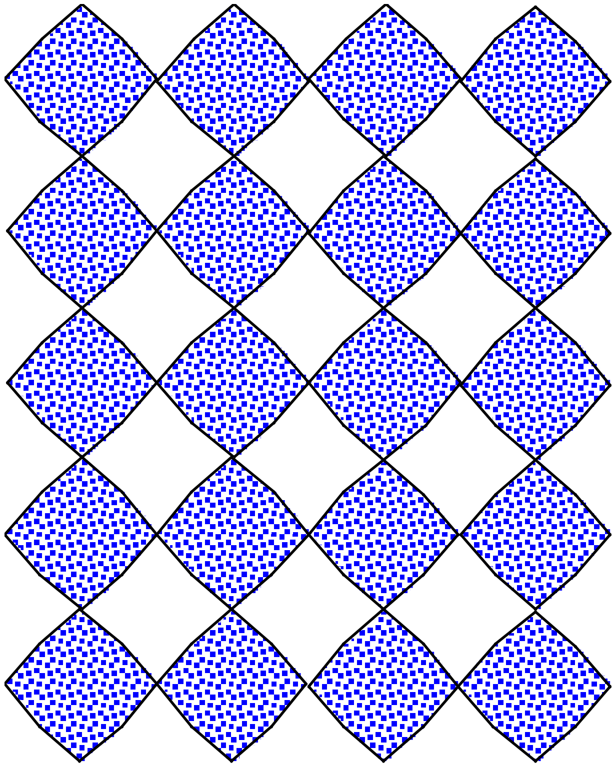
A model of variable packing density

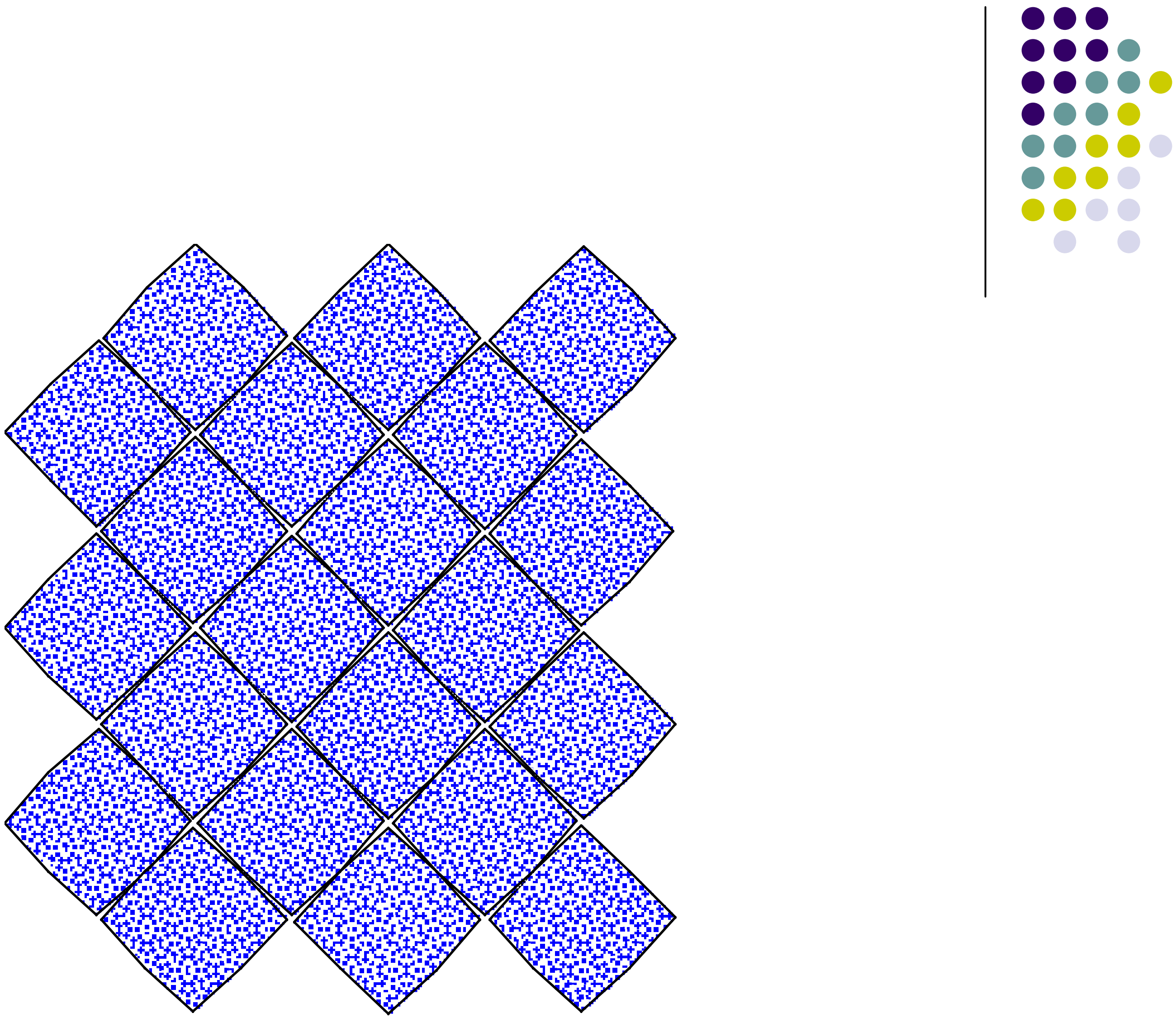
q-space plot results

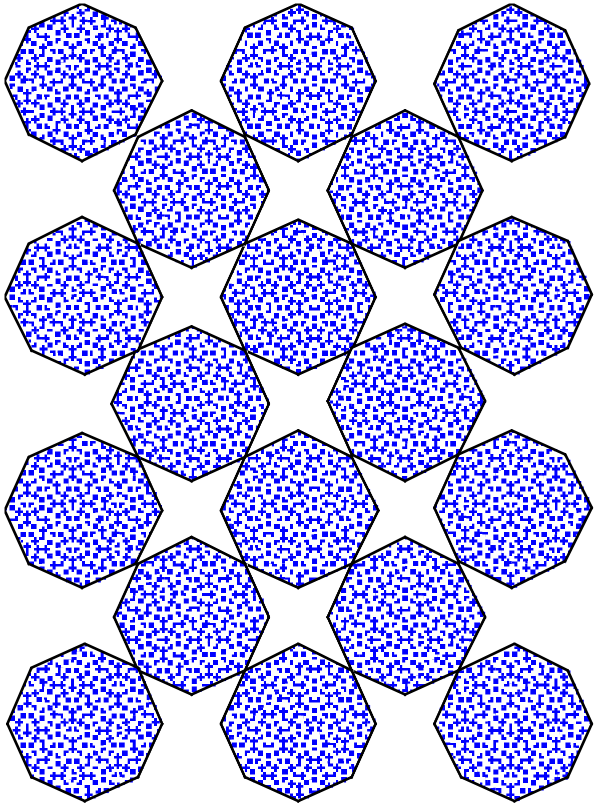
...octagon-star system

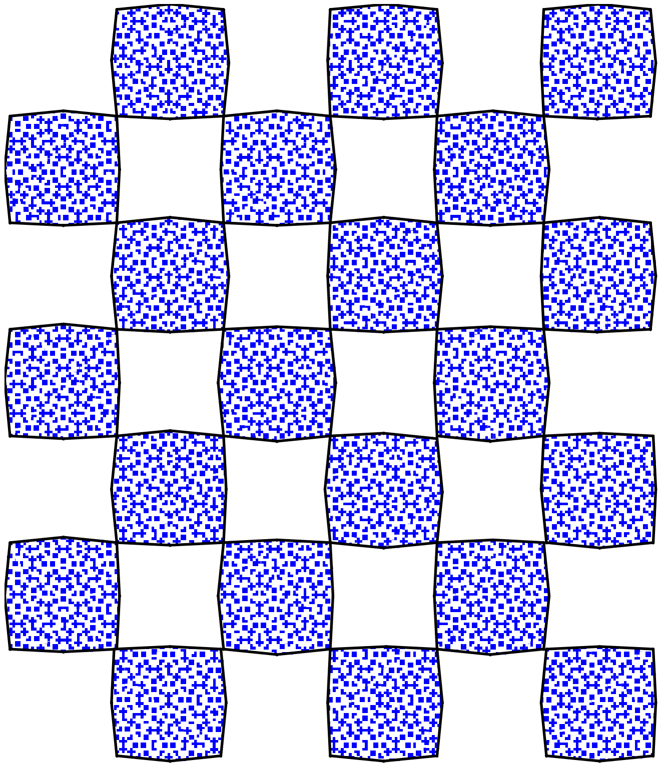
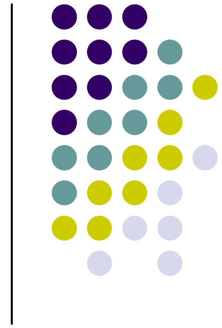




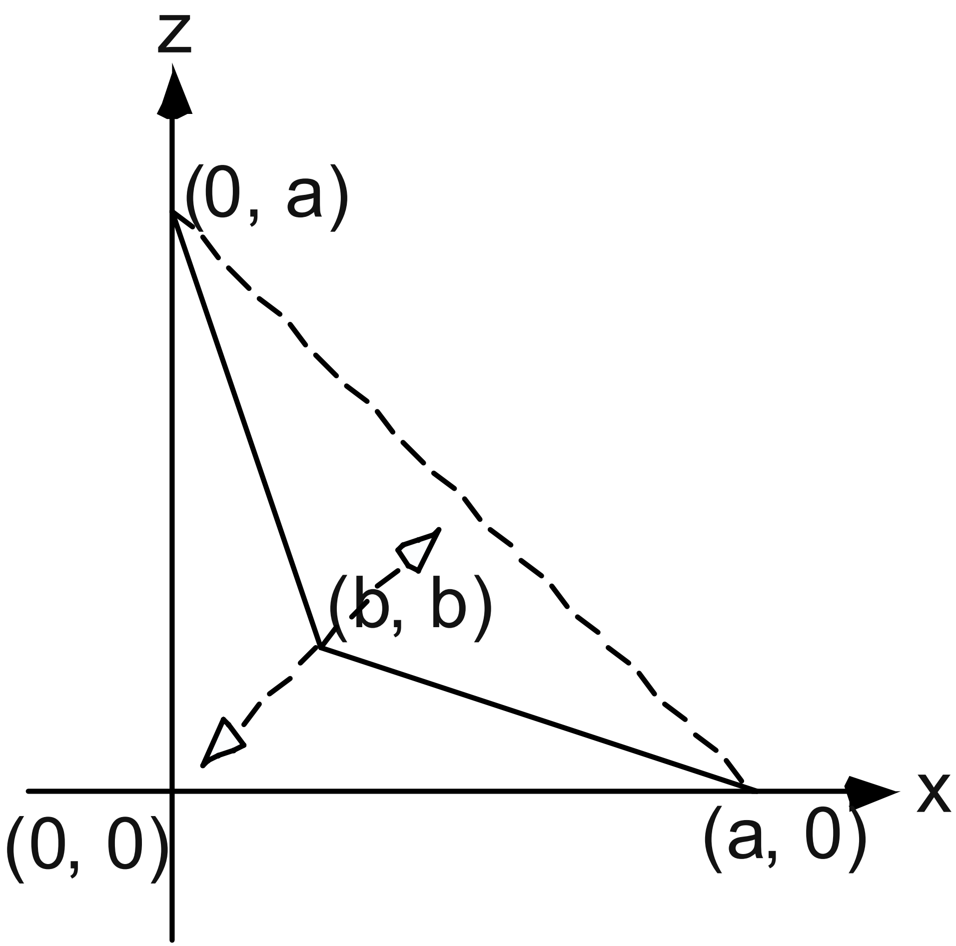




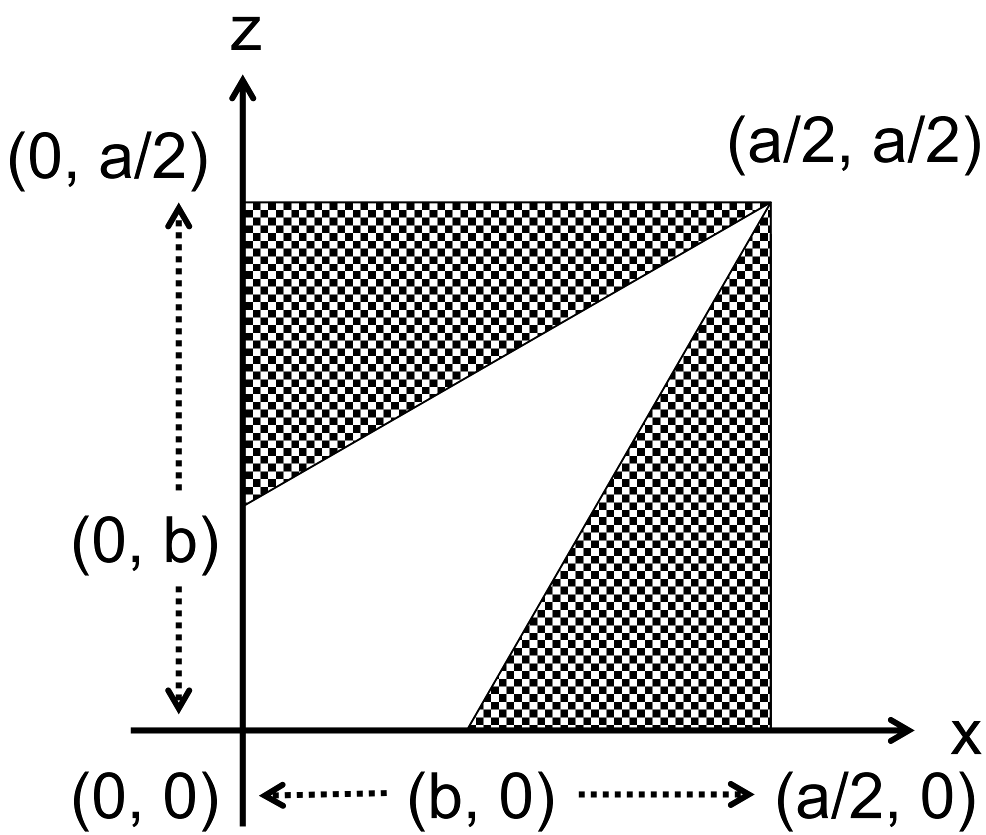


Construction element for *q*-space signal intensity for octagon-star model

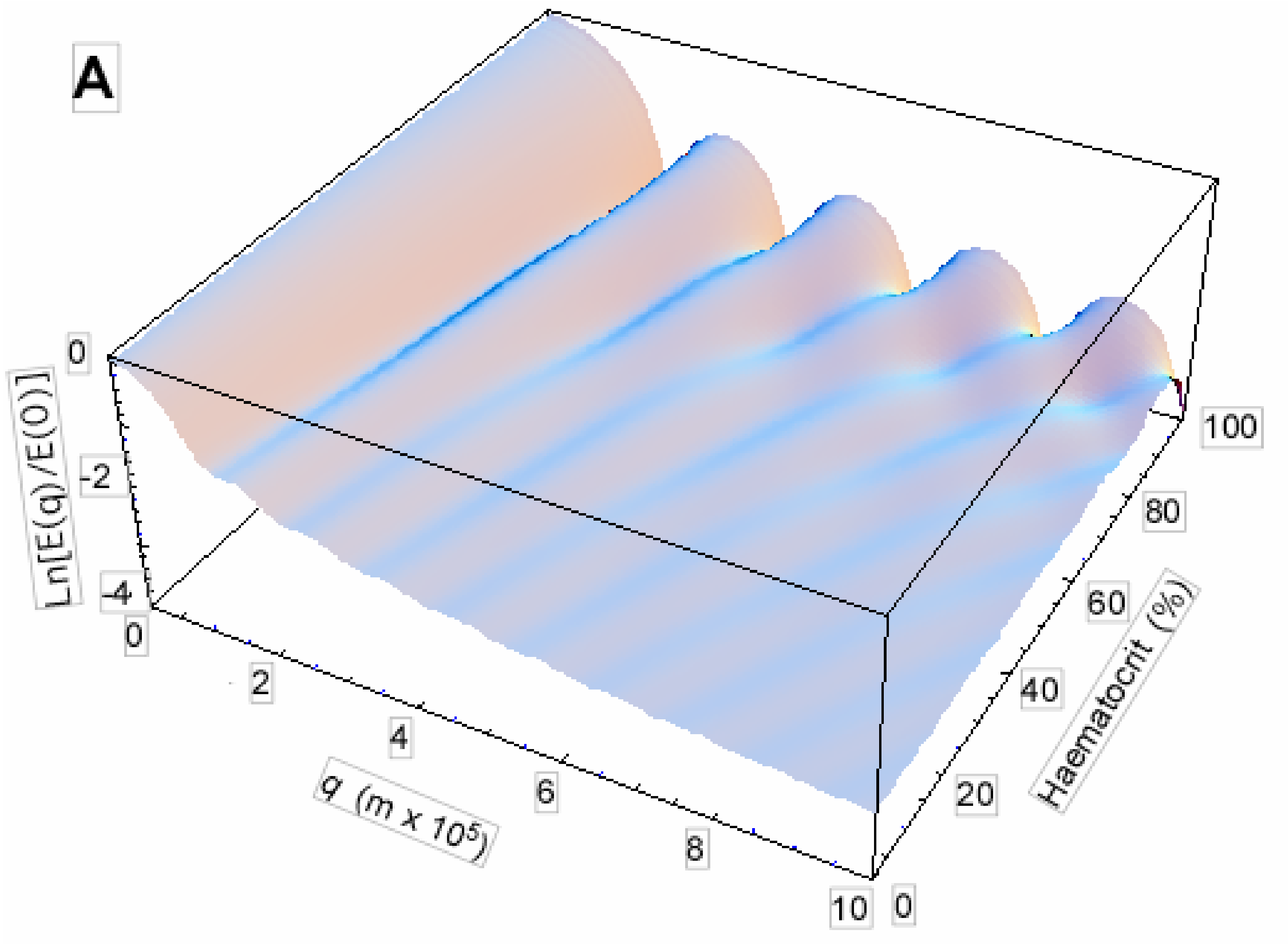


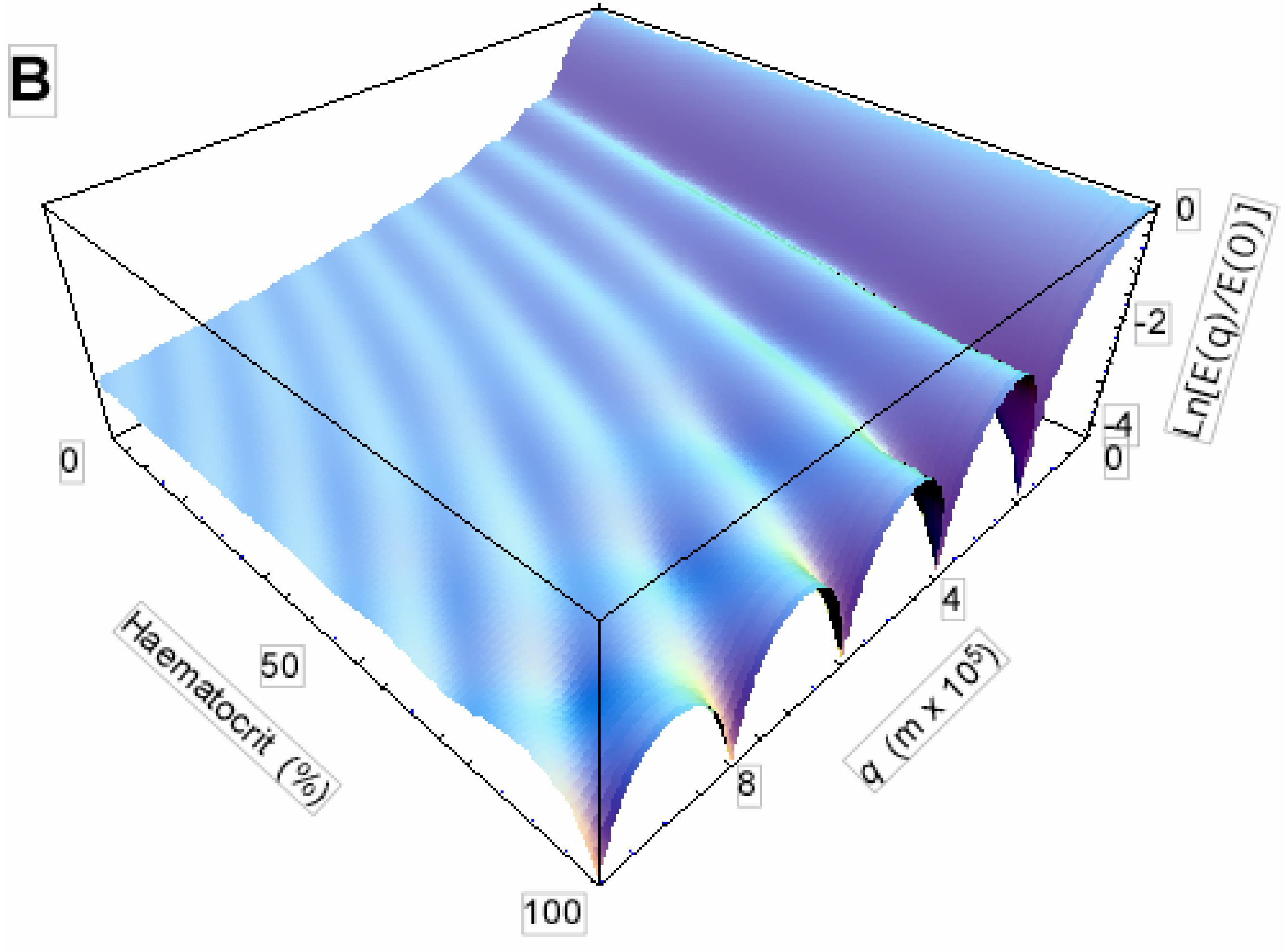
Construction element for *q*-space signal intensity for octagon-star model…90° rotation

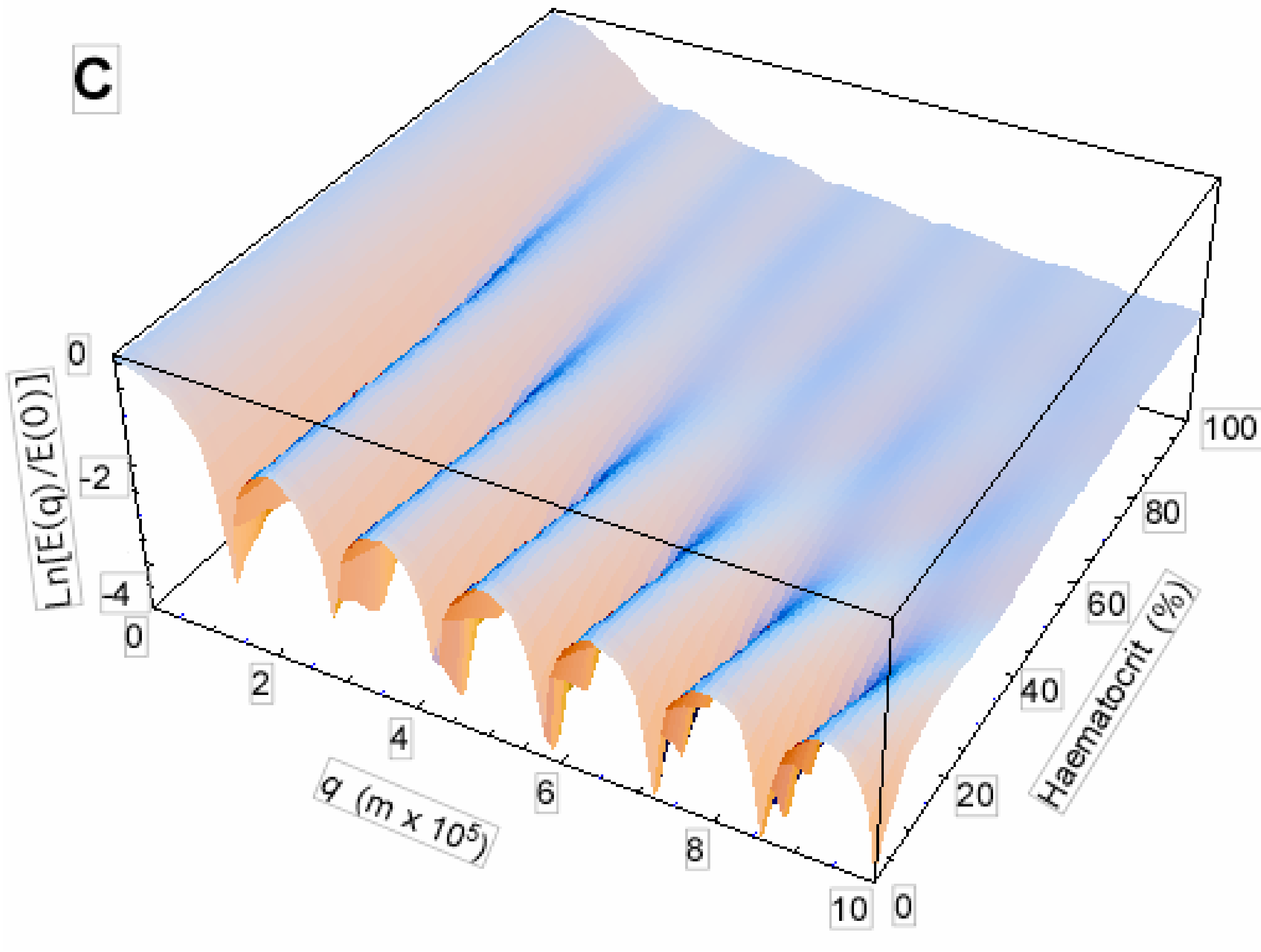


Expression for *q*-space signal intensity from stars alone

$$E_{star}[q,\infty] = \frac{1}{8a^2(a-2b)^2\pi^4 q^4} \times$$
$$\Big(a^4 - 4a^3b + 20a^2b^2 - 32ab^3 + 16b^4 + 2a^2(a-2b)^2b^2\pi^2q^2 - a^2(a-2b)^2 Cos[2b\pi q] +$$
$$4(a-b)b\Big((a-2b)^2 Cos[a\pi q] - a\big(a Cos[(a-2b)\pi q] + 2(a-2b)b\pi q Sin[a\pi q]\big)\Big) +$$
$$2a^3(a-2b)b\pi q Sin[2b\pi q]\Big)$$


A
0
-2
-4
Ln[E(q)/E(0)]
0
2
4
6
8
10
q (m x 10^5)
0
20
40
60
80
100
Haematocrit (%)

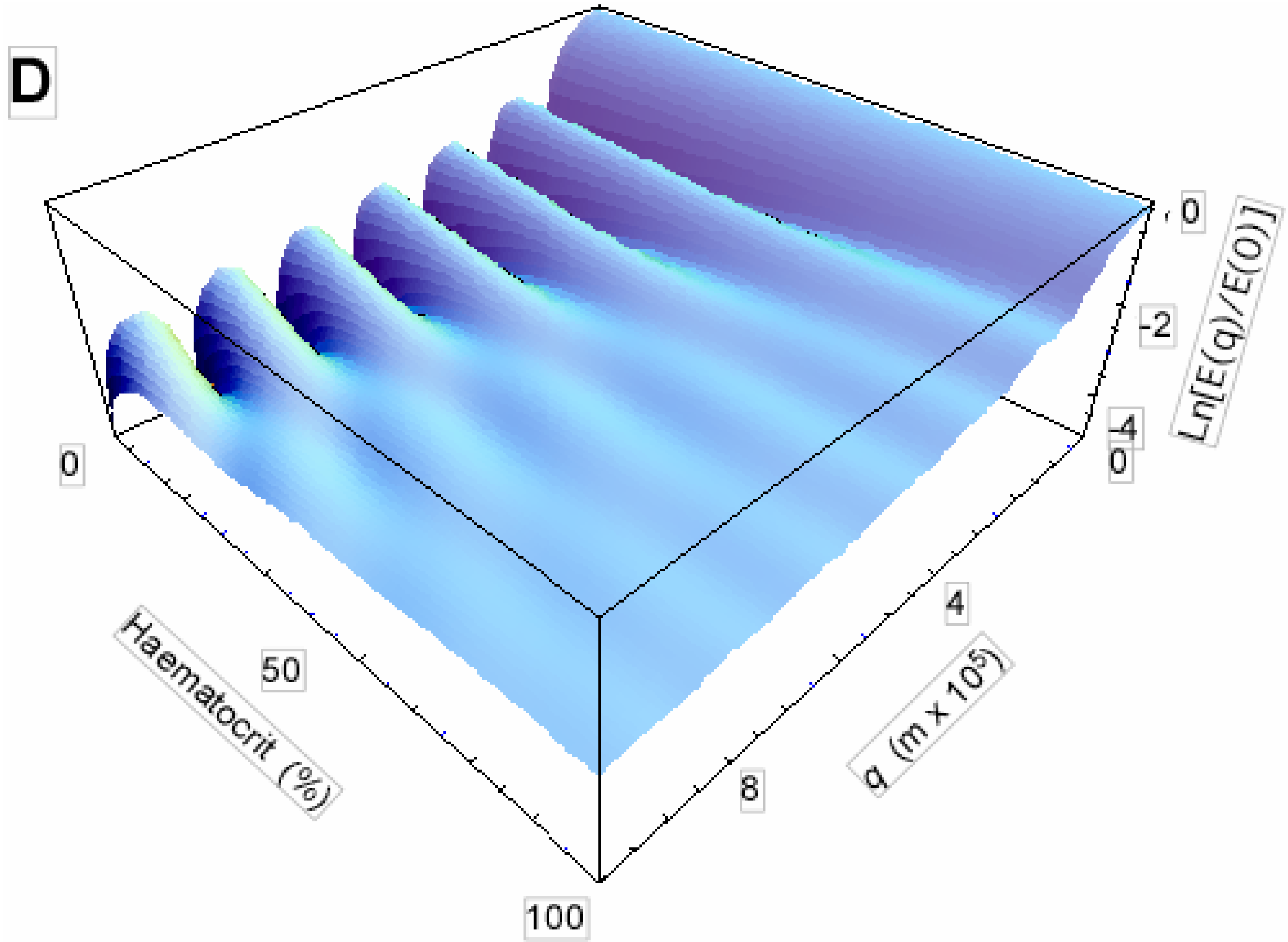

B
0
50
100
Haematocrit (%)
0
-2
-4
Ln[E(q)/E(O)]
0
4
8
q (m x 10^5)


C
Ln[E(q)/E(0)]
0
-2
-4
0
2
4
6
8
10
q (m x 10^5)
0
20
40
60
80
100
Haematocrit (%)

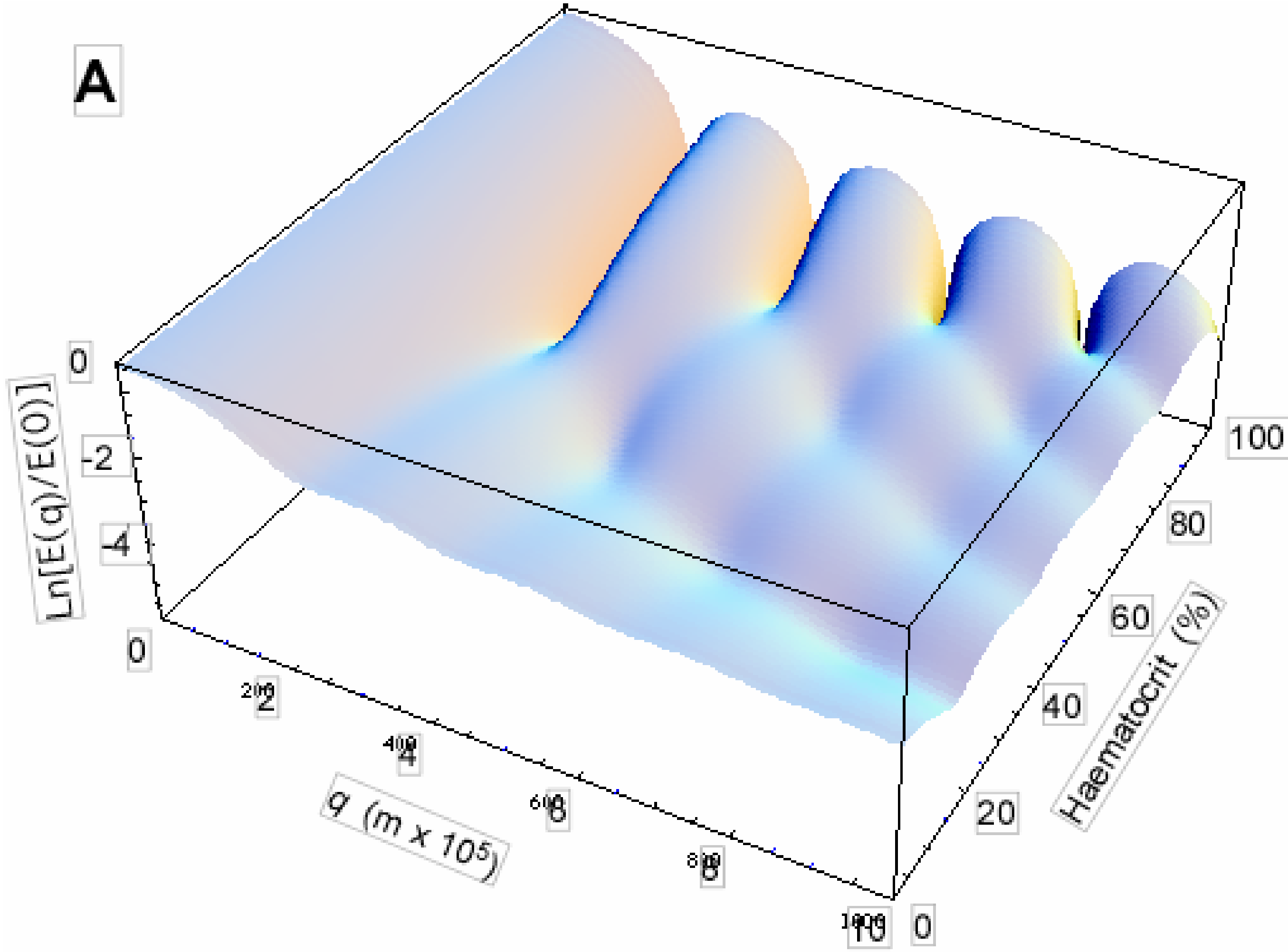
q-space plot from octagon-star system as Ht increases

QuickTime™ and a
decompressor
are needed to see this picture.

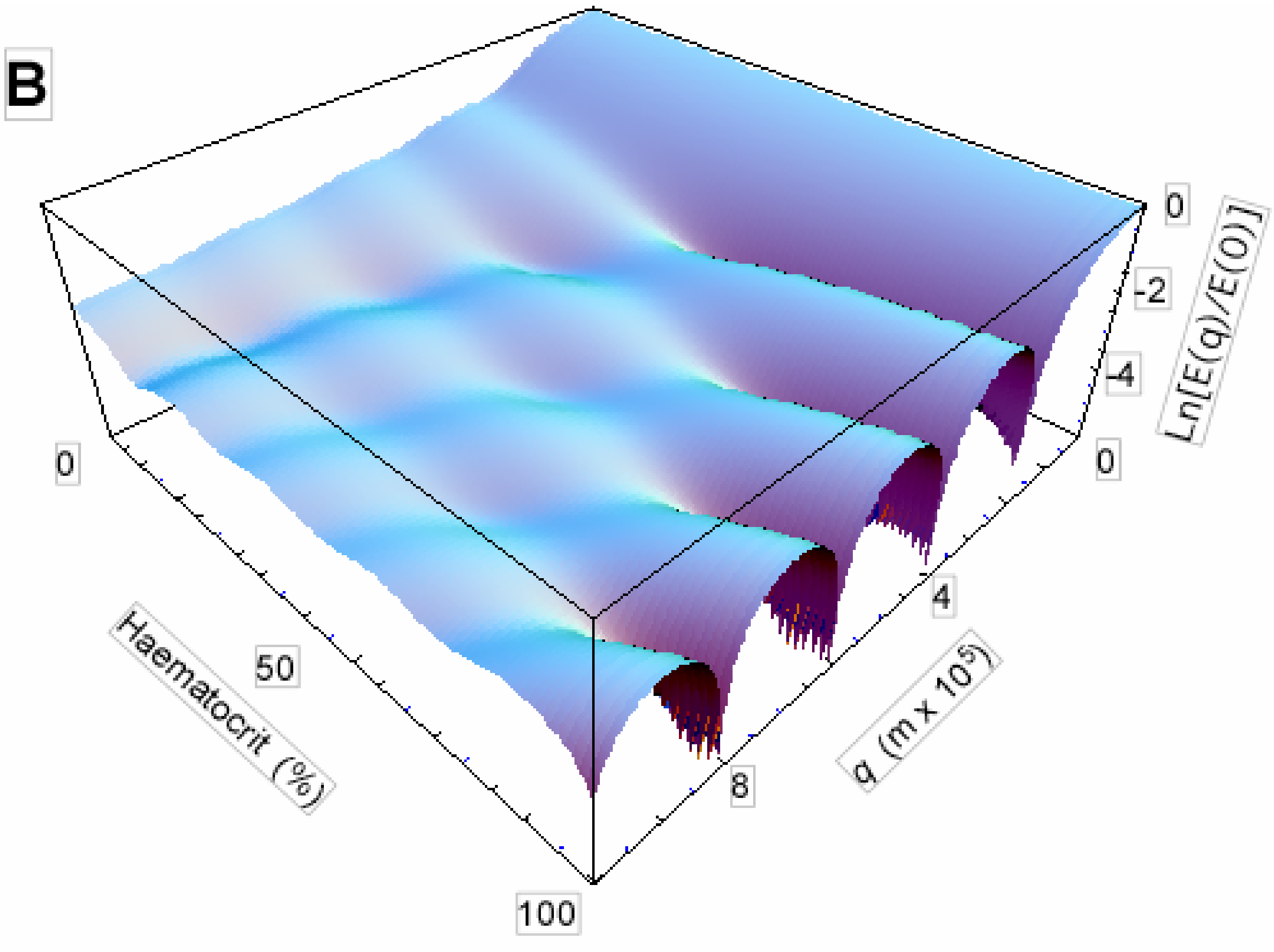
Movie showing change in shape of the q-space
plot-function as Ht is increased


D
0
-2
-4
Ln[E(q)/E(0)]
0
50
100
Haematocrit (%)
0
4
8
q (m x 10^5)

q-space plot from stars only



q-space plot from stars only



Thanks to past and present students…

TIFF (U
are n

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TIFF (Uncom
are neede

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Bill Price is my name!

Bill Bubb	NMR
Bob Chapman	NMR
Tom Eykyn	NMR
David Jacques	DIC
Tim Larkin	*Mathematica*
Guilhem Pages	NMR & fast *q*-space
David Regan	NMR & simulation
David Szekely	DIC & *Mathematica*

Chris Garvey
Bill Price
Peter Stilbs

Grazie!