The influence of particle anisometry on the magnetic characteristics of dipolar cubic colloids.

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Fakultät für Physik

Dipolar Soft Matter

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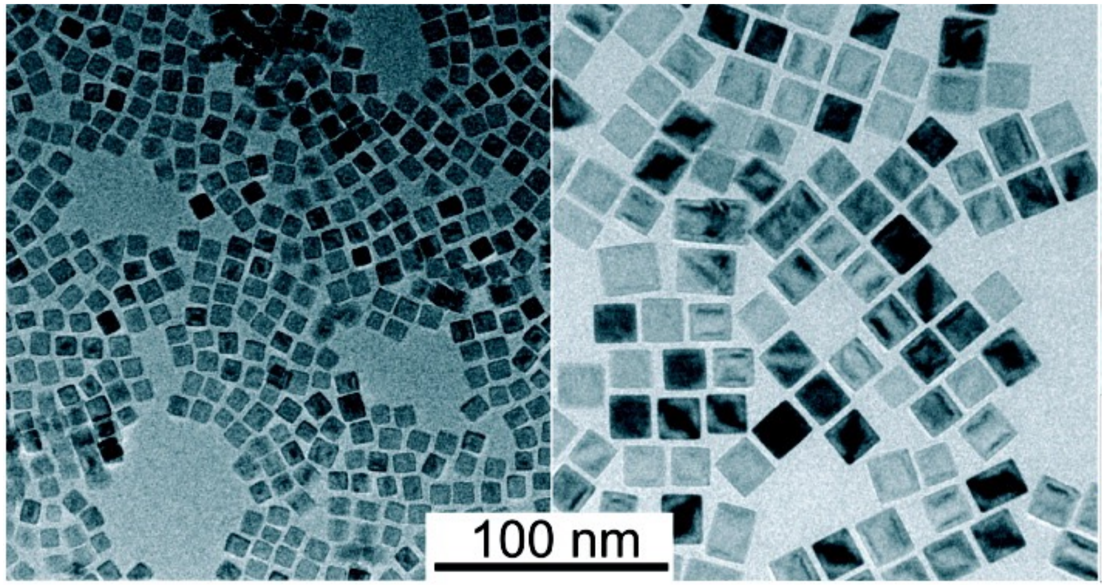
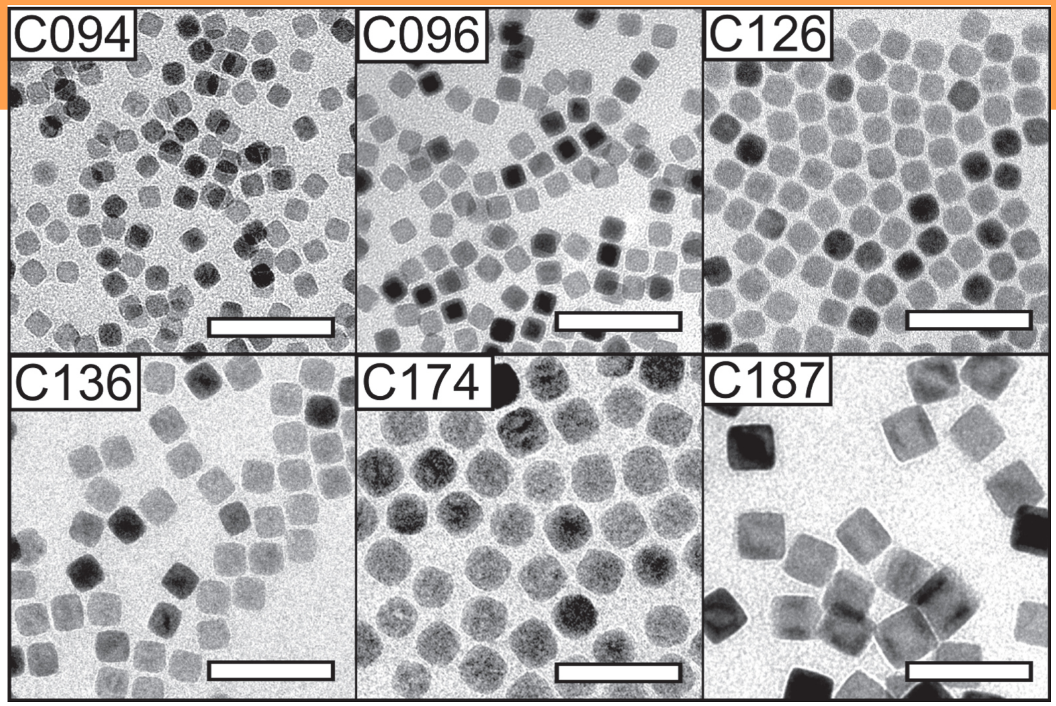
Motivation

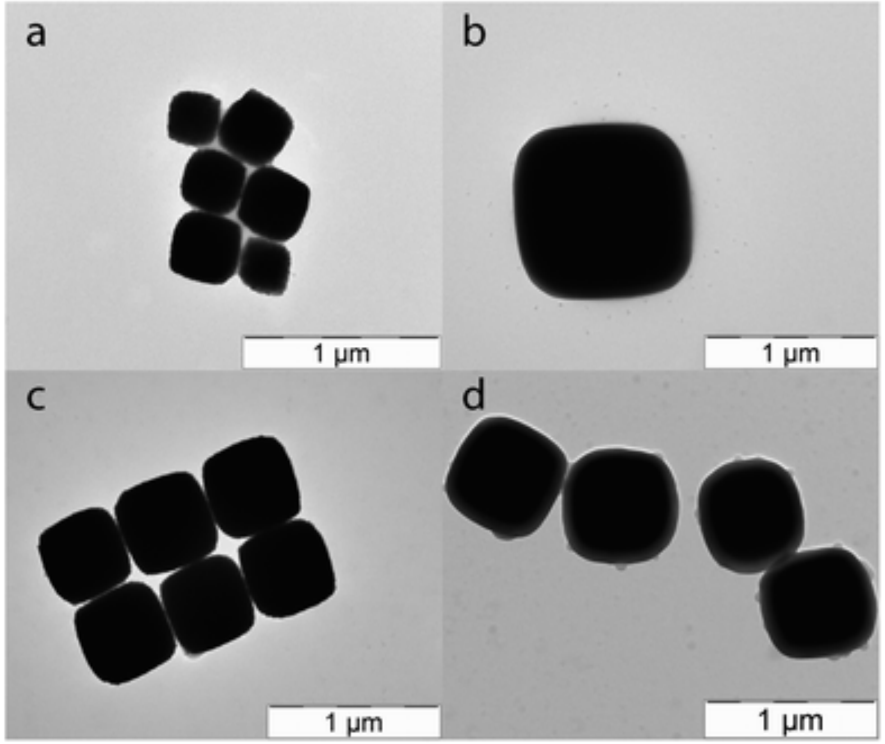
Colloidal Magnetic Cubes in Experiment



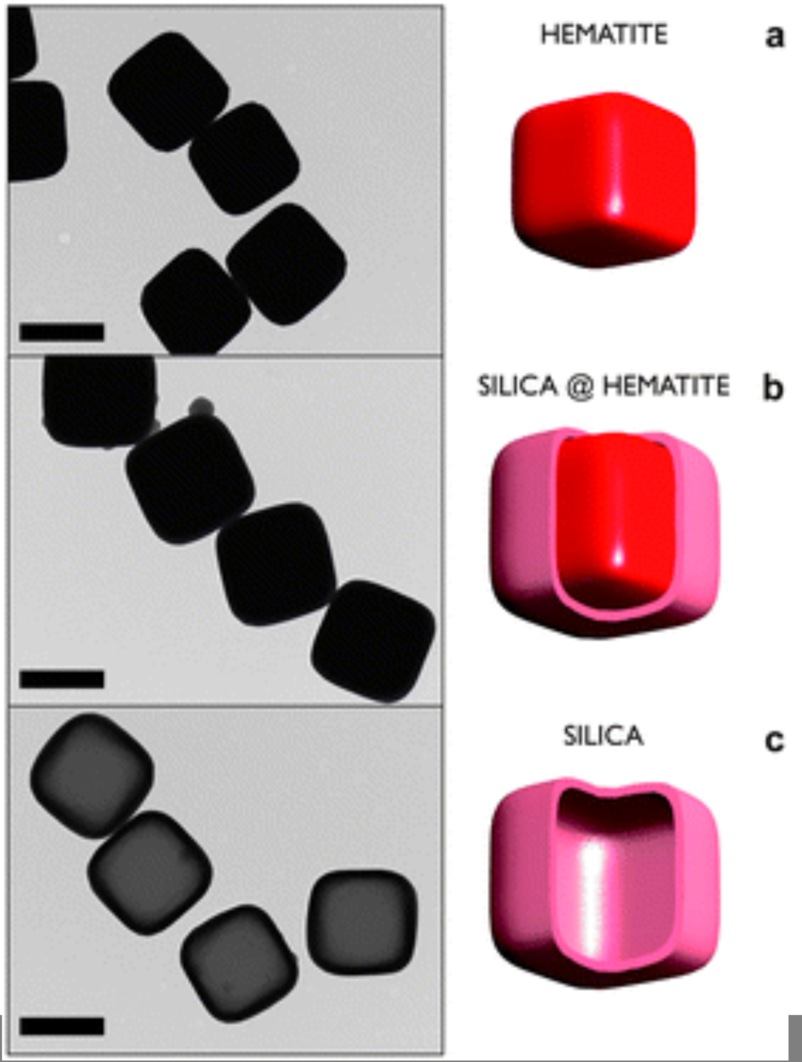
Kovalenko et al 2007



Wetterskog et al 2014



Meijer et al 2013



Ross et al 2011

Motivation

Colloidal Magnetic Cubes
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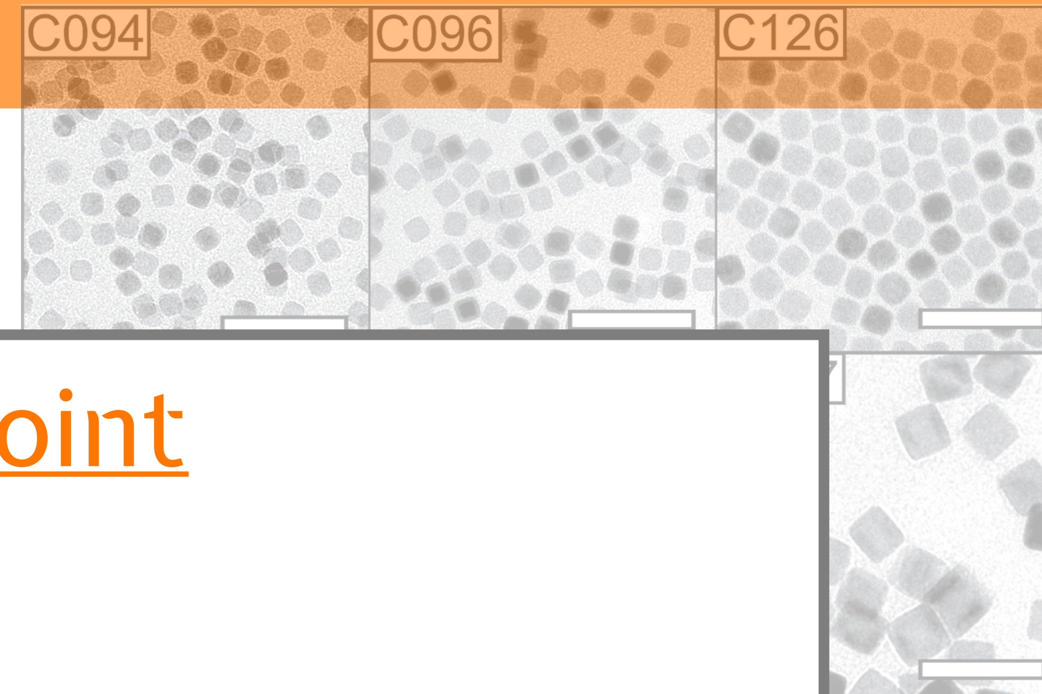
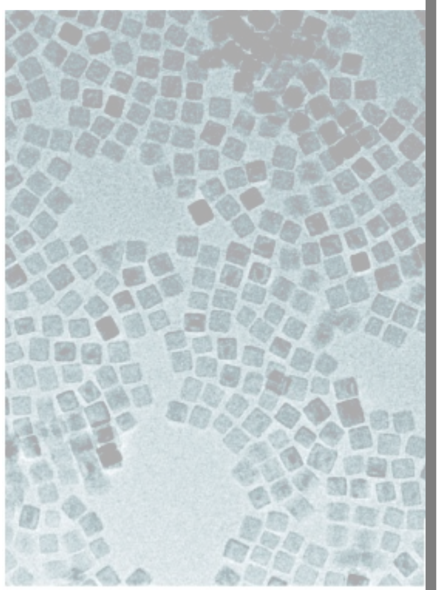
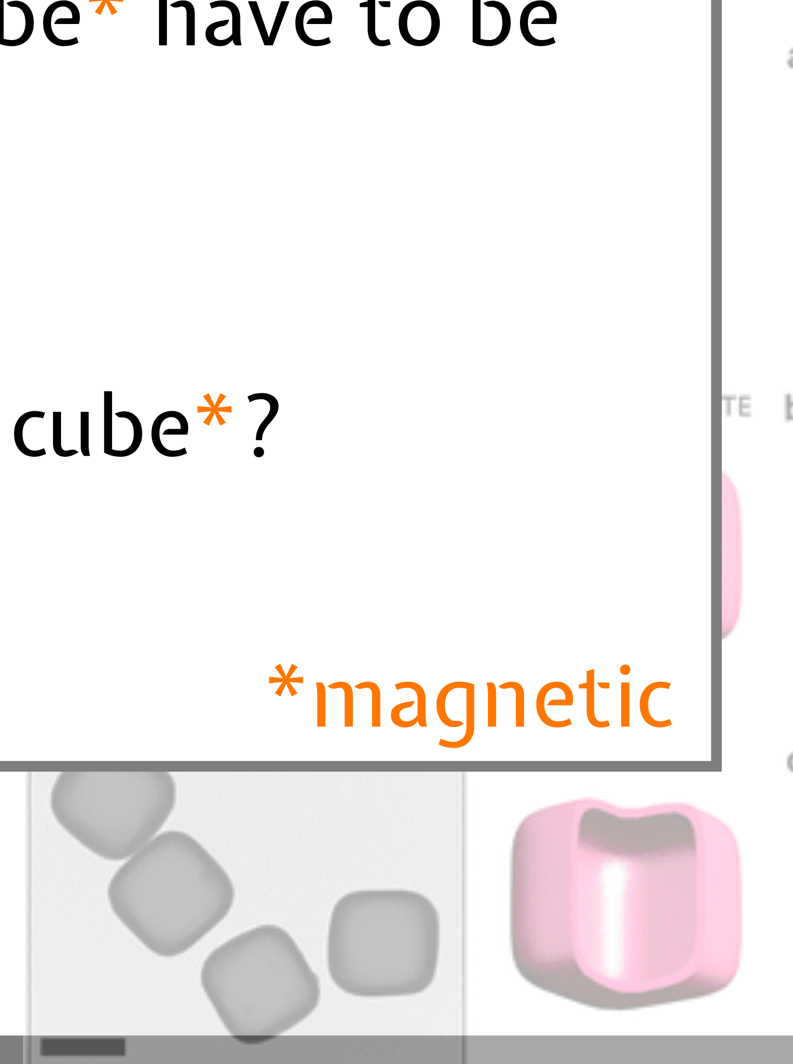




Kovalenko et al 20

Meijer



Ross et. al 2011

Talking Point

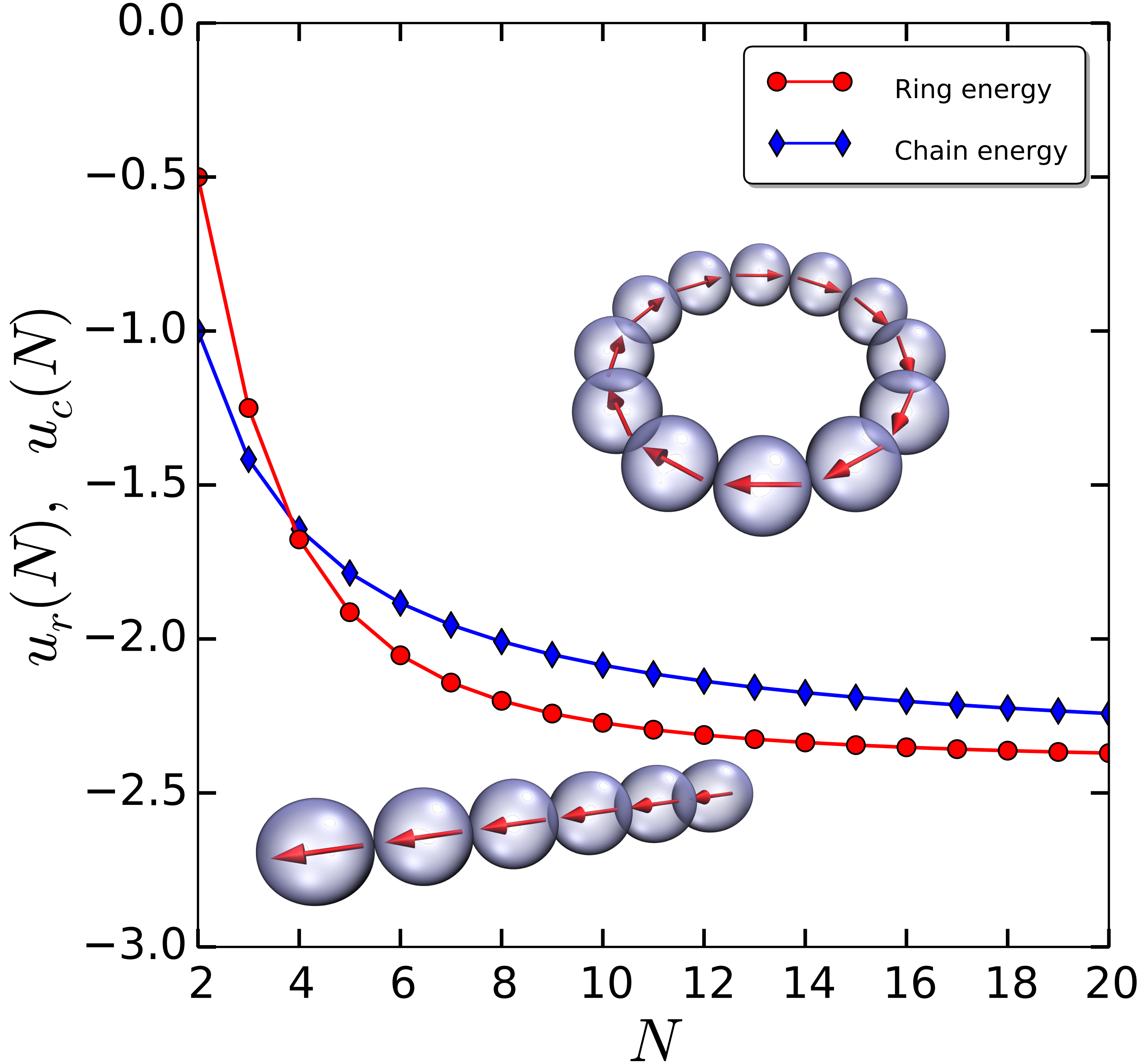
How cubie / cubish / cubic does a cube* have to be

to behave like a cube*?

*magnetic

What we know already

Spherical particle ground state



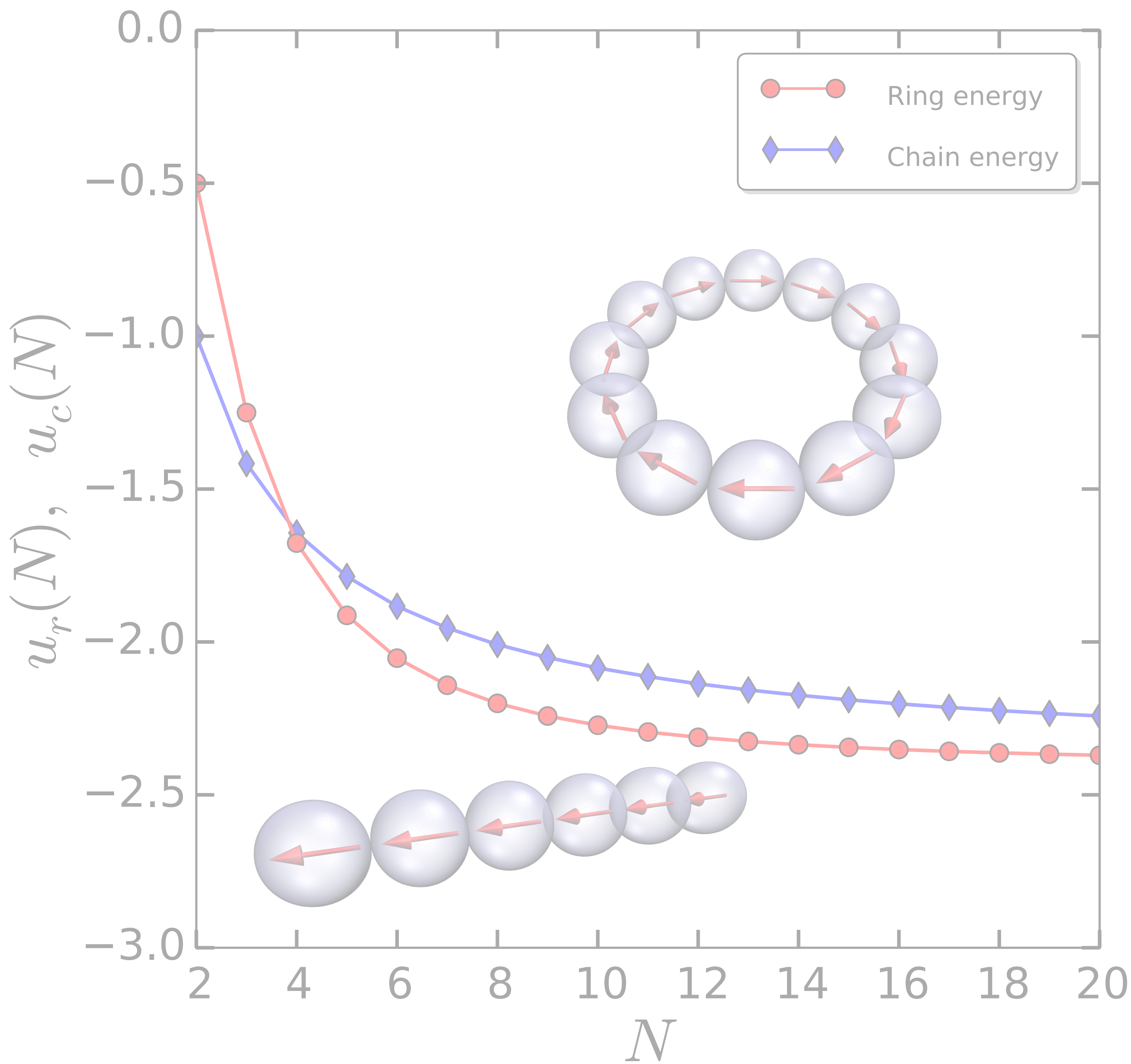
Conclusion

Chain structure is the preferred GS-cluster for $N < 4$

Ring structure is the preferred GS-cluster for $N \geqslant 4$

What we know already

Spherical particle ground state



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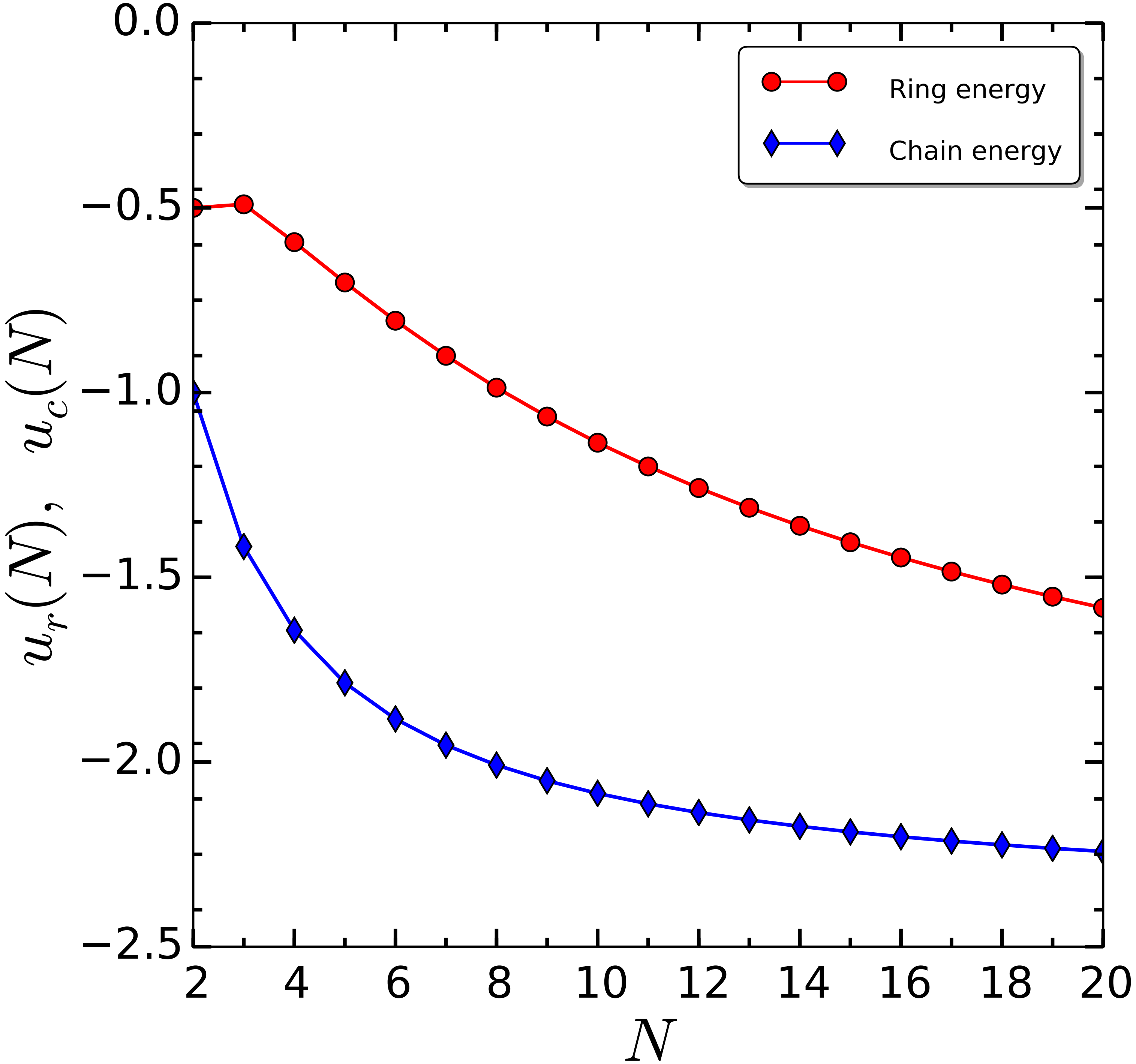
Chain structure is the preferred GS-cluster for $N < 4$

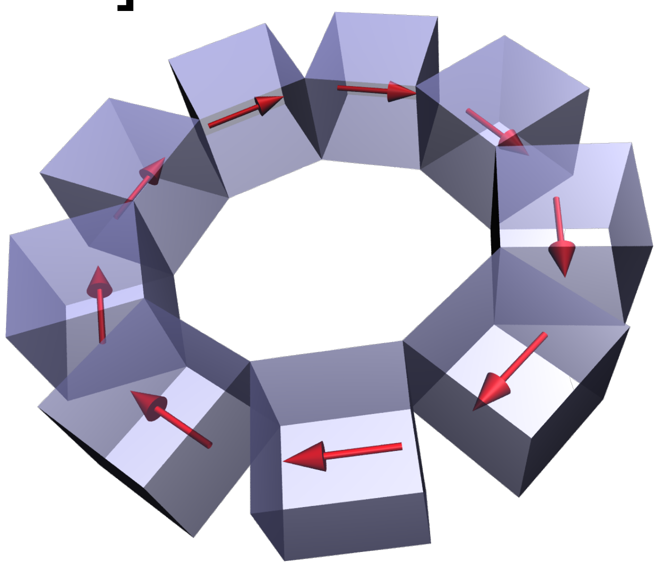
Ring structure is the preferred GS-cluster for $N \geqslant 4$

T. A., Prokopieva *et al*, **PRE**, 2009, **80**, 031404

What we know already

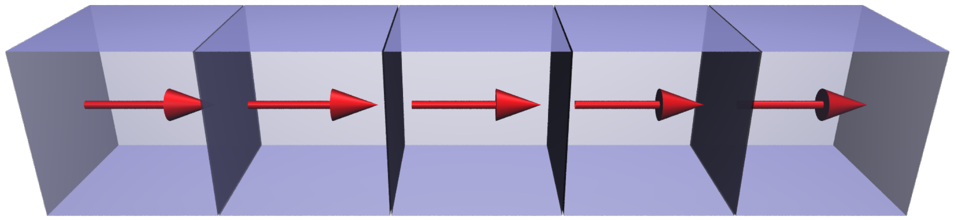
Cube particle ground state - [001]





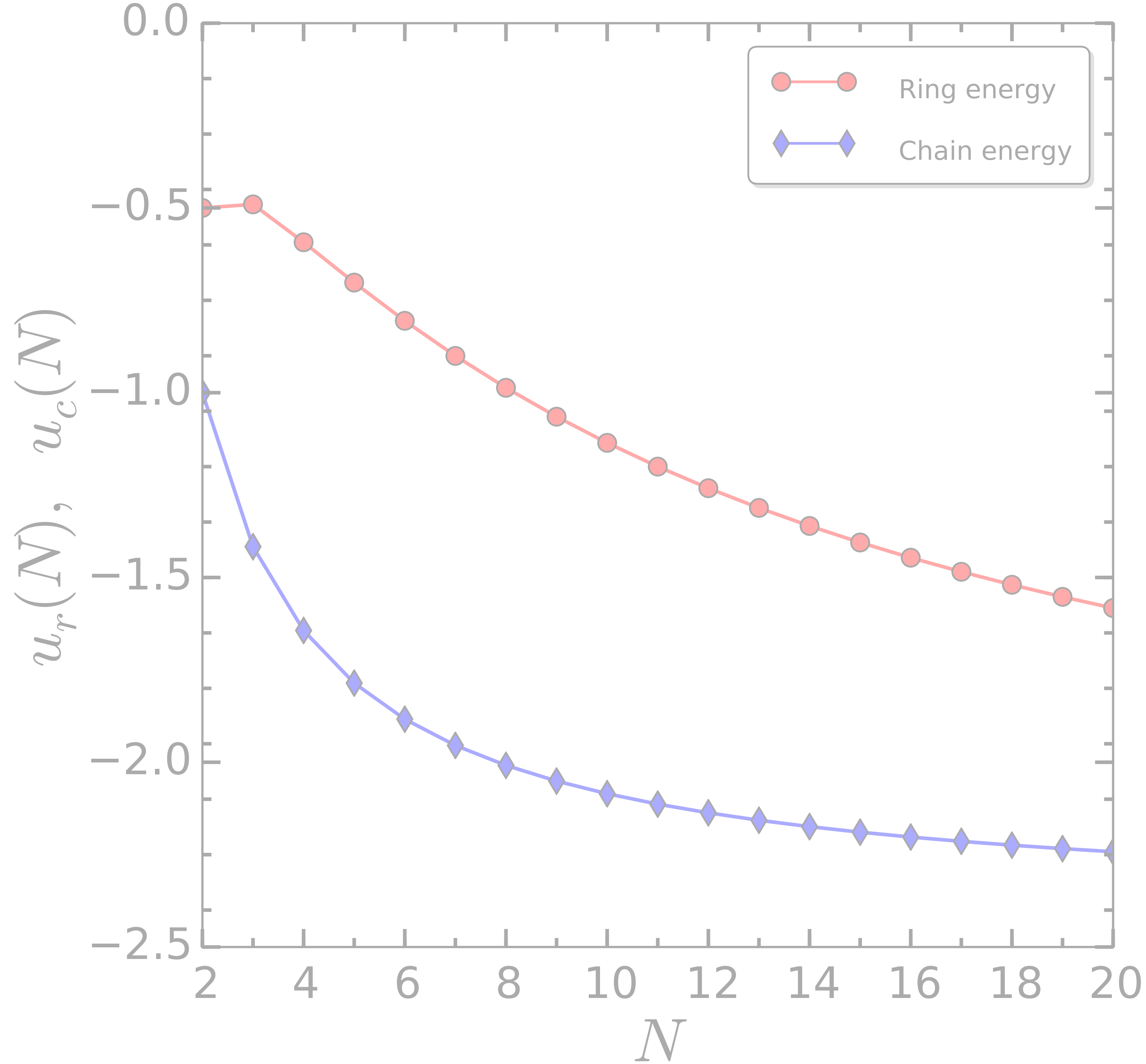
Conclusion

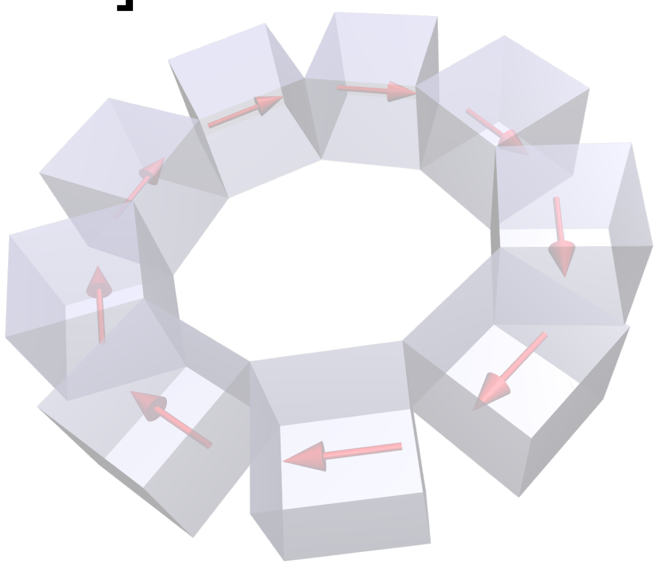
Chain structure is the preferred GS-cluster regardless of N.



What we know already

Cube particle ground state - [001]





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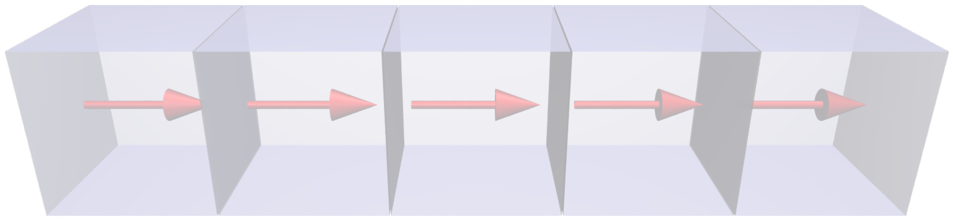
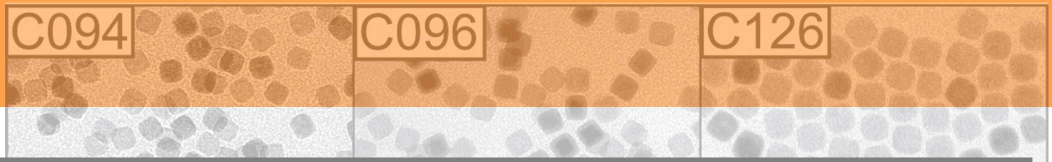
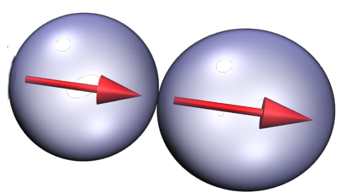


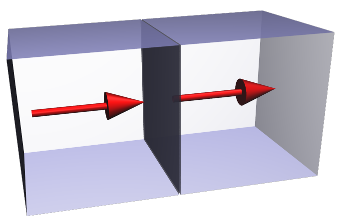
Motivation

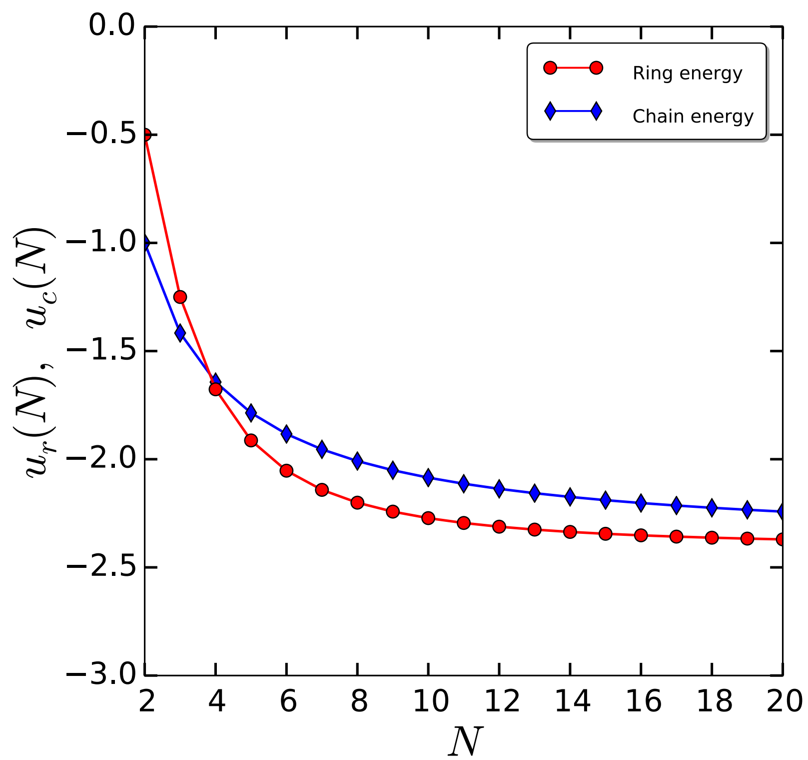


Talking Point 1.1

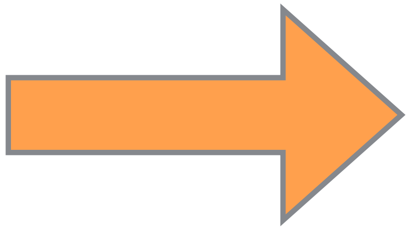
How cubie does a cube* have to be to behave like a cube*?

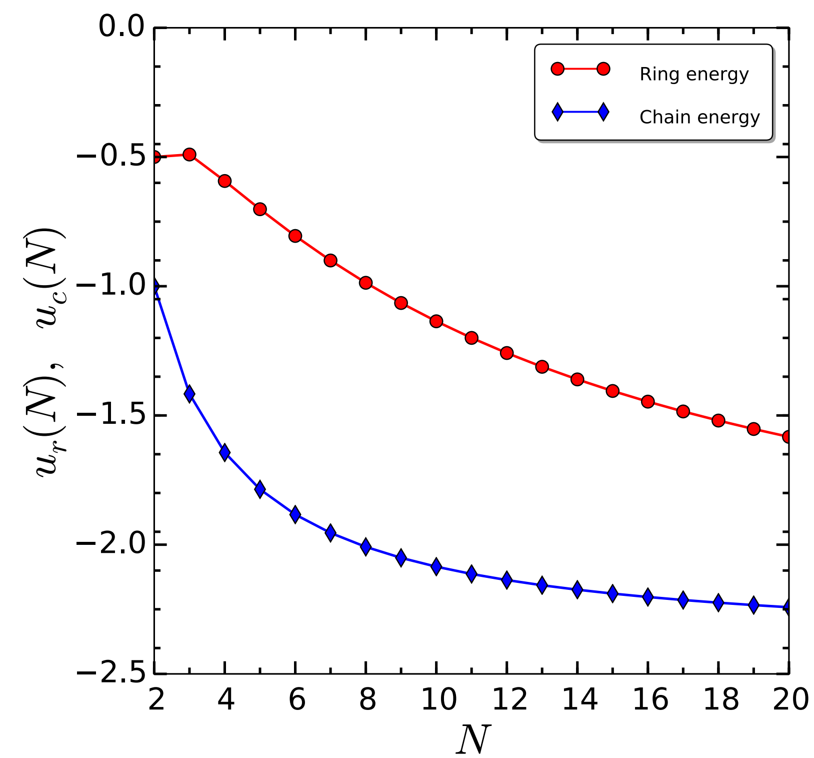


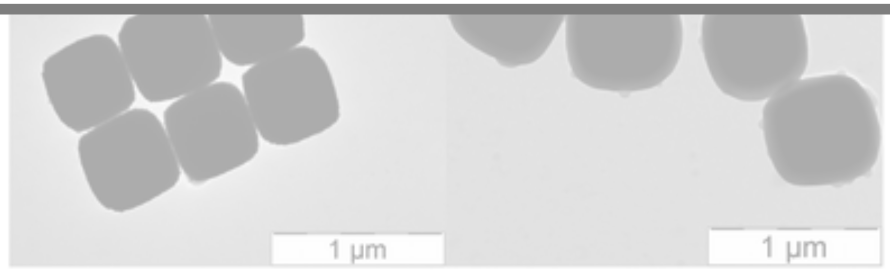




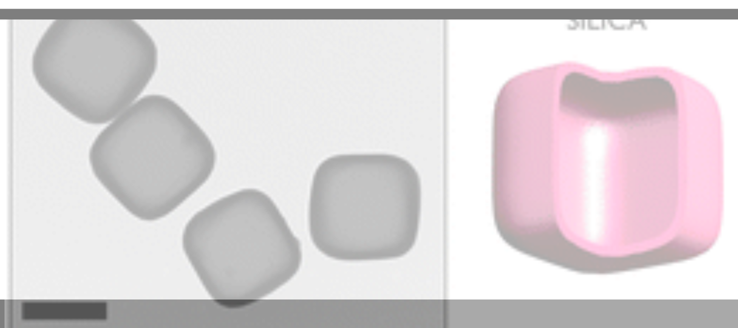
?







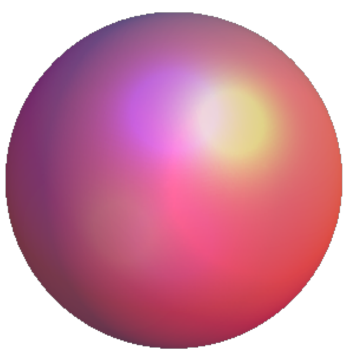
Meijer



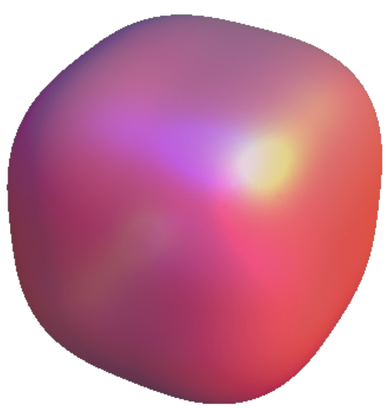
Ross et

What we now know

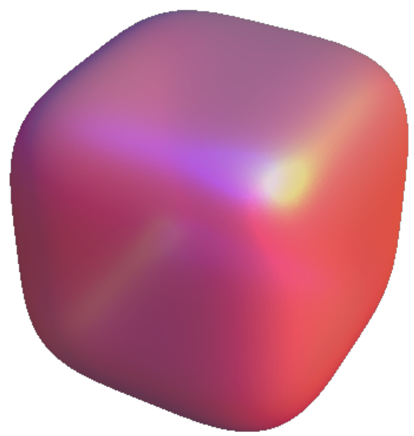
Super-quadrics
spheres to cubes → $$\left|\frac{2x}{h}\right|^{2q}+\left|\frac{2y}{h}\right|^{2q}+\left|\frac{2z}{h}\right|^{2q}\leqslant 1 \qquad q\in[1,\infty]$$



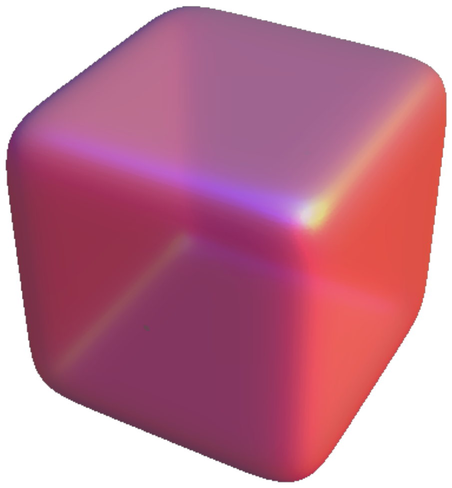
$q=1$



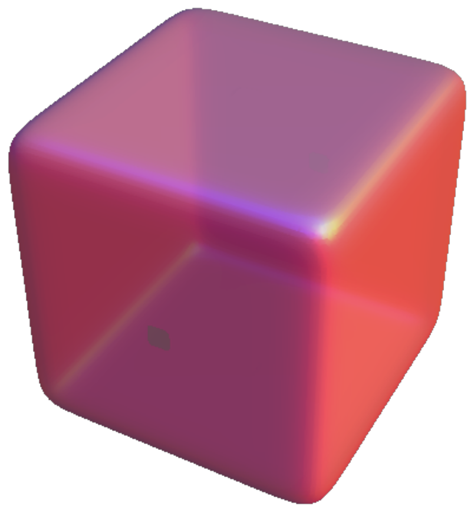
$q=1.5$



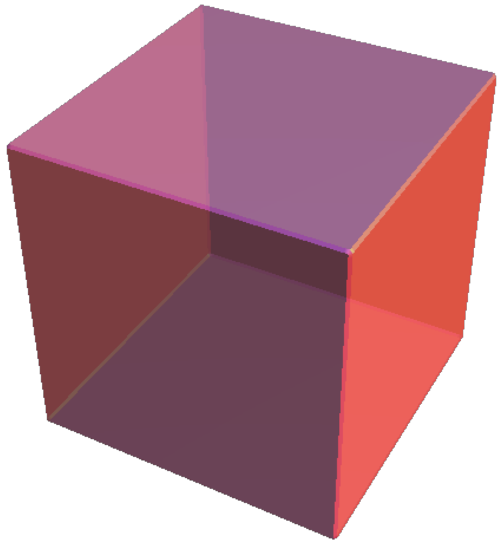
$q=2$



$q=4$



$q=6$



$q\to\infty$

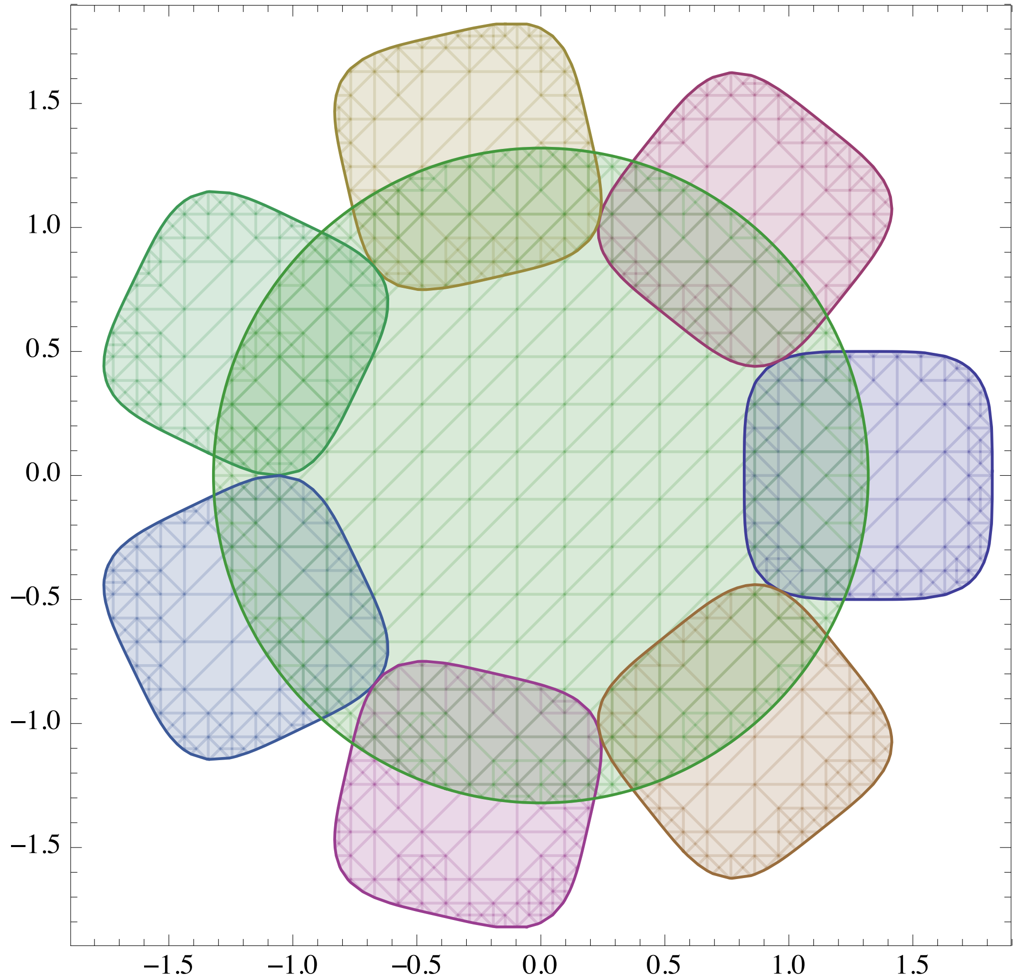
Effect of curvature parameter, q

What we now know

Super-ball ground state - [001]

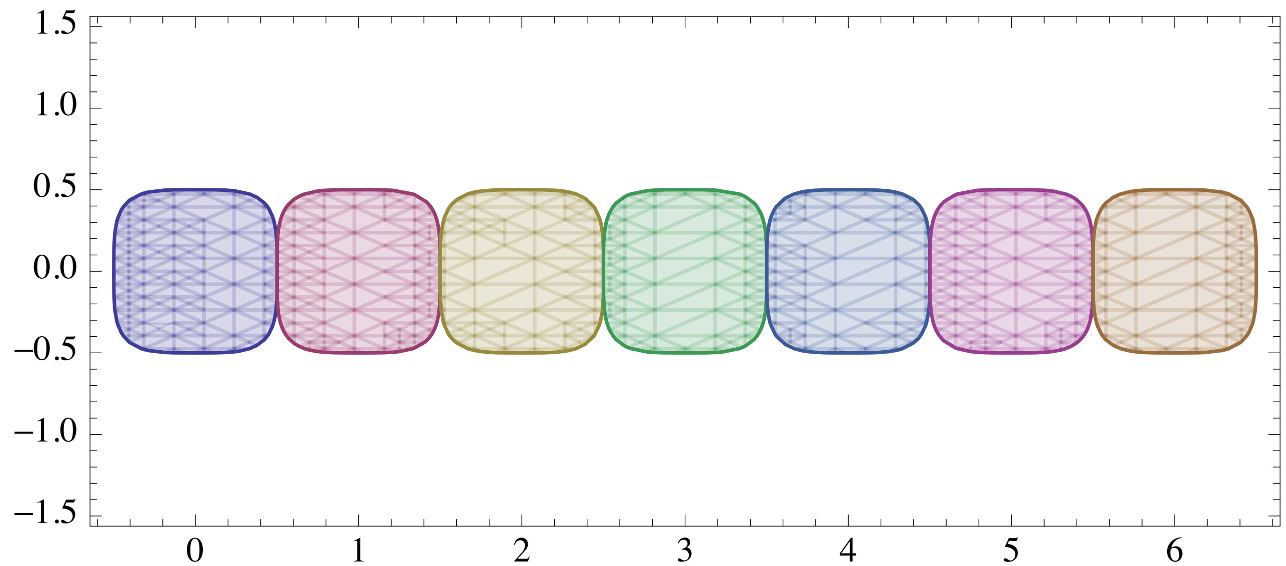
Ring

$$u_r(q,N) = \frac{-\sin^3(\frac{\pi}{N})}{d(q,N)^3}\left[\sum_{k=1}^{[\frac{N-1}{2}]} \frac{\cos^2(\frac{\pi k}{N})+1}{\sin^3(\frac{\pi k}{N})} + \frac{\mathrm{mod}(N+1,2)}{2}\right]$$



Chain

$$u_c(N) = -\frac{2}{N}\sum_{k=1}^{N-1}\frac{N-k}{k^3}$$



What we now know

Super-ball ground state - [001]

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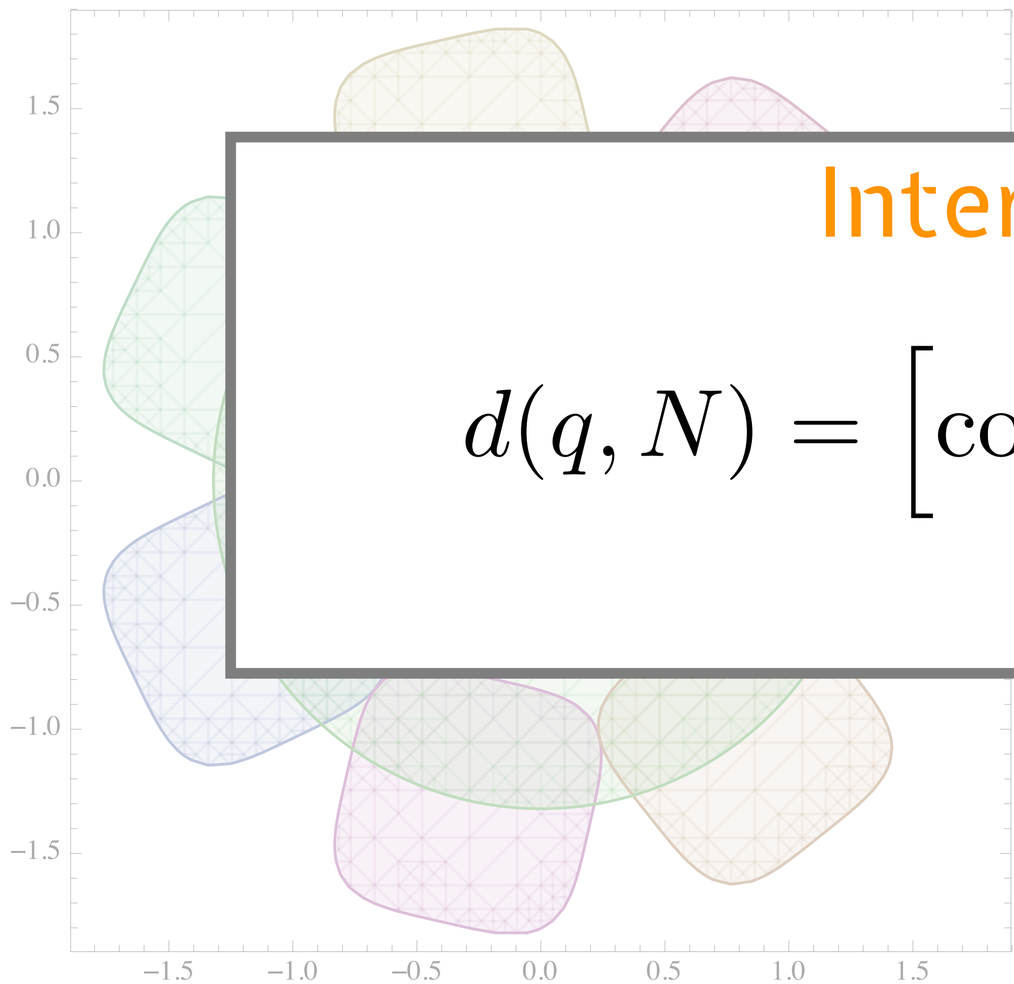
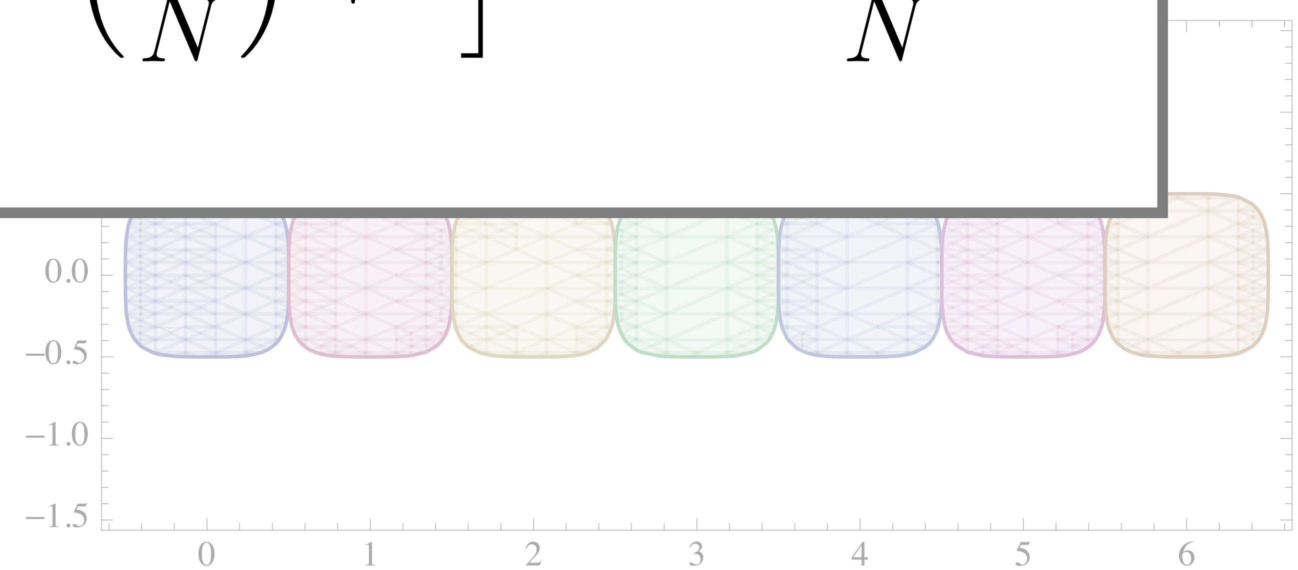
$$u_r(q,N) = \frac{-\sin^3\left(\frac{\pi}{N}\right)}{d(q,N)^3}\left[\sum_{k=1}^{\left[\frac{N-1}{2}\right]} \frac{\cos^2\left(\frac{\pi k}{N}\right)+1}{\sin^3\left(\frac{\pi k}{N}\right)} + \frac{\mathrm{mod}(N+1,2)}{2}\right]$$





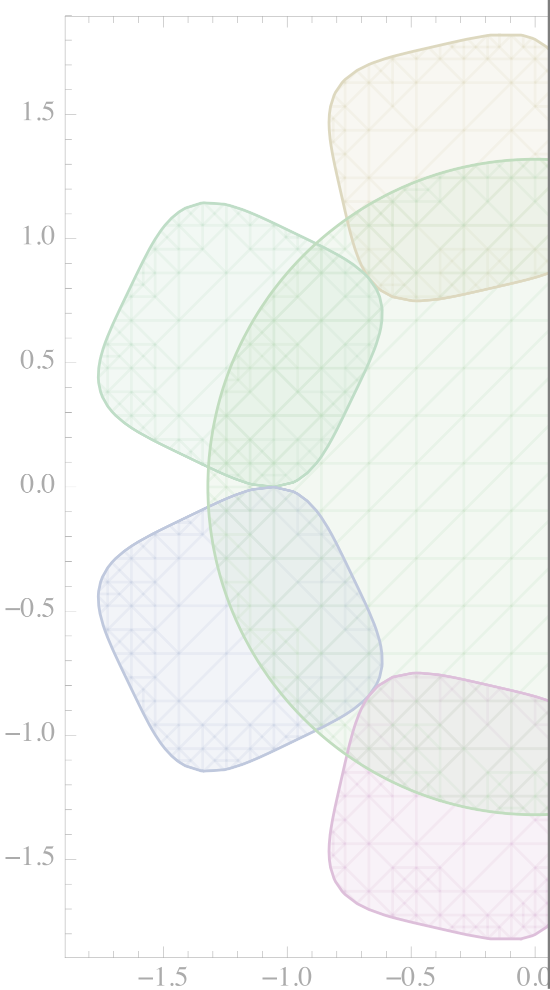
Inter-dipolar distance

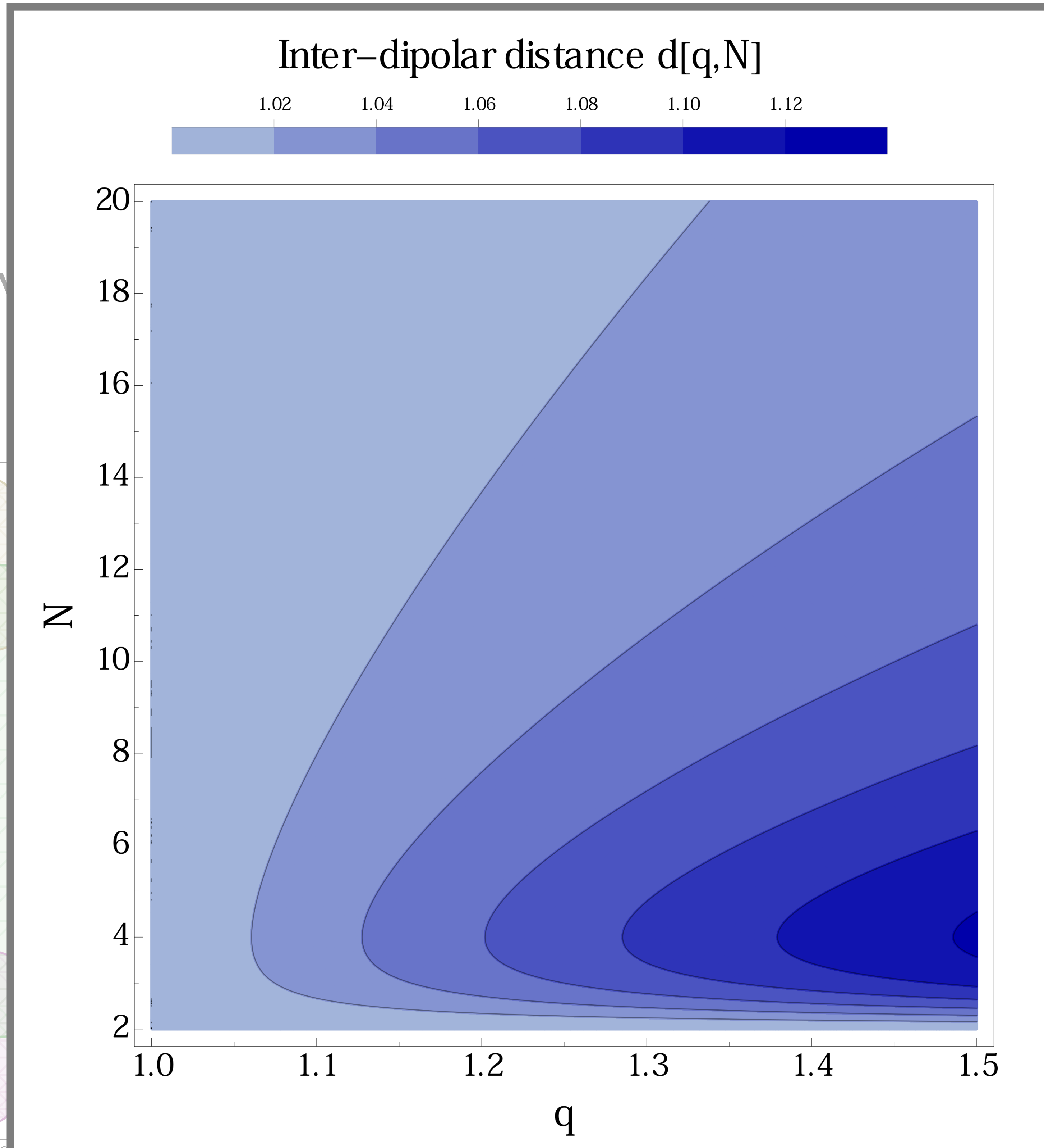
$$d(q,N) = \left[\cot^{\frac{2q}{2q-1}}\left(\frac{\pi}{N}\right)+1\right]^{\frac{2q-1}{2q}} \sin\frac{\pi}{N}$$

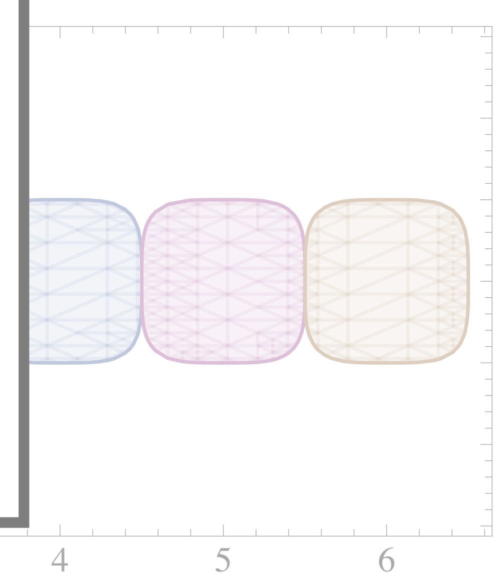
What we now know

Ring $u_{ring}(N$ … $N+1,2)$ … $\frac{}{2}$]

$\sum_{k=1}^{N-1} \frac{N-k}{k^3}$

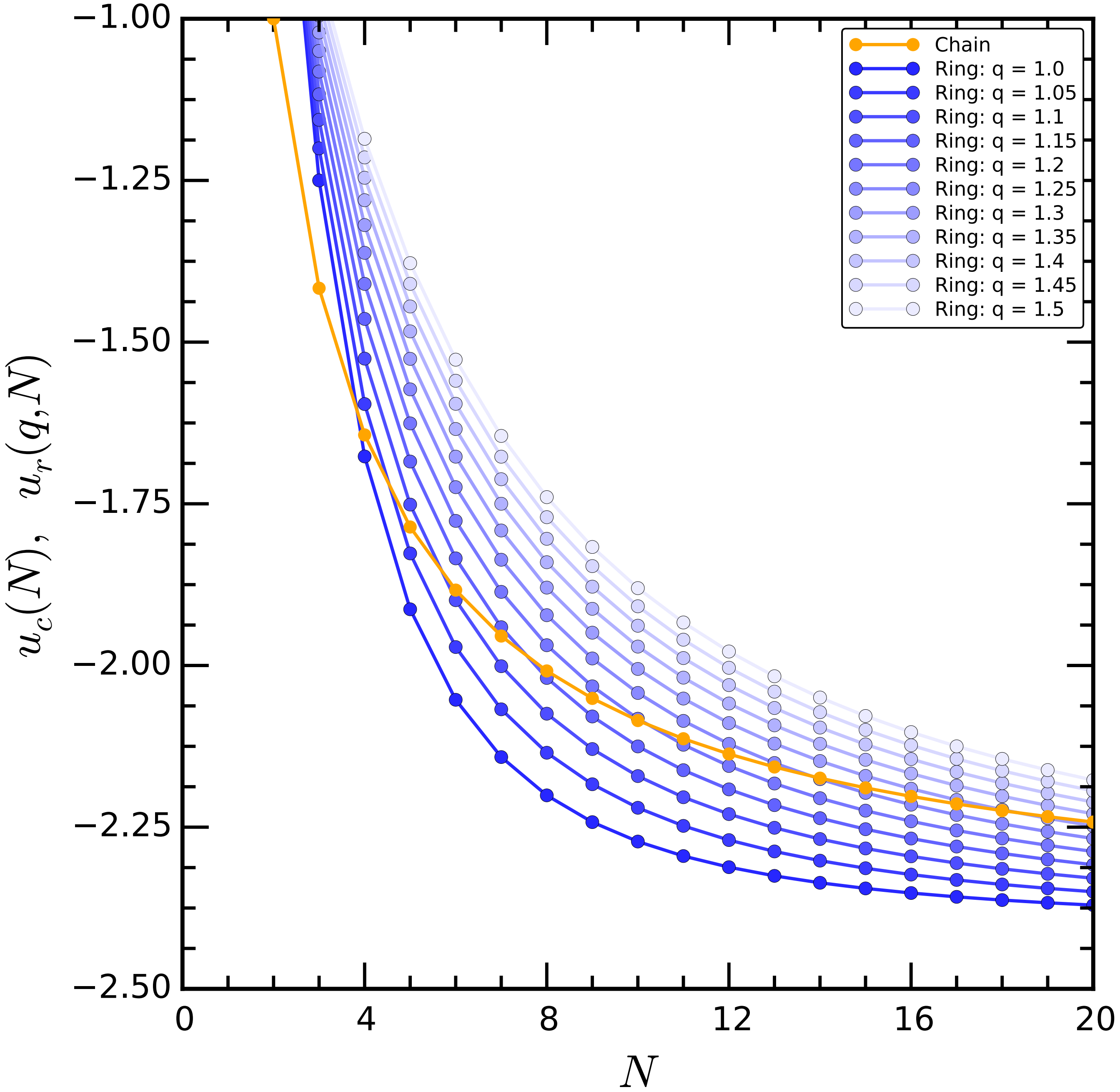


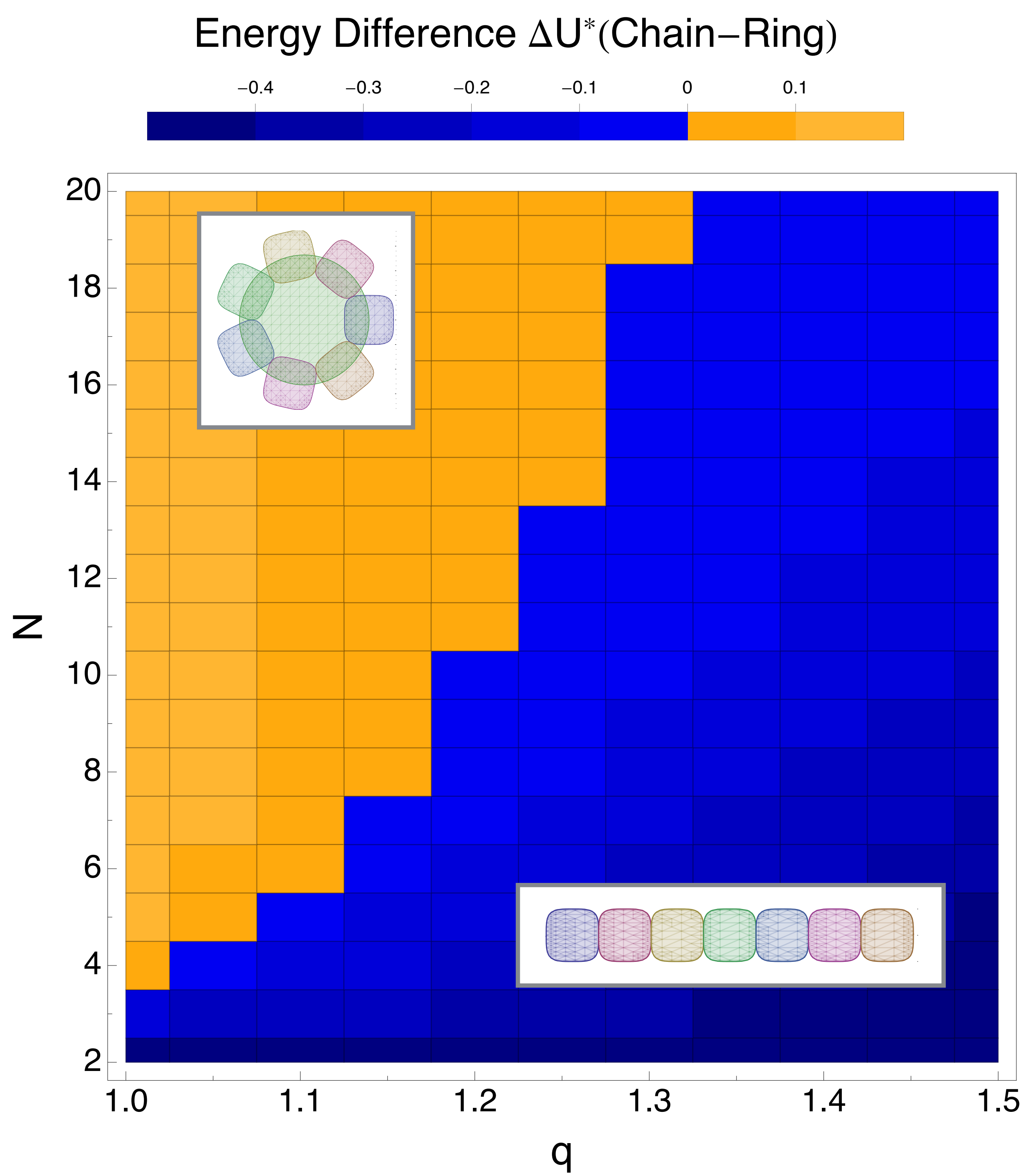


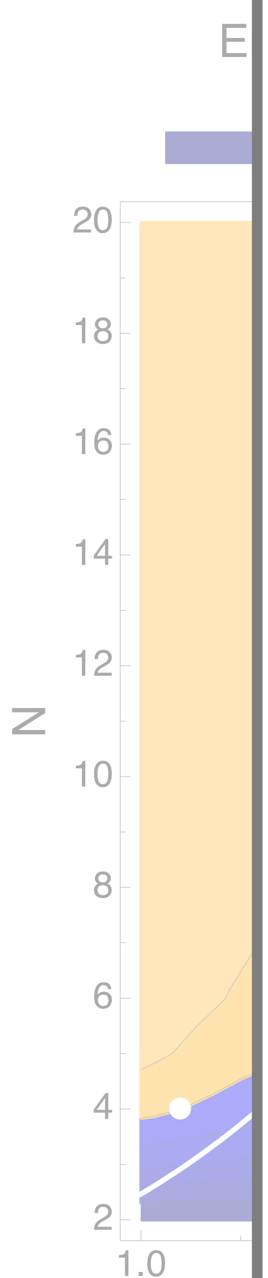


What we now know

Super-ball ground state - [001]







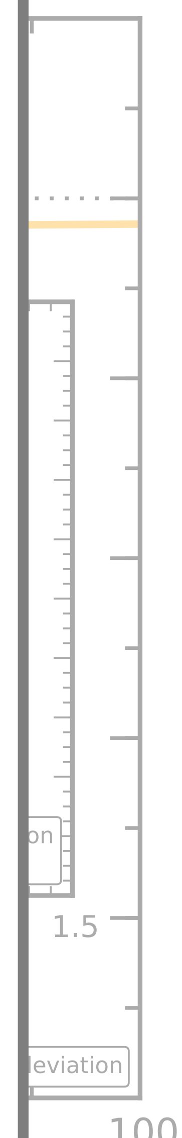
Ring-chain transition

$$u_r(q, N) = u_c(N)$$

$$\cot^{\frac{2q}{2q-1}}\left(\frac{\pi}{N}\right) + 1 = \left[\frac{\tilde{u}_r(N)}{u_c(N)}\right]^{\frac{2q}{3(2q-1)}}$$

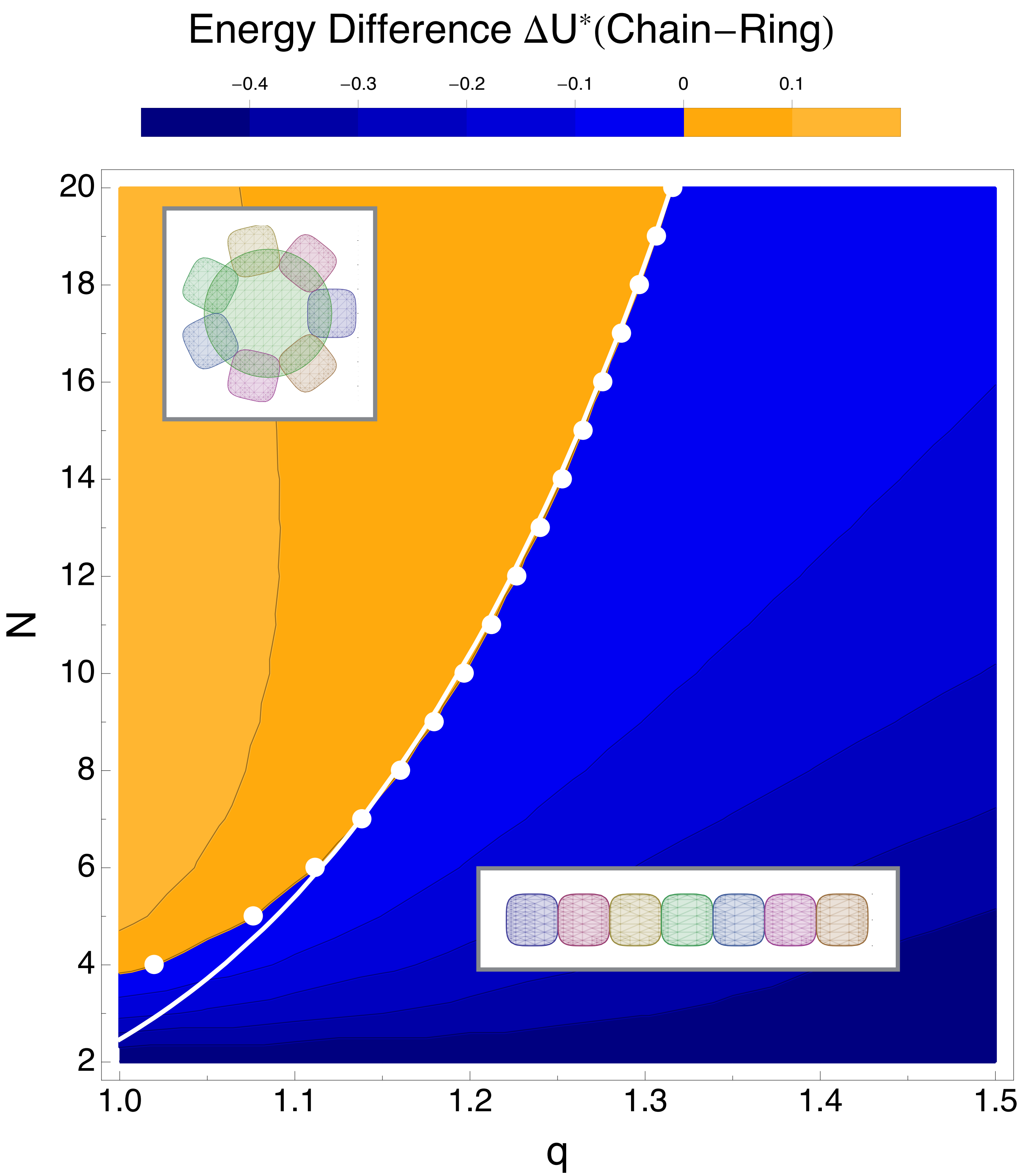
Large N approx

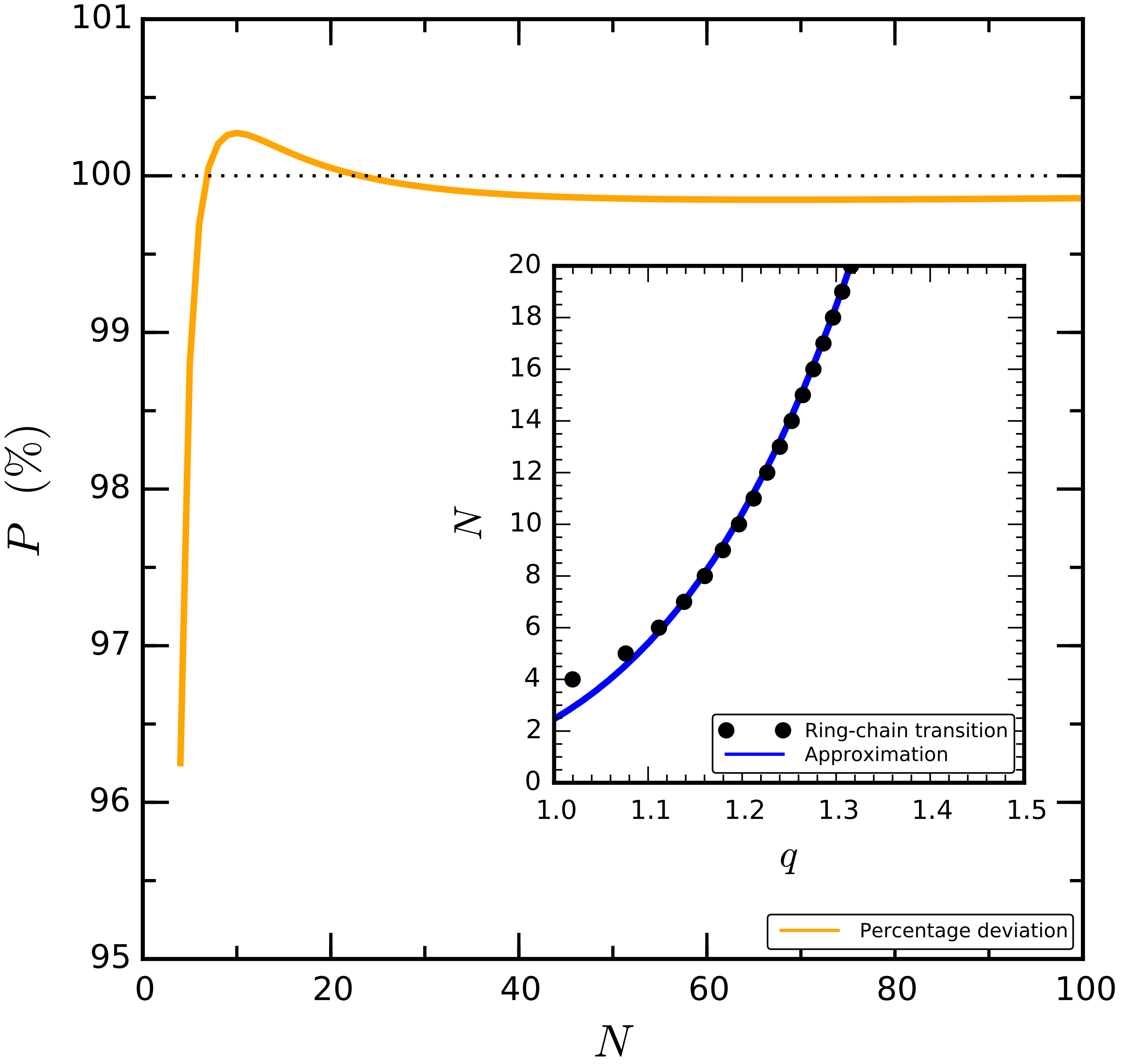
$$N(q) = \pi^{2q}\left[\frac{3(2q-1)\zeta(3)}{2q\zeta(2)}\right]^{2q-1} - \left[\frac{(2q-1)\zeta(3)\pi^2}{\zeta(2)} + \frac{8q-3}{6}\frac{\zeta(2)}{\zeta(3)}\right]$$



What we now know

Ring-chain transition





Conclusions

- The value of q doesn't need to deviate significantly from one (sphere) to exhibit properties similar to that of perfect dipolar cubes.

- Ring-chain GS transition occurs for N increasing with increasing q.

Acknowledgements

Dr. Sofia Kantorovich

&

The Univie Dipolar Soft Matter Group

Der Wissenschaftsfonds.

Thanks for listening