Chiral particles in micro-flows

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NORDITA

Soft Matter

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PAPER

Separation of chiral colloidal particles in a helical flow field†

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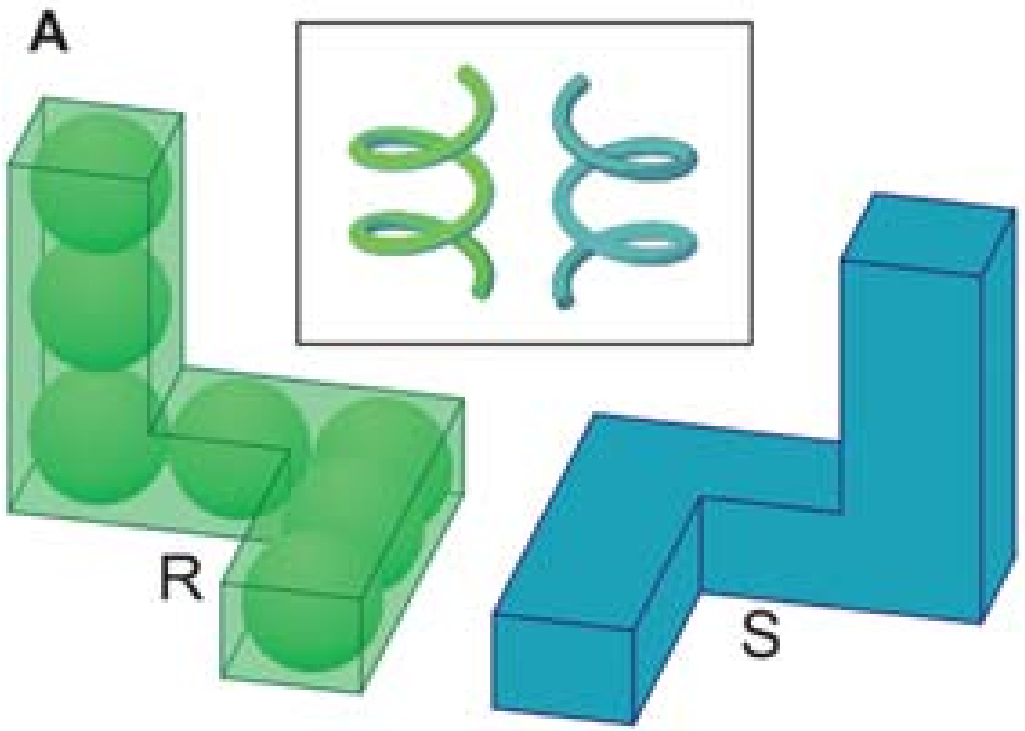
Maria Aristov,[ac] Ralf Eichhorn[b] and Clemens Bechinger*[ac]

Chiral Particles



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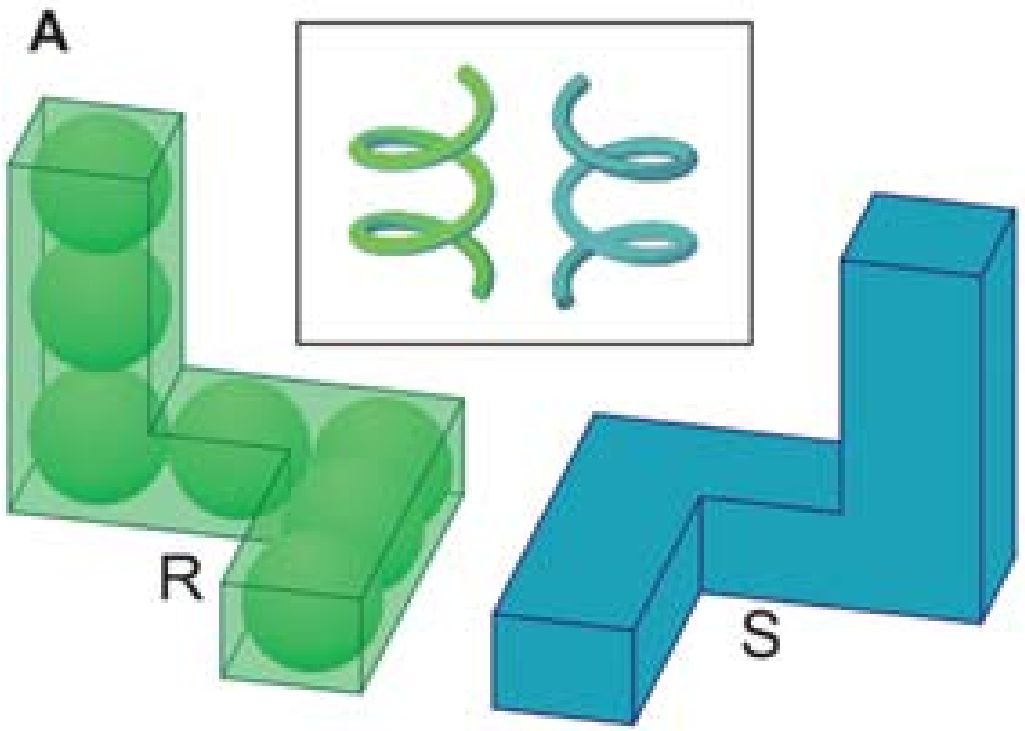
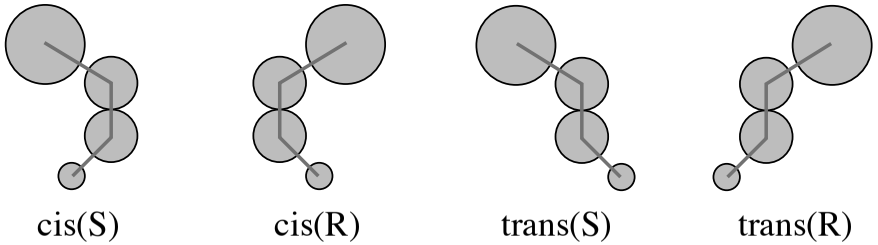


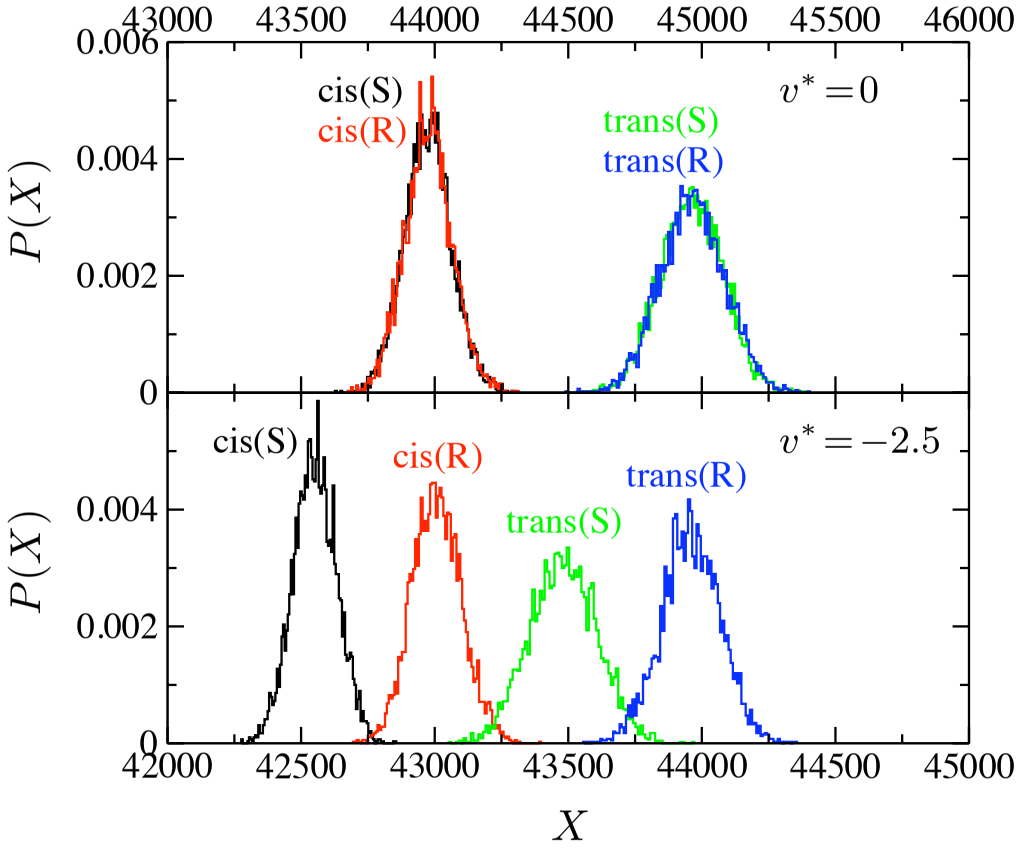
Is it possible to differentiate between
mirror-imaged particles
in fluid flows?

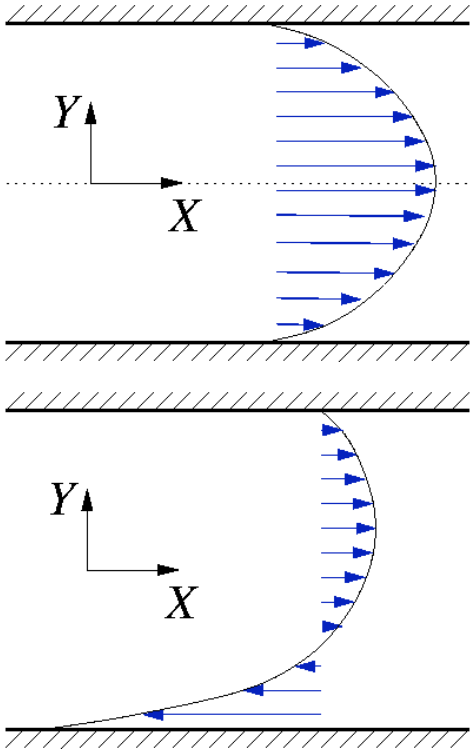
Chiral Separation: Theory

more general:

stereoisomer separation







[PRL **105**, 034502 (2010)]

Chiral Separation: Theory

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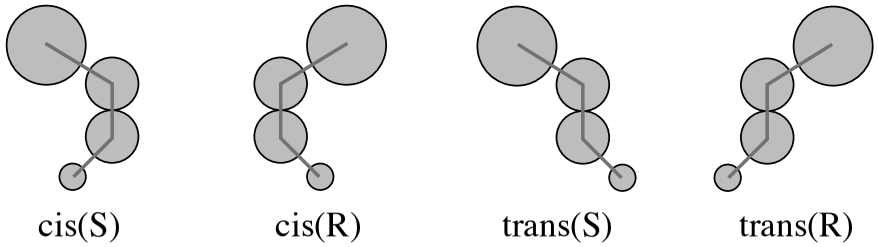
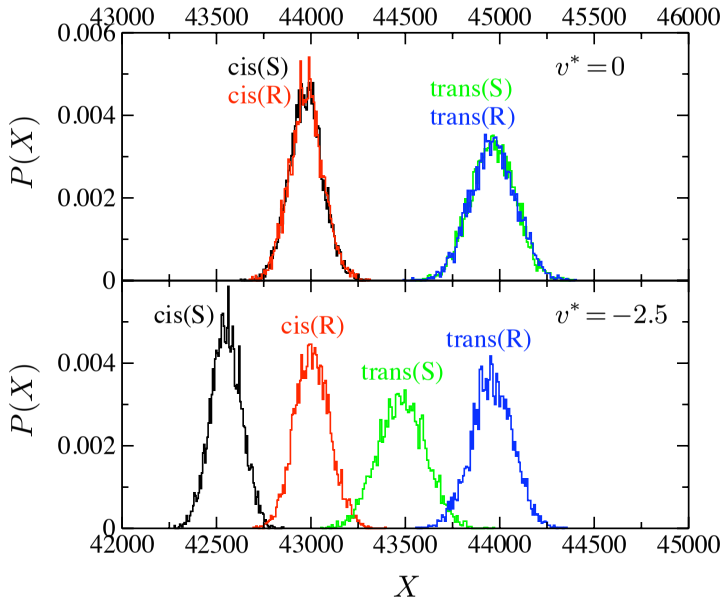
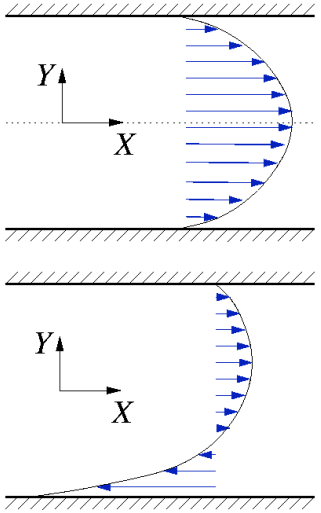






example: $B \approx 5\,\mu$m, $T = 293\,$K, monomer sizes ≈ 250–$750\,$nm

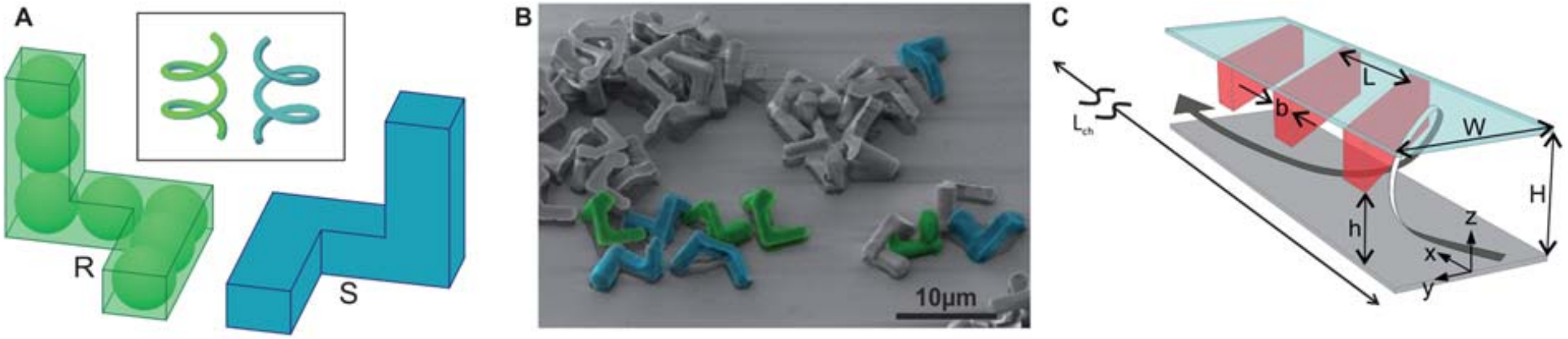
$v_0 \approx 10\,\mu$m/s, $v^* \approx -0.5\,\mu$m/s

$\Rightarrow$ separation distance $\approx 4.5\,$cm, separation time $\approx 4700\,$s

[PRL **105**, 034502 (2010)]

Chiral Separation: Experiment

(Maria Aristov, Clemens Bechinger, Stuttgart University)



[Soft Matter **9**, 2525 (2013)]

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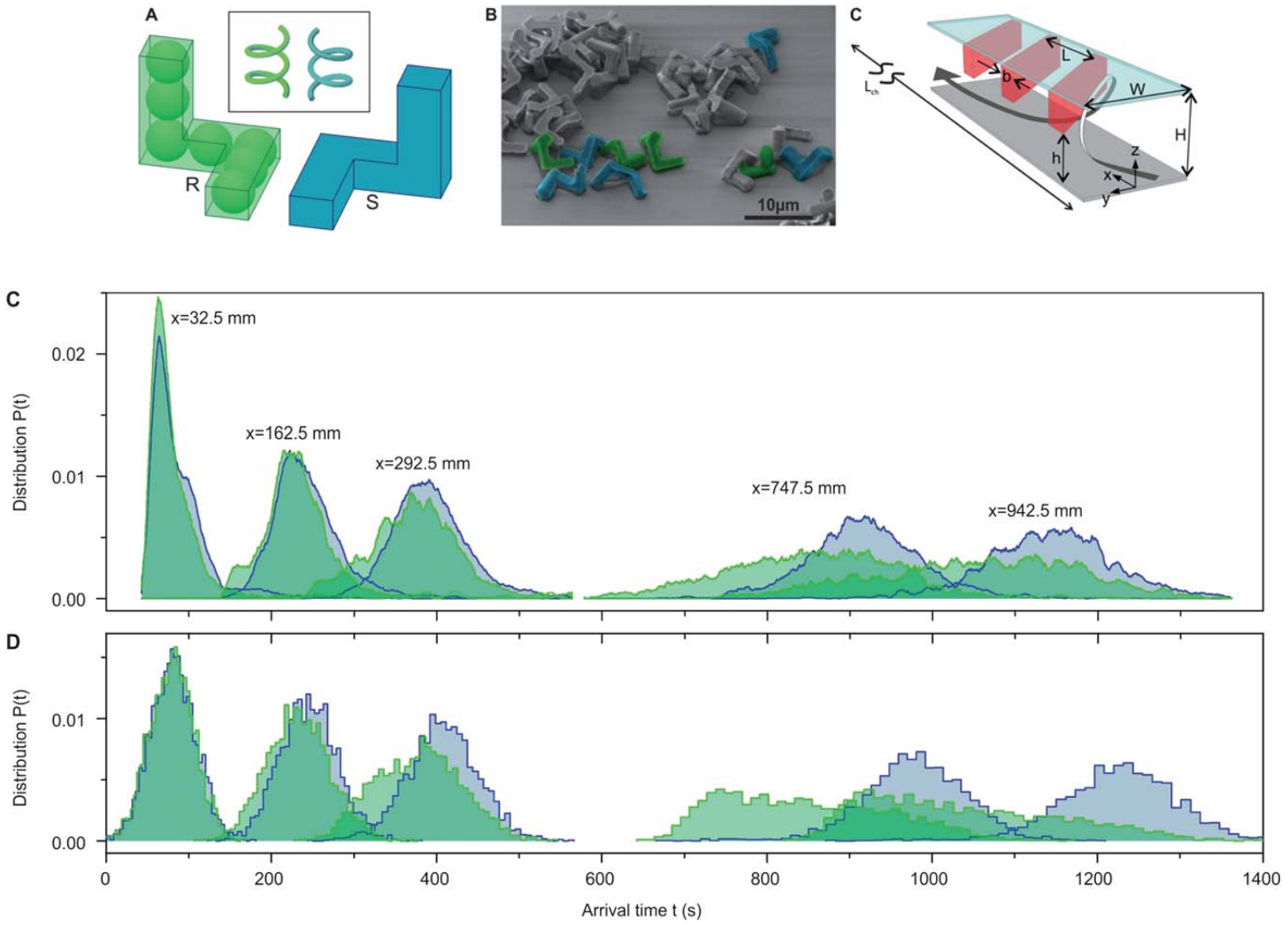
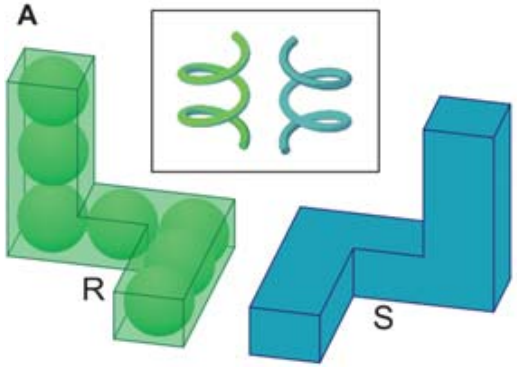


[Soft Matter **9**, 2525 (2013)]

Chiral Separation: Model



$$
\begin{aligned}
0 &= -\eta_i^t(\dot{\vec{r}}_i - \vec{u}_i) + \vec{F}_i \\
0 &= -\eta_i^r(\dot{\vec{\varphi}}_i - \vec{\omega}_i) + \vec{T}_i
\end{aligned}
$$

$$
\begin{aligned}
\dot{\vec{r}}_i &= \sum_j \mu_{ij}^{tt}\vec{F}_j + \sum_j \mu_{ij}^{tr}\vec{T}_j + \vec{v}(\vec{r}_i) \\
\dot{\vec{\varphi}}_i &= \sum_j \mu_{ij}^{rt}\vec{F}_j + \sum_j \mu_{ij}^{rr}\vec{T}_j + [\vec{\nabla}\times\vec{v}(\vec{r}_i)]/2
\end{aligned}
$$

$$
\Rightarrow \quad \begin{pmatrix} \dot{\vec{r}} \\ \dot{\vec{\varphi}} \end{pmatrix} = \begin{pmatrix} \mu^{tt} & \mu^{tr} \\ \mu^{rt} & \mu^{rr} \end{pmatrix} \begin{pmatrix} \vec{F} \\ \vec{T} \end{pmatrix}
$$

[Soft Matter **9**, 2525 (2013)]

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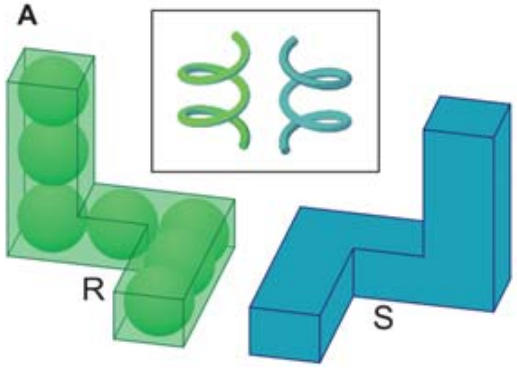

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$$

with $\quad \langle \xi_i(t)\xi_j(s)\rangle = 2\,kT \begin{pmatrix} \mu^{tt} & \mu^{tr} \\ \mu^{rt} & \mu^{rr} \end{pmatrix}_{ij} \delta(t-s)$

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Chiral Separation: Experiment

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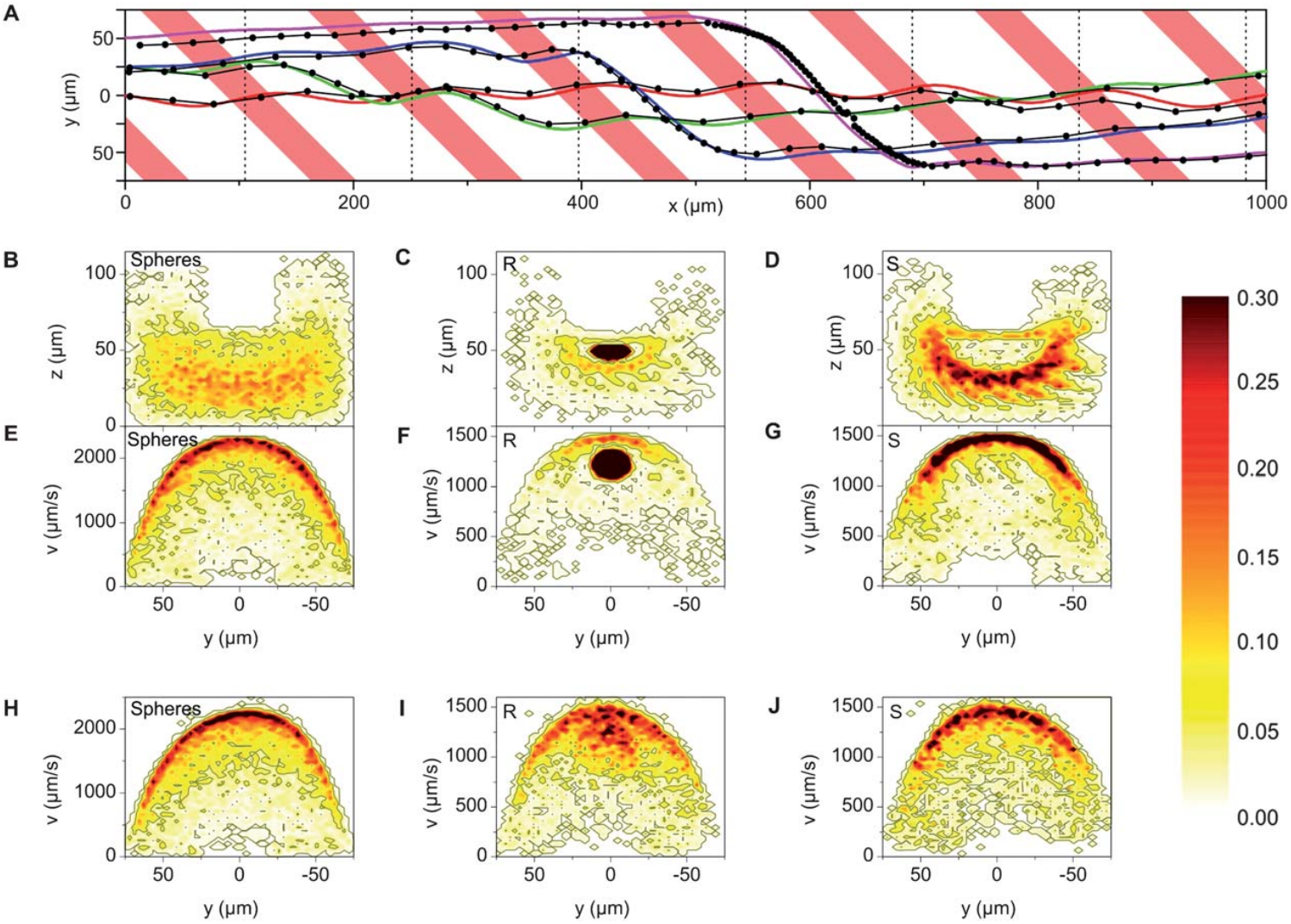

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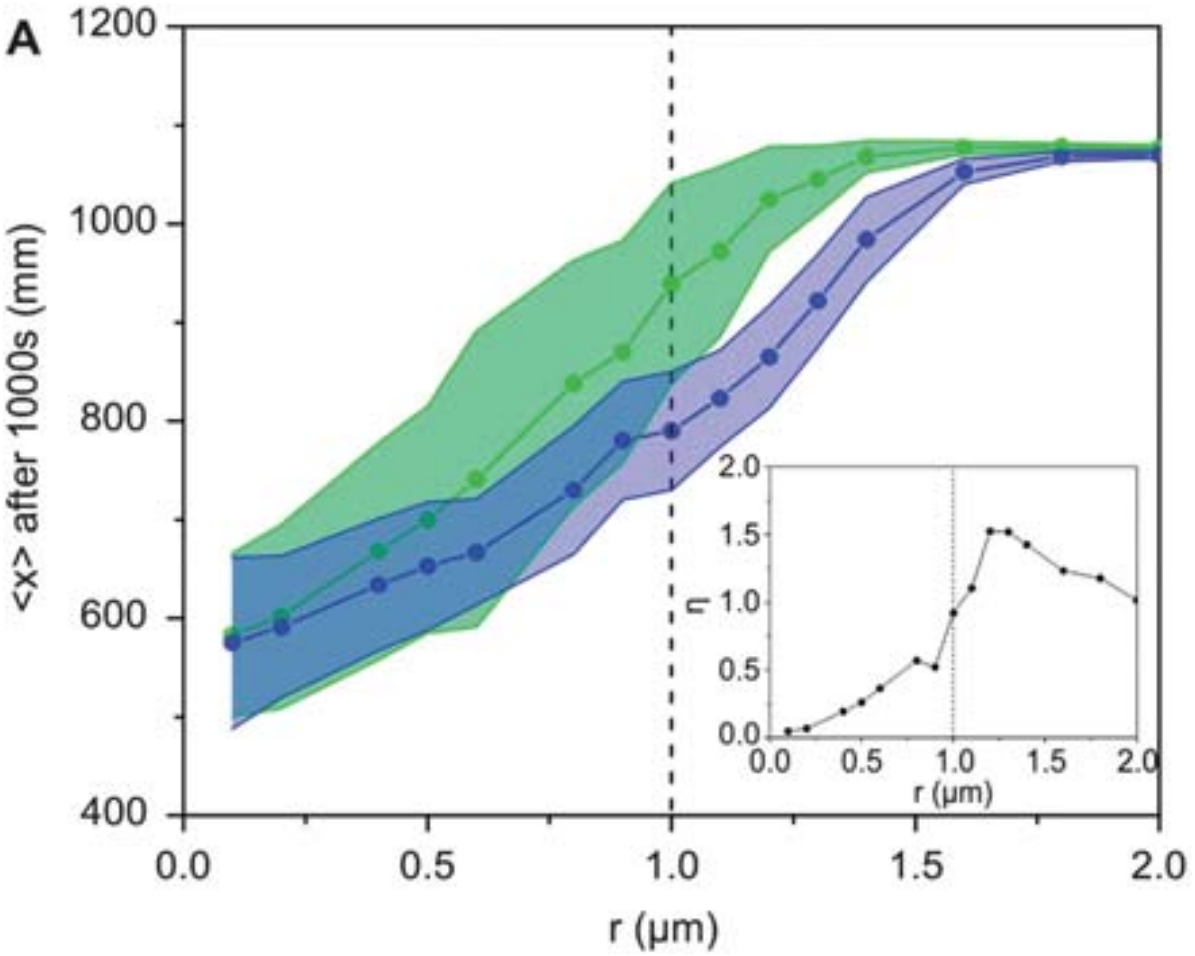

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Microfluidic devices

LAB ON A CHIP

Cover illustration
Bubbles moving in a serpentine microchannel mix red and blue streams into purple. (Courtesy of G. M. Whitesides and M. Fuerstman.)

The ability to perform laboratory operations on a small scale using miniaturized (lab-on-a-chip) devices is very appealing. Small volumes reduce the time taken to synthesize and analyse a product; the unique behaviour of liquids at the microscale allows greater control of molecular concentrations and interactions; and reagent costs and the amount of chemical waste can be much reduced. Compact devices also allow samples to be analysed at the point of need rather than a centralized laboratory.

Initially, however, pioneers of the field asked in *Chimia* whether their ideas about miniaturization would be "next century's technology or just a fashionable craze". The advantages are compelling, but designing and making devices of reduced size that operate effectively is challenging. The pioneers recognized the huge financial input and research effort needed to realize the full potential of the concept.

Now, well into that next century, it is clear that labs on chips are here to stay. Physicists and engineers are creating exciting functionality, and are starting to construct highly integrated compact devices. Chemists are using such tools to synthesize new molecules and materials, and biologists are using them to study complex cellular processes. Furthermore, labs on chips offer point-of-care diagnostic abilities that could revolutionize medicine. Such devices may find uses in other areas, including a range of industrial applications and environmental monitoring. Commercial exploitation has been slow, but is gaining pace, with some products now on the market. A technology for this century? The signs are looking good.

In this Insight, we present a collection of topical Reviews that discuss the history, design, application and future of lab-on-a-chip technologies, focusing on microfluidic flow devices. We hope you enjoy it.

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Rosamund Daw, Senior Editor
Joshua Finkelstein, Associate Editor

nature insight

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Microfluidic devices

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nature insight

microfluidic

- actuators
- valves
- pumps
- mixers
- sorters/separators

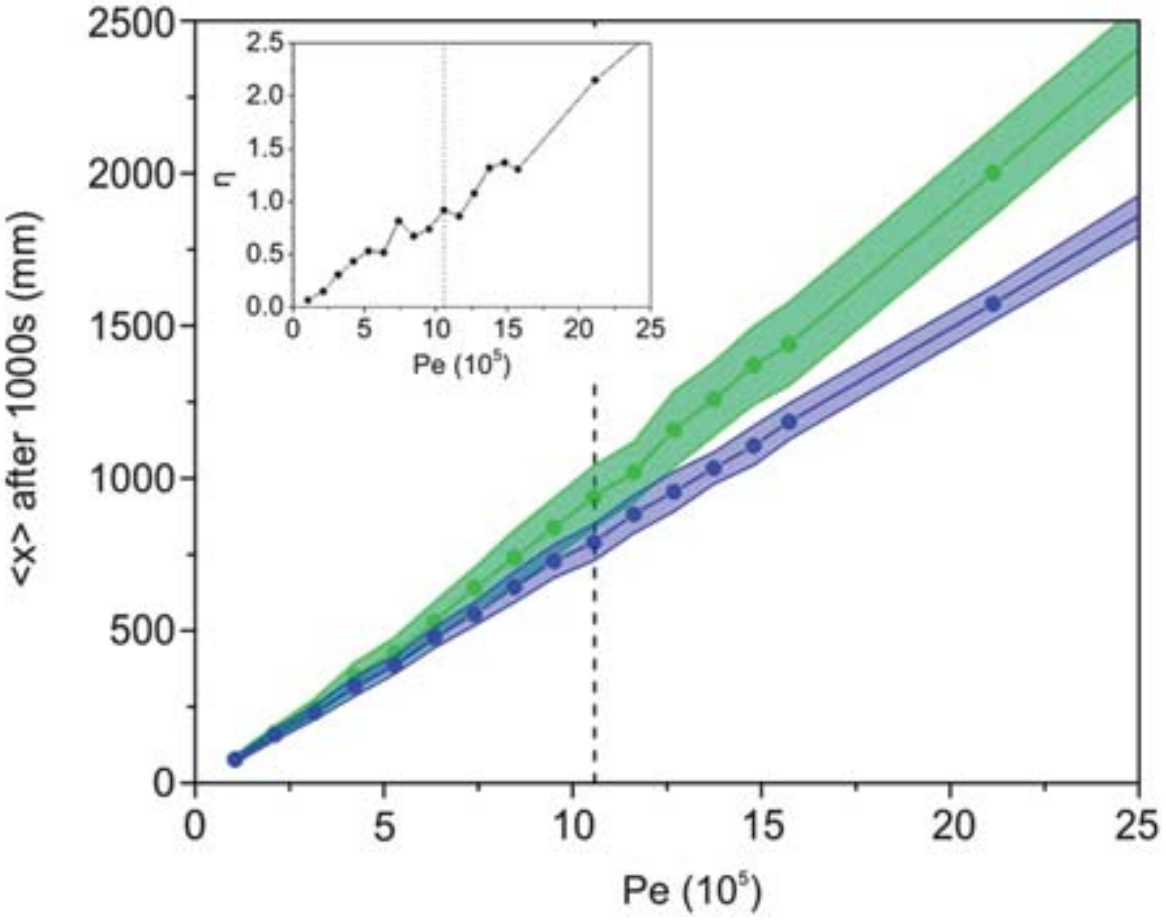
etc.

here:

label-free separation of chiral particles

Chiral Separation: Experiment

(Maria Aristov, Clemens Bechinger, Stuttgart University)



[Soft Matter **9**, 2525 (2013)]

Chiral Drugs

[I. Szelenyi et al., Drug News Perspect 1998]

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https://www.youtube.com/watch?v=Jbh9YNzkl4Q