# Chiral particles in micro-flows



## Soft Matter

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PAPER

## Separation of chiral colloidal particles in a helical flow fieldt

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Maria Aristov,<sup>ac</sup> Ralf Eichhorn<sup>b</sup> and Clemens Bechinger<sup>\*ac</sup>

## **Chiral Particles**



## **Chiral Particles**



Is it possible to differentiate between mirror-imaged particles

in fluid flows?















[PRL 105, 034502 (2010)]

 $\gtrsim$ 



### more general: stereoisomer separation









 $\Rightarrow$  separation distance  $\approx 4.5\,\text{cm},$  separation time  $\approx 4700\,\text{s}$ example:  $B \approx 5 \,\mu$ m,  $T = 293 \,\text{K}$ , monomer sizes  $\approx 250-750 \,\text{nm}$  $v_0 \approx 10 \,\mu$ m/s,  $v^* \approx -0.5 \,\mu$ m/s

[PRL 105, 034502 (2010)]

(Maria Aristov, Clemens Bechinger, Stuttgart University)



[Soft Matter 9, 2525 (2013)]

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## **Chiral Separation: Model**



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

$$\begin{split} \vec{r}_i &= \sum \mu_{ij}^{tt} \vec{F}_j + \sum \mu_{ij}^{tr} \vec{T}_j + \vec{v}(\vec{r}_i) \\ j & j & j \\ \vec{\varphi}_i &= \sum \mu_{ij}^{rt} \vec{F}_j + \sum \mu_{ij}^{rr} \vec{T}_j + [\vec{\nabla} \times \vec{v}(\vec{r}_i)]/2 \\ & \Rightarrow & \left( \begin{array}{c} \vec{r} \\ \vec{\varphi} \end{array} \right) = \left( \begin{array}{c} \mu^{tt} & \mu^{tr} \\ \mu^{rt} & \mu^{rr} \end{array} \right) \left( \begin{array}{c} \vec{F} \\ \vec{T} \end{array} \right) \end{split}$$

## **Chiral Separation: Model**



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

$$\begin{split} \vec{r}_{i} &= \sum_{j} \mu_{ij}^{tt} \vec{F}_{j} + \sum_{j} \mu_{ij}^{tr} \vec{T}_{j} + \vec{v}(\vec{r}_{i}) \\ \vec{\varphi}_{i} &= \sum_{j} \mu_{ij}^{rt} \vec{F}_{j} + \sum_{j} \mu_{ij}^{rr} \vec{T}_{j} + [\vec{\nabla} \times \vec{v}(\vec{r}_{i})]/2 \\ \Rightarrow \quad \left( \begin{array}{c} \vec{r} \\ \vec{\varphi} \end{array} \right) = \left( \begin{array}{c} \mu^{tt} & \mu^{tr} \\ \mu^{rt} & \mu^{rr} \end{array} \right) \left( \begin{array}{c} \vec{F} \\ \vec{T} \end{array} \right) + \left( \begin{array}{c} \vec{\xi}_{r}(t) \\ \vec{\xi}_{\varphi}(t) \end{array} \right) \\ \text{with} \quad \langle \xi_{i}(t) \xi_{j}(s) \rangle = 2 kT \left( \begin{array}{c} \mu^{tt} & \mu^{tr} \\ \mu^{rt} & \mu^{rr} \end{array} \right)_{ij} \delta(t-s) \end{split}$$





(Maria Aristov, Clemens Bechinger, Stuttgart University)



## **Microfluidic devices**

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Vol 442 | Issueno. 7101 | 27 July 2006



LAB ON A CHIP

and analyse a product; the unique behaviour of liquids at the microscale allows greater control of molecular he ability to perform laboratory operations into purple. (Courtesy of G. M. Whitesides and M. Fuerstman.) Bubbles moving in a serpentine microchannel mix red and blue streams Cover illustration

on-a-chip) devices is very appealing. Small volumes reduce the time taken to synthesize

on a small scale using miniaturized (lab-

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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

Now, well into that next century, it is clear that labs

needed to realize the full potential of the concept.

creating exciting functionality, and are starting to construct highly integrated compact devices. Chemists other areas, including a range of industrial applications and environmental monitoring. Commercial exploitation has been slow, but is gaining pace, with 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 on chips are here to stay. Physicists and engineers are are using such tools to synthesize new molecules Marketing Robin Black Editorial Assistant La ura Shaw

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The origins and the future of microfluidics G. M. Whitesides

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- actuators
- valves
- sdwnd
- mixers
- sorters/separators

etc.

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label-free separation here:

of chiral particles

(Maria Aristov, Clemens Bechinger, Stuttgart University)



## **Chiral Drugs**



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

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