Electronic Supplementary Material (ESI) for Soft Matter.

Electronic supplementary information (ESI)

Twisting microfluidics in a planetary centrifuge

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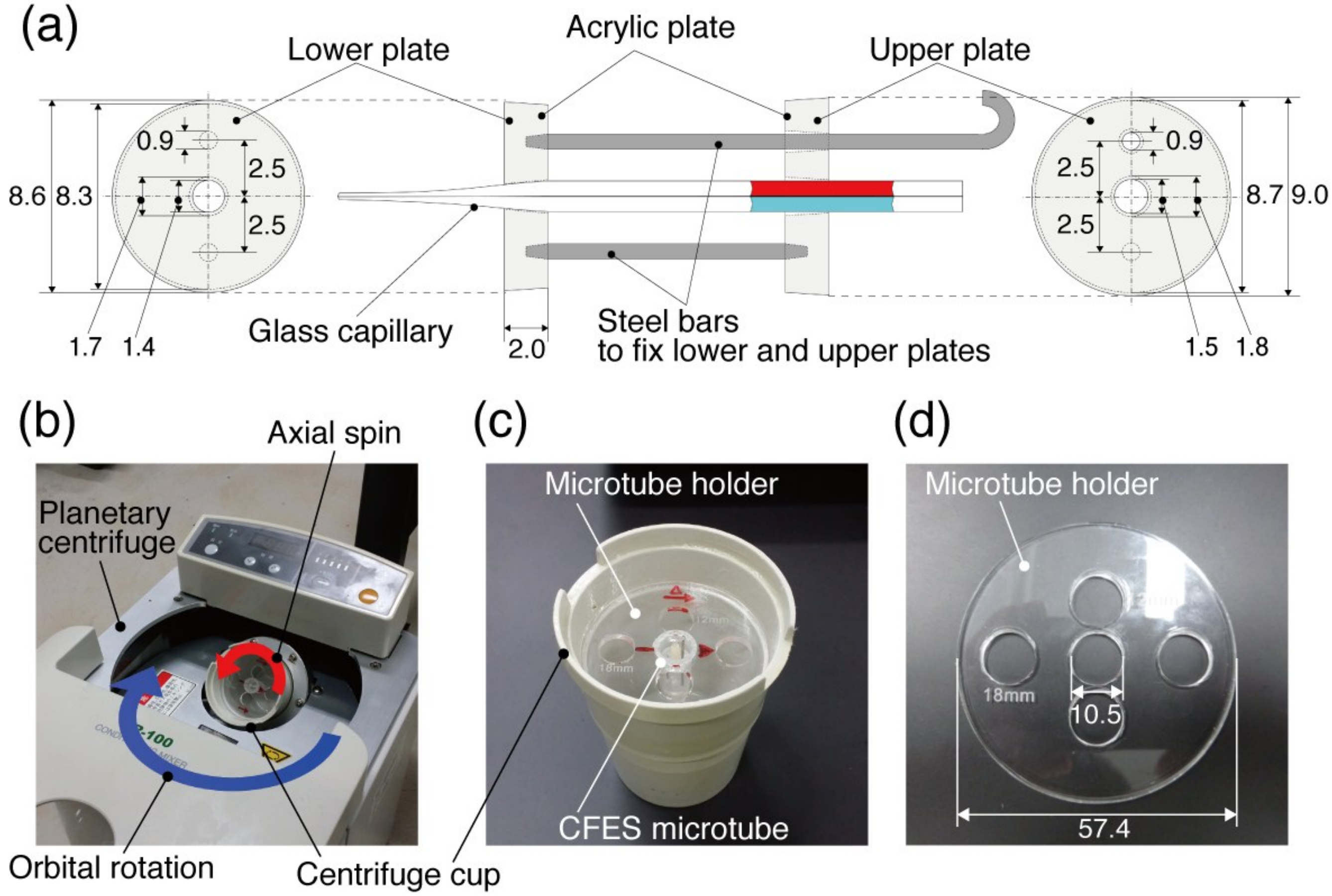

Fig. S1. Details of the centrifuge-based fluid extruding system (CFES) and the planetary centrifuge. (a) Design details of the acrylic holder used to fix the glass capillary in the CFES microtube. (b) Photograph of the inside of the planetary centrifuge. Blue and red arrows indicate the directions of rotation and spin, respectively. (c) Image of CFES microtube fixed in the centrifuge cup. (d) Design details of the acrylic microtube holder used to fix a CFES microtube in the planetary centrifuge. The unit of all lengths is mm.

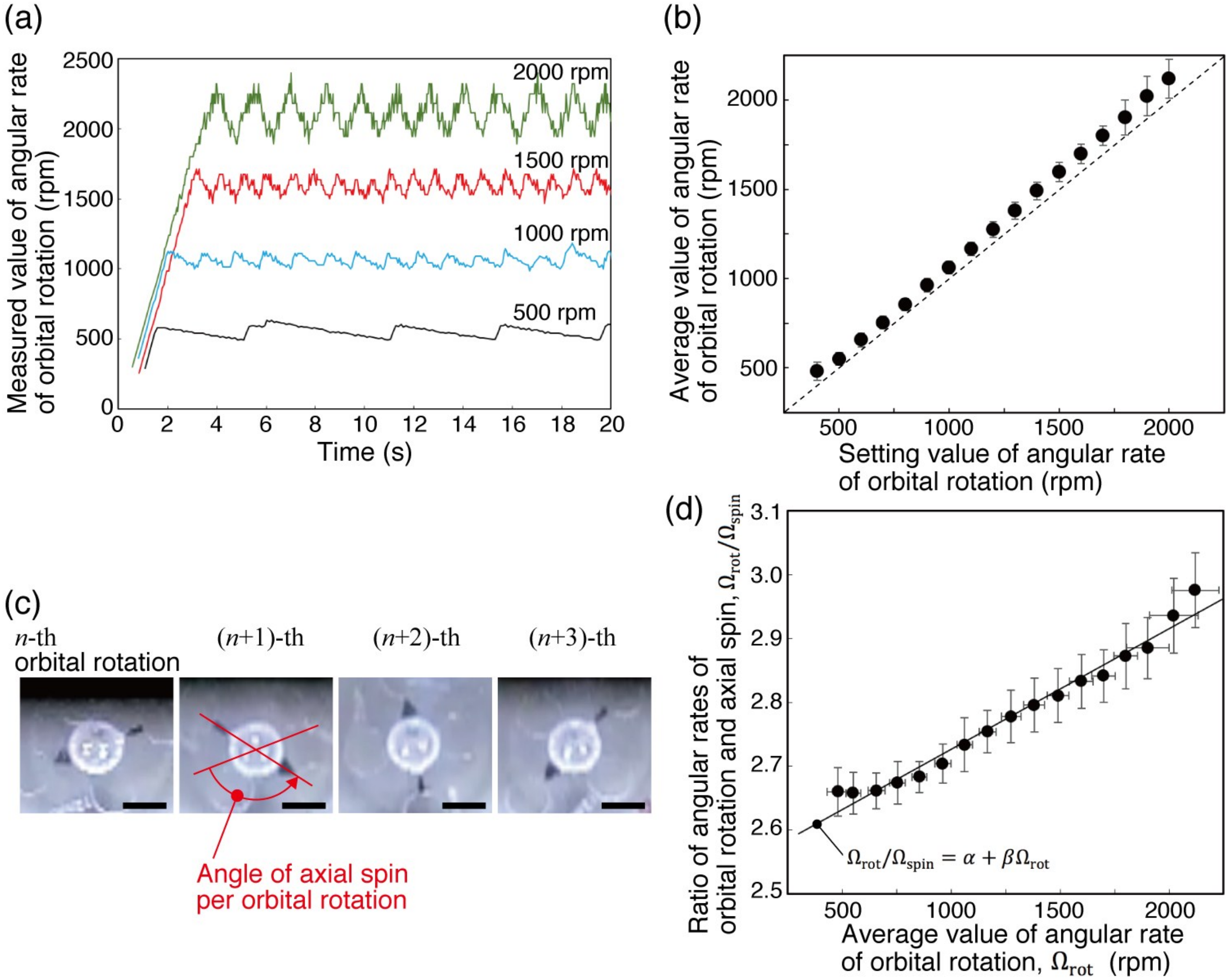

Fig. S2. Measurements of rotation and spin properties of the planetary centrifuge. (a) Time courses of the angular rate of orbital rotation, Ω_{rot}, from the beginning to 20 s. Here, $\Omega_{rot} =$ 500 rpm (black), 1000 rpm (cyan), 1500 rpm (red), and 2000 rpm (green). In this planetary centrifuge, Ω_{rot} fluctuated probably because of the centrifuge's feedback control system. The data were obtained with the use of a stroboscope function equipped in the planetary centrifuge to light up its interior during every rotation. (b) Relationship between averaged angular rates of orbital rotation Ω_{rot} and corresponding setting values. The horizontal- and vertical-axis values are identical on the broken line. (c) High-speed photographs acquired to observe the angle change in the axial spin per orbital rotation in the planetary centrifuge. The photographs were acquired with the use of the stroboscope function. The photographs show that the axial spin per orbital rotation was about 120 degrees when $\Omega_{rot} = 2120$ rpm. The black arrow serves as a marker for the spin-angle observation. Frame rate: 1200 fps. Scale bars: 10 mm. (d) Relationship between angular rates of orbital rotation Ω_{rot} and axial spin Ω_{spin}. The solid line is a fitting line ($\Omega_{rot}/\Omega_{spin} = \alpha + \beta\Omega_{rot}$) to the experimental data, with $\alpha \approx 2.5$ and $\beta \approx 1.9 \times 10^{-4}$ rpm^{-1}. In all experiments, the planetary centrifuge was operated in the mixing mode.

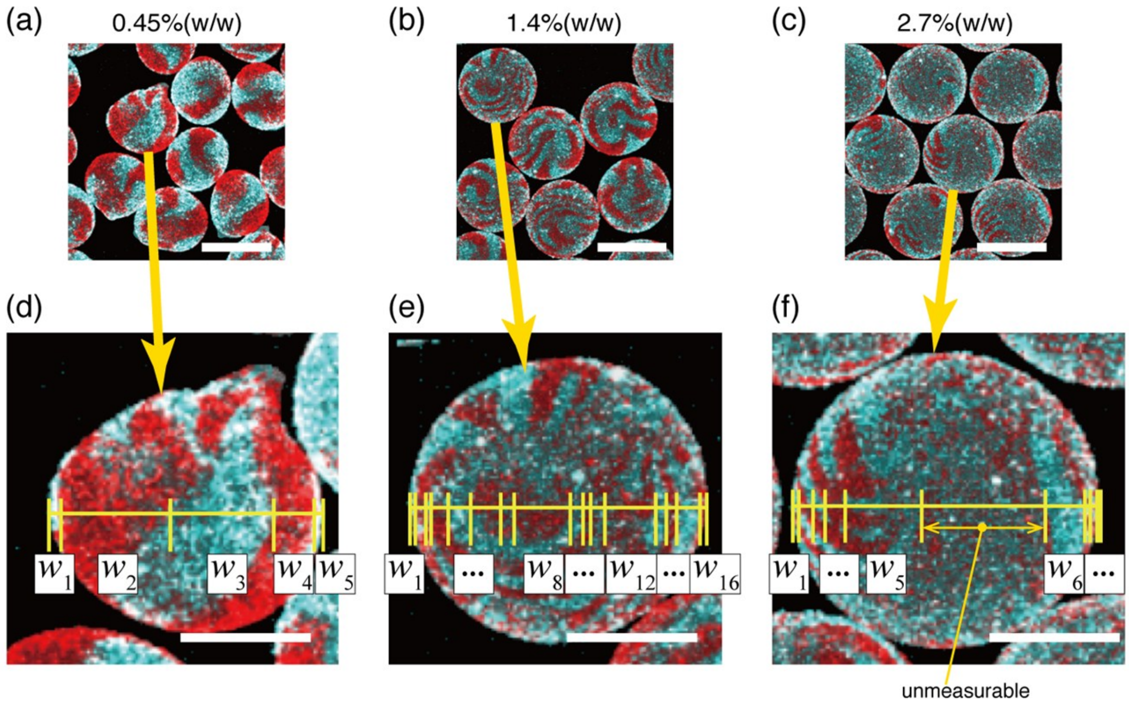

Fig. S3. Semi-quantitative measurement of stripe coarseness M. (a), (b), and (c) 3D-reconstructed images of CLSM observations of stripe-patterned microbeads generated using sodium alginate sol with $c_{alg} = 0.45$% (w/w) (a), 1.4% (w/w) (b), and 2.7% (w/w) (c). (d), (e), and (f) Typical examples of the measurements of the width of the *k*-th measurable stripe w_k of a stripe-patterned microbead. First, a line was drawn along the diameter of the bead; then, vertical lines were drawn at the intersections of the diameter line and stripe edges; finally, the lengths between the vertical lines were measured as w_k, and $M = \left\{ \sum_{k=1}^{n} \left(w_k / d_{\text{bead}} \right) \right\} / n$ was calculated, where *n* represents the total number of measurable stripes in the bead and d_{bead} represents the bead diameter (see also Fig. 2d). When stripes were too fine or fluorescent nanobeads in the microbead were almost homogeneously mixed, we judged such areas as unmeasurable areas (e.g., (f)), and we did not include such areas in the calculation of M. M is defined as an average measurable stripe width, and should be used as a semi-quantitative index of the stripe coarseness of the bead. Scale bars: 200 μm for (a)-(c) and 100 μm for (d)-(f).

Definition of coefficient of determination

We used the standard definition of the coefficient of determination R^2 for estimating the goodness of data fitting:

$$R^2 \equiv 1 - \frac{\sum_{i=1}^{N} \{y_i - f(x_i)\}^2}{\sum_{i=1}^{N} \{y_i - \bar{y}\}^2}, \qquad (S1)$$

where (x_i, y_i) $(i = 1, 2, \cdots, N)$ represents the observed experimental data (N: data point number); $f(x)$ is a fitting model; and $\bar{y} = \frac{1}{N}\sum_{i=1}^{N} y_i$.