Abstract Submitted
for the MAR16 Meeting of
The American Physical Society

Mirror-symmetry breakings in human sperm rheotaxis NORBERT STOOP, Massachusetts Inst of Tech-MIT, ANTON BUKATIN, IGOR KUKHTEVICH, Russian Academy of Sciences, St. Petersburg Academic University, JOERN DUNKEL, Massachusetts Inst of Tech-MIT, VASILY KANTSLER, University of Warwick — Rheotaxis, the directed response to fluid velocity gradients, has been shown to facilitate stable upstream-swimming of mammalian sperm cells along solid surfaces, suggesting a robust mechanism for long-distance navigation during fertilization. However, the dynamics by which a human sperm orients itself w.r.t. ambient flows is poorly understood. Here, we combine microfluidic experiments with mathematical modeling and 3D flagellar beat reconstruction to quantify the response of individual sperm cells in time-varying flow fields. Single-cell tracking reveals two kinematically distinct swimming states that entail opposite turning behaviors under flow reversal. We constrain an effective 2D model for the turning dynamics through systematic large-scale parameter scans, and find good quantitative agreement with experiments. We present comprehensive 3D data demonstrating the rolling dynamics of freely swimming sperm cells around their longitudinal axis. Contrary to current beliefs, this analysis uncovers ambidextrous flagellar waveforms and shows that the cells turning direction is is not defined by the rolling direction. Instead, the different rheotactic turning behaviors are linked to a broken mirror-symmetry in the midpiece section, likely arising from a buckling instability.

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Date submitted: 06 Nov 2015 Electronic form version 1.4