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Capturing the continuous complexity of natural behavior in the movement of C. elegans TOSIF AHAMED, OIST Graduate University, GREG STEPHENS, Vrije Universiteit Amsterdam and OIST Graduate University — Progress in imaging and machine vision has made it possible to quantify animal movement at unprecedented spatiotemporal scales and resulting analyses have suggested a picture of behavior composed of discrete, stereotyped motifs and transitions between them. However this description is only an approximation to more fundamental continuous dynamics and ignores the variability within each motif. Here, we combine video tracking of the nematode C. elegans with concepts from nonlinear dynamics to reconstruct the phase space of the worms locomotion. We show that the dynamics lie on a 6D attractor, which is globally composed of three sets of cyclic trajectories that form the animal's most stereotyped behaviors: forward, backward and turning locomotion. In contrast to such global stereotypy, we also observe substantial local variability, which is reflected in positive Lyapunov exponents for each set of cycles. Across the full attractor we find that the Lyapunov spectrum is symmetric about a small negative value, suggesting a dissipative Hamiltonian structure in the underlying dynamics. Finally, we estimate the Kolmogorov-Sinai entropy through the sum of the positive exponents to show that local variability decreases as the animals adapt from a diffusive to a ballistic search strategy.

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