

Serotonergic Axons

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Physics



Interdisciplinary Team



(left to right)

Thomas Vojta, Physicist, Missouri S&T, Rolla, MO, USA

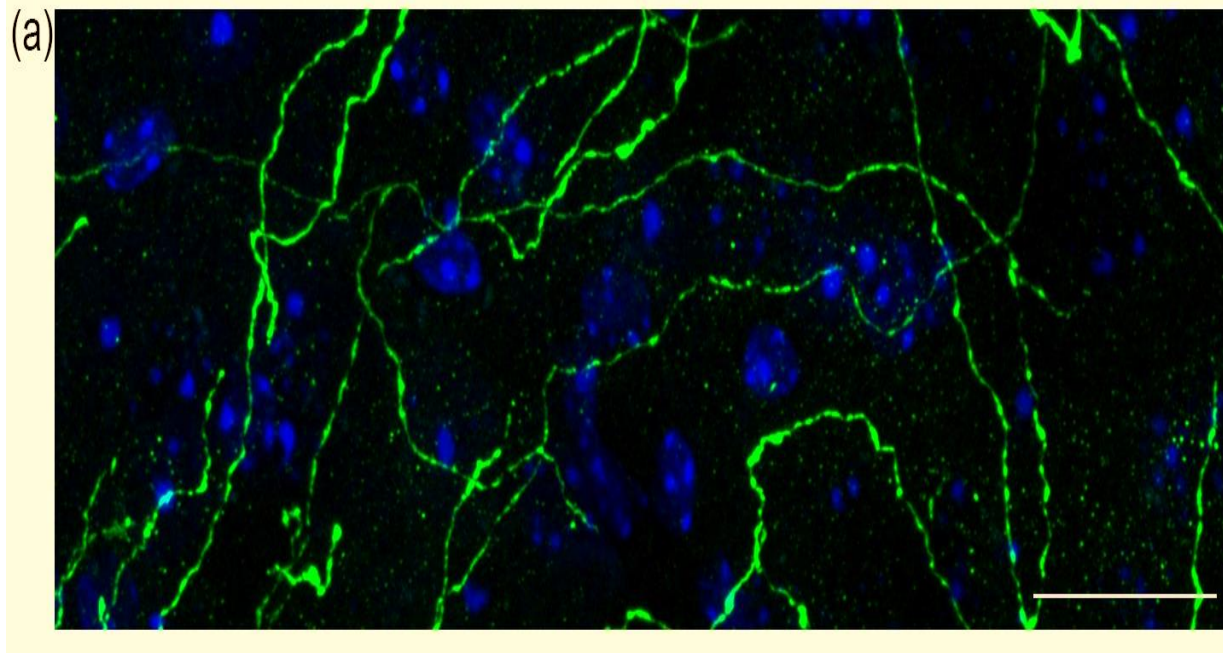
Skirmantas Janusonis, Neuroscientist, UCSB, Santa Barbara, CA, USA

Ralf Metzler, Mathematical Physicist, Potsdam, Brandenburg, Germany

Serotonin – A Neurotransmitter

- Crucial role in the central nervous system: affecting mood, behavior, cognition, learning, memory, appetite, and sleep
- 98% of serotonin in humans is OUTSIDE the central nervous system
- 1-2% found in the brain is very important, medical professionals attempt to correct imbalances in the CNS

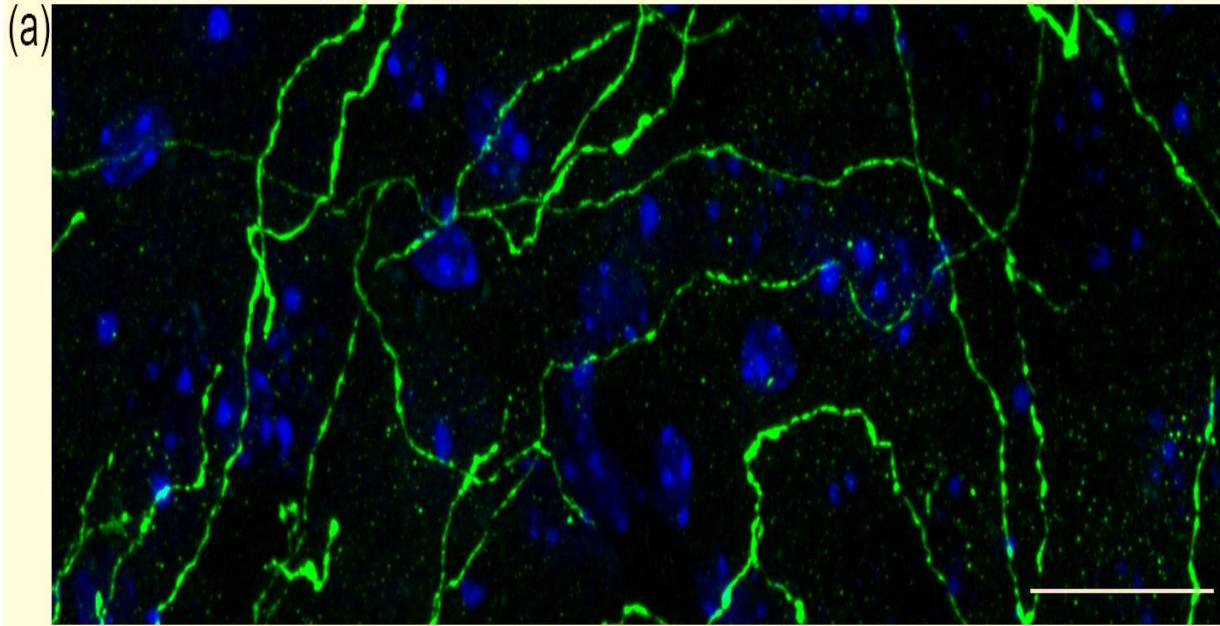
Serotonergic Axons



Green axons; Blue nuclei; 20 μm scale bar

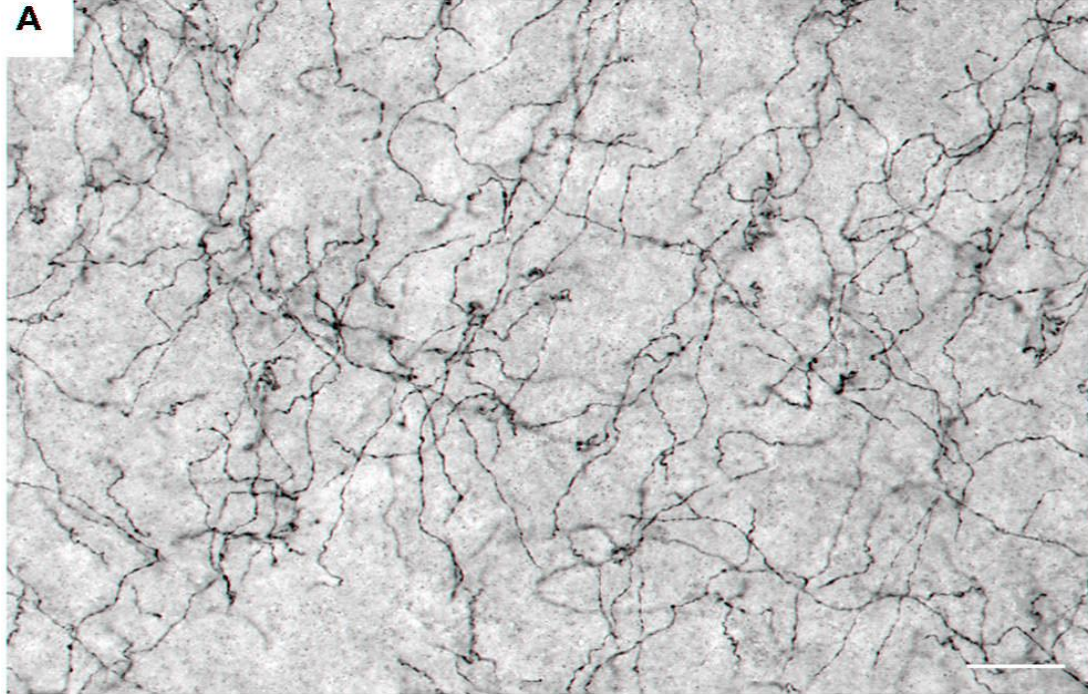
Axon: part of nerve cell that transmits signals using electric potential and/or chemical neurotransmitters

Project Goals: Understanding Inhomogeneous Fiber Distribution



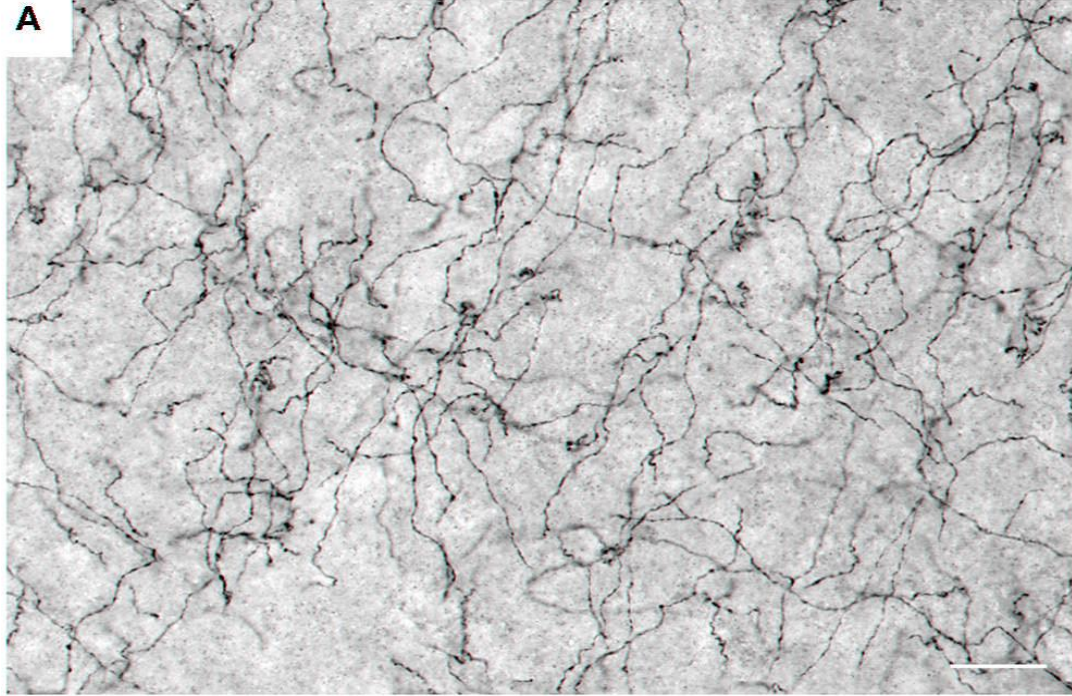
- Analyze inhomogeneous random network
- Develop mathematical concepts and tools
- Model the fiber network in 3 dimensions
- Compare simulations with anatomical data

Modeling



- Trajectories seem random
- Less jagged than traditional Brownian Motion

Modeling: FBM

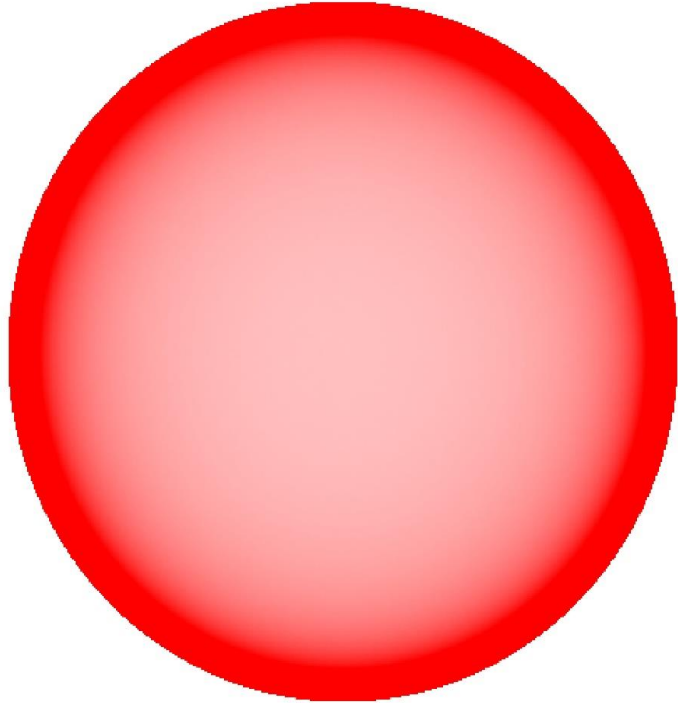


Fibers from mouse
brain



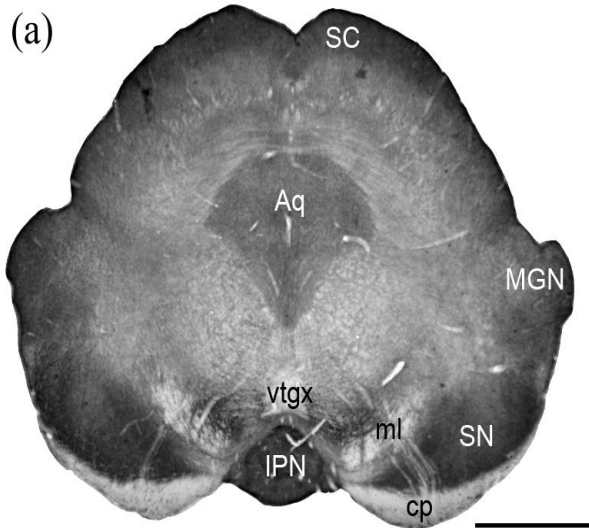
Simulated FBM sample
paths

Test Calculations

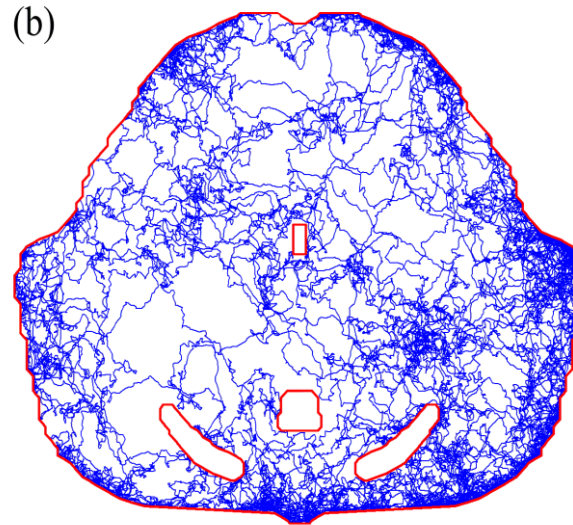


- Used Monte Carlo 2D simulations of reflected FBM
- Modeled the densities of serotonergic fibers in a disk with a bounded radius

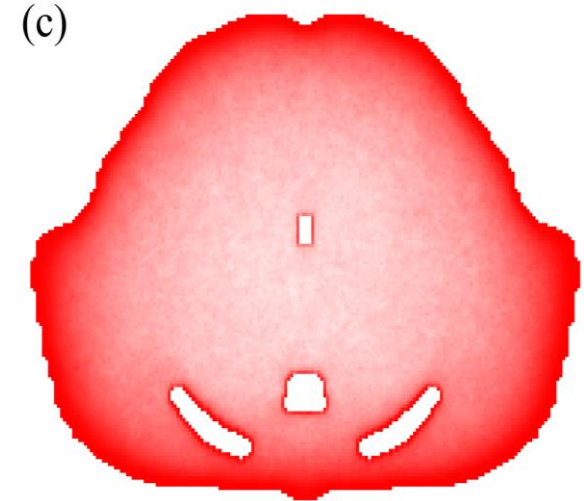
Modeling: Mouse Brain



Cross section of a mouse midbrain



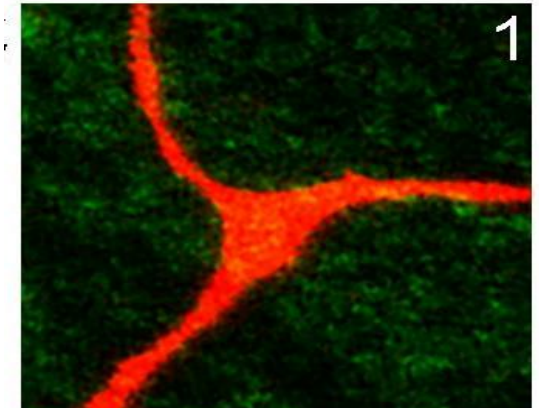
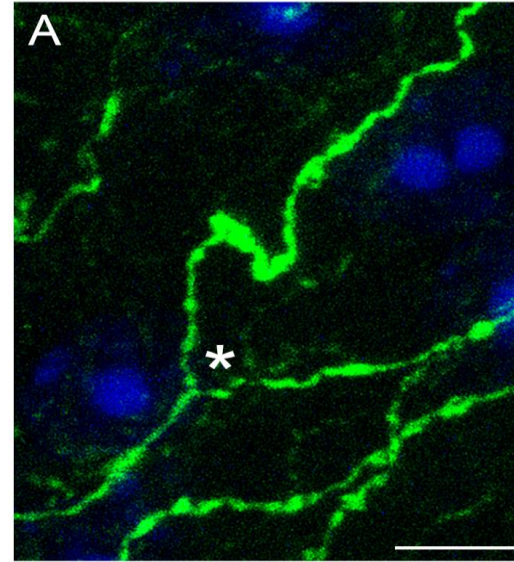
Single fiber modeled as a superdiffusive FBM trajectory



Heat map of the simulated fiber density (192 fibers)

Paths to Take

- 3-dimensional brain geometry
- Branching of fibers
- Non-uniform growth conditions
- Interactions between fibers



Summary

- **Interdisciplinary project, coordinating the work of mathematicians, physicists, and neurobiologists**
- **Analyze network of serotonergic fibers and modify a model to incorporate aspects and features with precision**
- **Result will contribute to fundamental understanding of impact of altered fiber densities, support development of new approaches to medical applications**

Thank
You



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