ODE/PDE α-synuclein Models for Parkinson's Disease

William E. Schiesser

This book discusses a mechanism for the evolution of Parkinson's disease (PD) based on the dynamics of the protein α-synuclein (α-syn), a monomer (mono) that has been implicated in PD. Specifically, mono α-syn misfolds and aggregates into a polymer (poly form), which can interfere with the functioning of neurons that then leads to neurodegenerative pathology.

The transition of α-syn from the mono form to the poly form is modeled mathematically by a system of convection-diffusion-reaction ordinary/partial differential equations (ODE/PDEs). The physical system is a neuron which is a long, slender cell with two ends, the soma and the synpase. The ends are assumed to have spatially uniform concentrations of α-syn, mono and poly, and are therefore modeled by ODEs.

The connecting axon has a significant length and therefore is modeled by PDEs. The solution of the ODE/PDE system gives the α-syn (mono and poly) concentrations as a function of space and time.

The computer-based integration (solution) of the ODE/PDEs is implemented with a series of documented R routines that are available via a download link so that the reader can duplicate the solutions reported in the book, then use the ODE/PDE model in computer-based experiments, for example, by varying the parameters and changing the form and number of ODE/PDEs, or through the implementation of an alternative model.

These suggested uses of the model illustrate an important feature of computer-based modeling, that is, the readily available procedure of numerically experimenting with a model. This experimentation might be guided by recent knowledge and data. The current model is offered as only a first step toward the resolution of the urgent PD medical problem.

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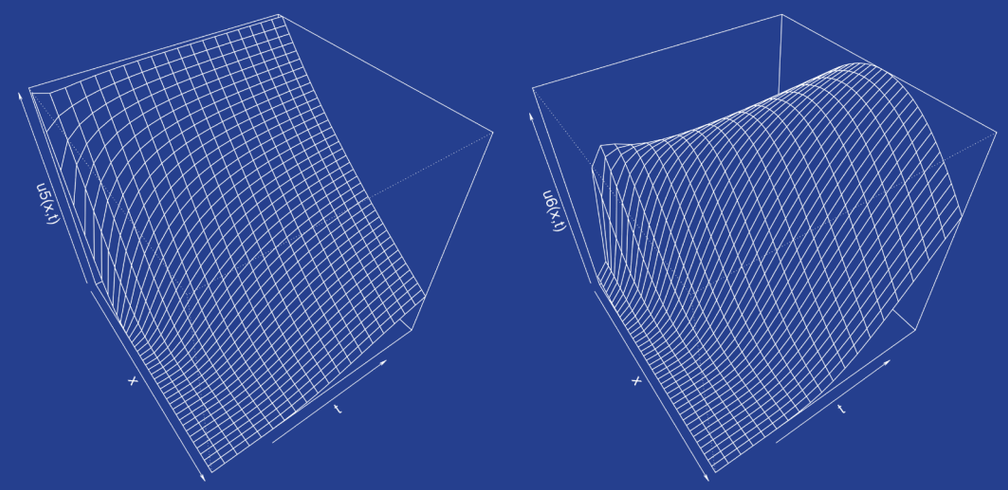

$$\frac{\partial u_5}{\partial t} = -v_5 \frac{\partial u_5}{\partial x} + D_5 \frac{\partial^2 u_5}{\partial x^2} - k_1 u_5 - k_2 u_5 u_6$$

$$\frac{\partial u_6}{\partial t} = -v_6 \frac{\partial u_6}{\partial x} + D_6 \frac{\partial^2 u_6}{\partial x^2} + k_1 u_5 + k_2 u_5 u_6$$

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