Neural geometrodynamics: a psychedelic perspective

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We explore the mathematical framework for the interaction of neural and connectivity dynamics of neural models in the light of distinct timescales and in the context of psychedelics. The shortest timescales characterize the system's dynamics as determined by (very fast) ephaptic and (fast) synaptic coupling. Trajectories within the resulting dynamical landscape are shaped by the structure of a differential equation and its connectivity parameters. However, as in terrestrial landscapes, connectivity evolves over slower timescales reflecting state-dependent and state-independent plasticity mechanisms. These two forms of plasticity are described by an equation governing the dynamical adaptation of connectivity. Finally, we introduce an ultraslow time scale relevant to the dynamics of plasticity processes (metaplasticity) and discuss it in the context of psychedelics. Drawing inspiration from the equations of general relativity, which define the interlocked dynamics of spacetime geometry and matter/energy, we employ the term neural geometrodynamics to describe the coupled dynamics of neuron population and connectivity state. Just as the spacetime metric evolves, so does the geometry of the neural phase space, shaped by the complex interplay between state-dependent and state-independent plasticity mechanisms. Inspired by general relativity, this work aims to bring a novel perspective to the understanding of neural system dynamics across various timescales.