



Eigenmode analysis of spherical brain activity via neural field theory

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Corticothalamic neural field theory (NFT) has successfully explained a wide variety of phenomena, ranging from EEG spectra and evoked potentials to nonlinear phenomena such as seizures and Parkinsonian oscillations. NFT has also been used to understand brain connectivities and its eigenmodes have been employed to solve the inverse problem of determining brain structure from functional connectivity. Most recently, its unihemispheric eigenmodes have been shown to be remarkably similar to spherical harmonics in structure. They are also the building blocks for bihemispheric modes, whose structure and symmetry properties explain many features of resting state and task-related activity. This eigenmode expansion is of use because it helps us understand the dynamics of the brain's activity in terms of its natural modes.

Here, corticothalamic NFT is analyzed on a sphere and used to derive the transfer function, the power spectrum, the correlation function, and the cross spectrum in terms of spherical harmonics. The results are analyzed and compared with planar NFT in both finite and infinite geometries. The results of spherical and finite-planar geometries converge to the infinite-planar geometry in the limit of large brain size. The main effects of the spherical modal structure are explored, particularly to understand the number of modes that contribute significantly to these observable quantities and the effects of the finite spatial extent of the cortex.

Key results are that when we truncate the modal series it is found that, for physiology plausible parameters, only the lowest few spatial eigenmodes are needed for an accurate representation of macroscopic brain activity. Cortical modal effects can lead to a double alpha peak structure in the power spectrum, although the main determinant of the alpha peak is corticothalamic feedback. In the spherical geometry, the coherence function between points decays monotonically as their separation increases at a fixed frequency, but persists further at resonant frequencies. The correlation between two points is found to be positive, regardless of the time lag and spatial separation, but decays monotonically as the separation increases at fixed time lag. At fixed distance the correlation has peaks at multiples of the period of the dominant

frequency of system activity.

This analysis of physiologically-based corticothalamic NFT in a spherical geometry will enable more realistic modeling and analysis of experimental brain signals in future.

Corticothalamic neural field theory, eigenmodes, EEG power spectrum