Dipartimento di Fisica
Università di Cagliari
INFN, Sezione di Cagliari

High Energy Physics Colloquia

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Sleep-wake models: from naps to maps with traps and gaps

Abstract

Sleep-wake regulation can be understood as the result of the interaction of two oscillatory processes: the circadian oscillation of our body clock, and a relaxation oscillator known as the 'sleep homeostat' that results in a sleep pressure that increases during wake and decreases during sleep. The resulting two-process model has been immensely successful, providing the very language which frames most sleep research. Yet, surprisingly, there has been very little mathematical analysis of the two-process model. Here, we show that a more physiological based model of sleep-wake regulation can be reduced to the two-process model. The two-process model itself can be seen a threshold system: the sleep pressure rises and falls between two thresholds modulated by the circadian oscillation. Threshold systems can be represented as a one-dimensional circle map. Tangencies between rising/falling flow and the thresholds lead to discontinuities and/or non-monotonicity. We will discuss the generic properties of such gaps and show how border collisions and saddle-node bifurcations are interspersed. This highlights how the Arnold tongue picture for tongues bordered by saddle-node bifurcations is amended once gaps are present. We will end this talk, by considering the implications of this structure for sleep-wake maps and how transitions between different sleep-wake cycles with differing numbers of daily sleep episodes can then be understood as the result of the tangencies.

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