Title. *Theta optimizes information rate in oscillation-driven neurons*

Abstract. Low-frequency oscillations in the local field potential are thought to modulate neuronal synaptic sampling in a periodic manner. Converging physiological evidence points to an analog-to-phase transform underlying the phase coding of synaptic inputs in oscillating areas like the hippocampus or the olfactory bulb. However, whereas theta-band oscillations (4-10 Hz) have been previously argued to optimize learning and plasticity, the information coding benefits of theta with respect to other frequency bands are still unclear. To shed light on the latter issue, we simulated stochastic leaky integrate-and-fire neurons driven by field oscillations, with physiologically-constrained parameters from the rodent hippocampus CA1 and the olfactory bulb. By estimating the information rate of phase coding for a range of noise levels we identified a noise-driven phase transition whereby a tradeoff between sampling frequency and coding precision emerges. We then observed that, under physiologically-relevant noise beyond the phase transition, theta optimizes such a sampling-precision tradeoff, effectively maximizing information rate in both hippocampal and olfactory neurons. Further, we demonstrated that theta remains optimal throughout the entire dorsoventral axis of the hippocampus despite having pronounced gradients of several physiological parameters. In addition, we find that optimal information rate relies on the concurrent modulation of both theta frequency and amplitude, hence explaining the speed-controlled changes in the ongoing hippocampal theta oscillation as observed in rodent experiments. Overall, our results suggest that local field oscillations are adapted to continuously maximize information rate given the temporal and physiological constraints under which neurons operate.