SYNCHRONOUS RHYTHMS IN RECIPROCALLY INHIBITORY NEURONS

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Abstract

This poster presents a model shows the mechanism of rhythmic generations in nonoscillatory neuron networks with using reciprocal inhibition between neurons. The model showed that they display postinhibitory rebound (PIR).

This mechanism plays role in the oscillatory behaviour of some central pattern generators (CPGs). Results showed that the release and escape cases may be studied by selectively controlling parameters that affect synaptic duration.

Model

Each model neuron possesses just two nonsynaptic ionic currents

- a constant conductance leakage current, I_L
- a voltage-dependent inward current referred to as the PIR current, I_{pir}

Each neuron has two dynamic variables:

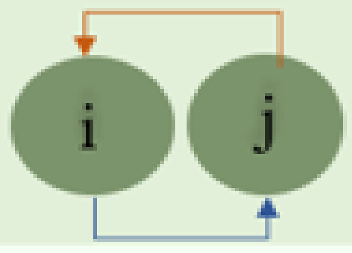
- membrane potential V and inactivation h for I_{pir}
- activation m is assumed instantaneous so we set $m = m_\infty(V)$

$$C\frac{dV_i}{dt} = -g_{pir}m_\infty^3(V_i)h_i(V_i - V_{pir}) - g_L(V_i - V_L) - g_{syn}s_{ji}(V_i - V_{syn})$$

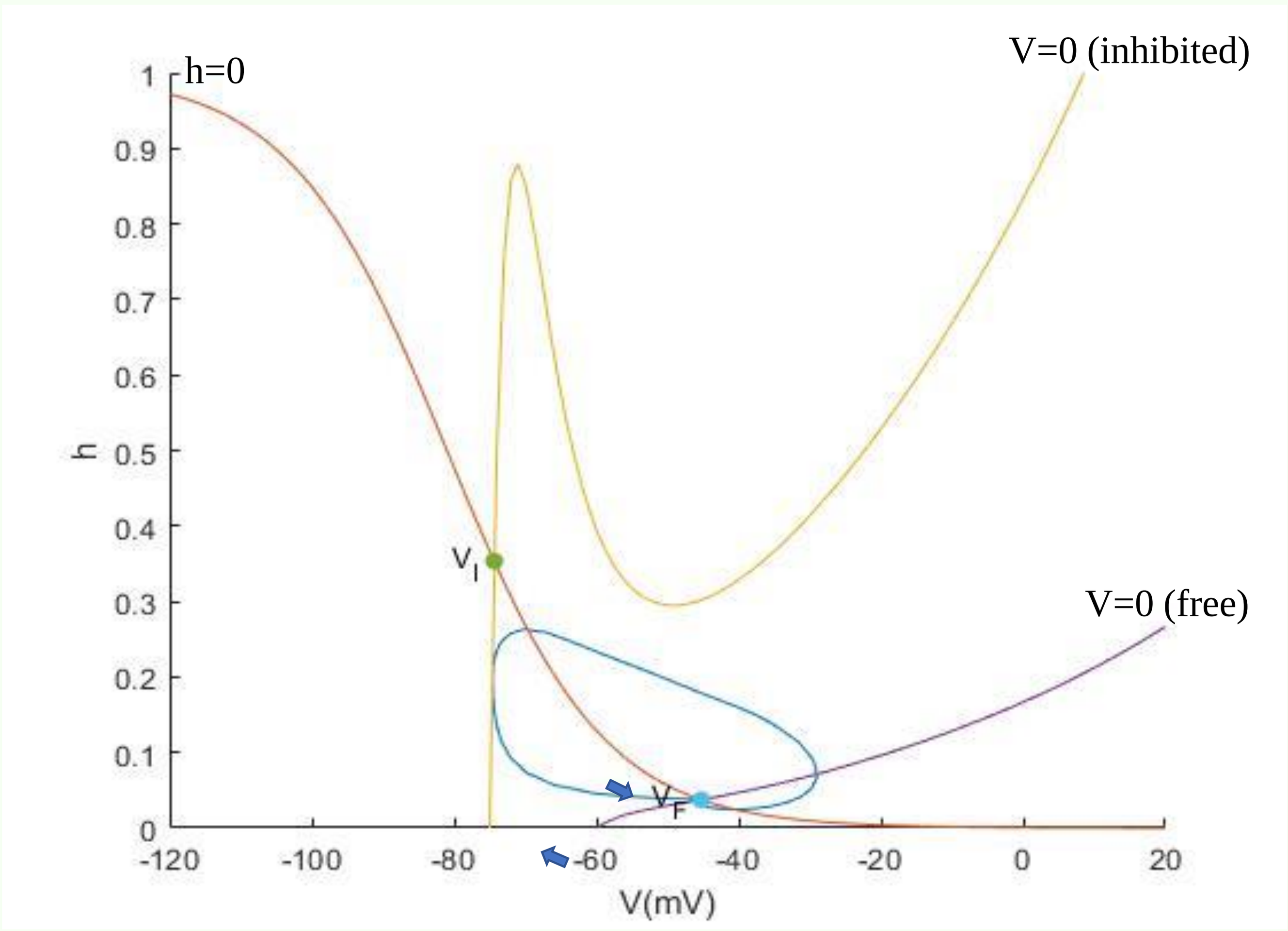
$$\frac{dh_i}{dt} = \phi[h_\infty(V_i) - h_i]/\tau_h(V_i)$$

where s_{ji} is the postsynaptic conductance in cell i due to activity in cell j;

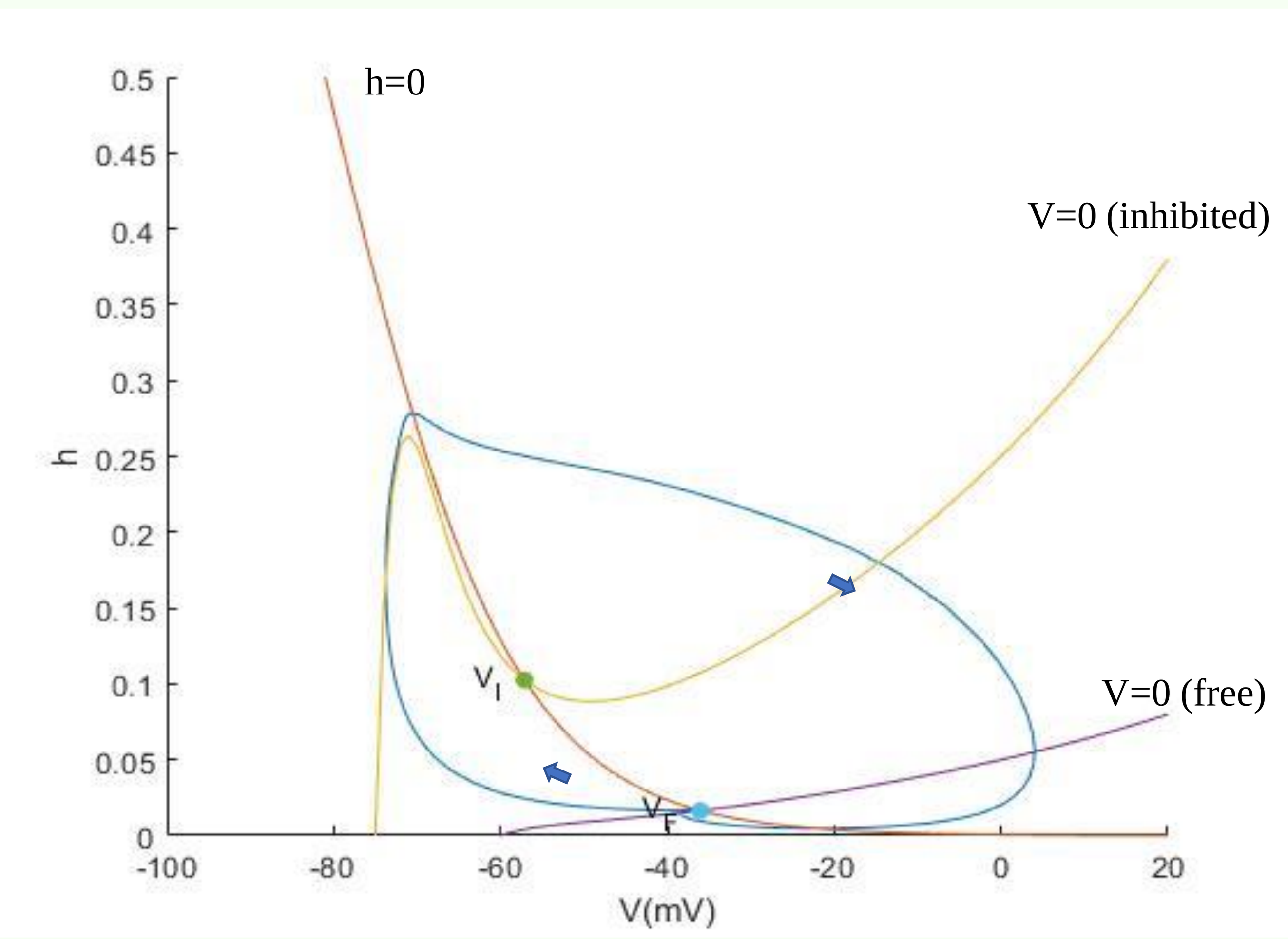
$$s_{ji} = S_\infty(V_j) = 1/1 + exp[-(V_j - \theta_{syn})/k_{syn}]$$



The V - h phase plane of a single neuron



Release



Escape

Introduction

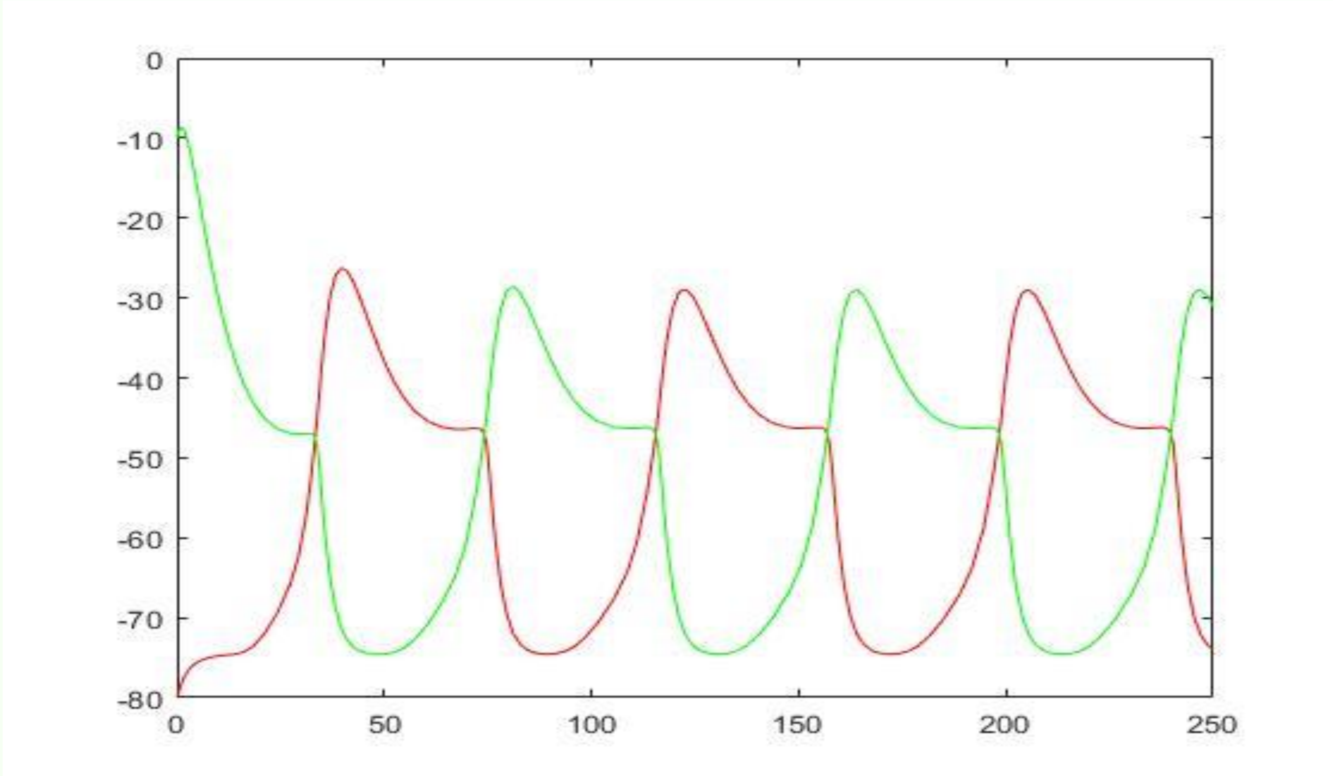
Postinhibitory rebound (PIR) is defined as membrane depolarization occurring at the offset of a hyperpolarizing stimulus and is one of several intrinsic properties that may promote rhythmic electrical activity (Angstadt et al., 2005).

Release and Escape mechanisms occurs in such dynamics:

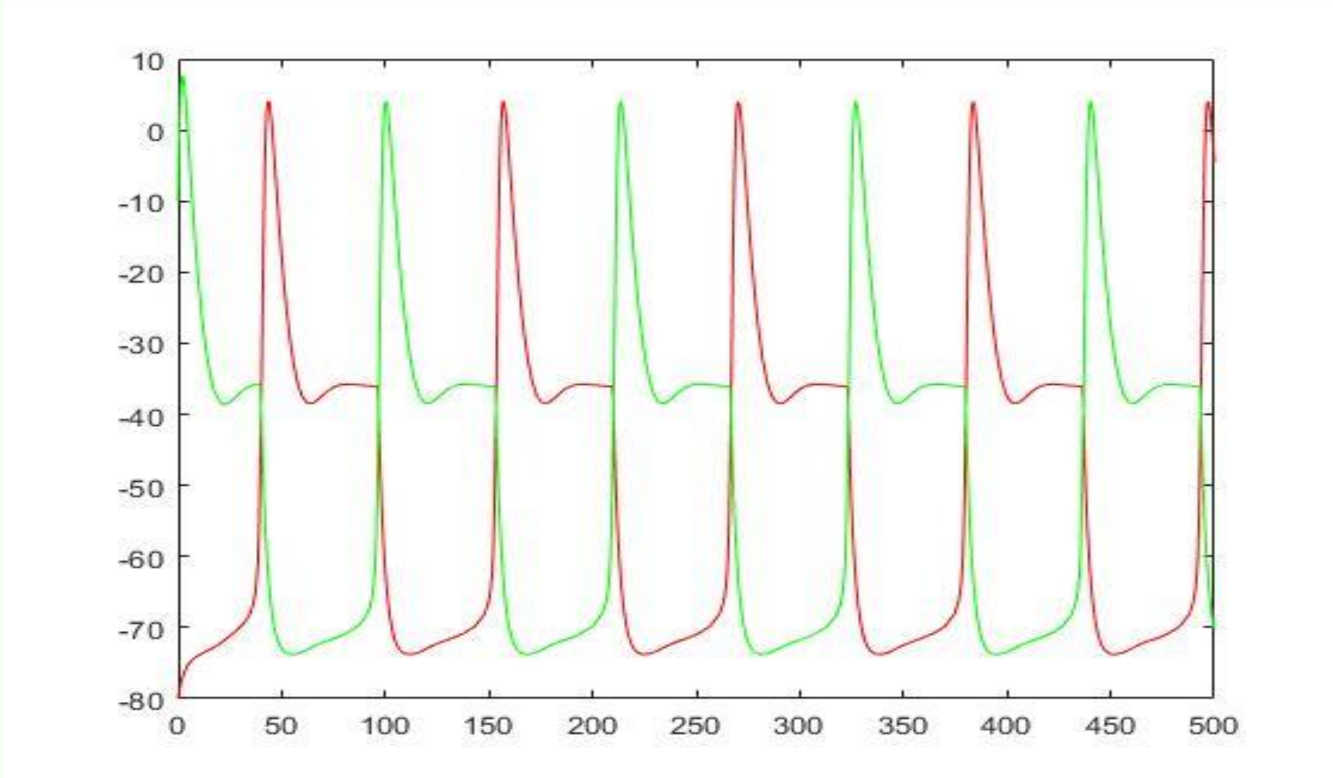
- In the release case, inhibition is terminated presynaptically. The oscillation period depending on the duration of synaptic input.
- In an escape event inhibition is initiated by a postsynaptic cell. Inward current slowly develops and overcomes the postsynaptic hyperpolarizing current so the inhibited cell gets depolarized (Wang & Rinzel, 1992).

These mechanisms have roles in the oscillatory behaviour of some CPGs like sea slugs, leeches and lobsters (Selverston & Moulins, 1985).

Two reciprocally inhibitory neurons establish an alternating rhythmic oscillations



Release



Escape

Conclusion

The ionic model showed that Release and Escape mechanisms underlie the alternating oscillation.

In release, but not escape, the oscillation period depends on the duration of synaptic hyperpolarization. In escape, a cell's intrinsic properties allow rebound excitation to proceed even under maintained synaptic inhibition. In either case the oscillations may coexist with a stationary pattern of both cells resting, or one resting and one inhibited, respectively.

Results suggest that the release and escape cases may perhaps be examined experimentally by selectively modulating parameters that control synaptic duration; or those that control the inward current that is exposed by hyperpolarization and that underlies PIR (Wang & Rinzel, 1992).

References

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Wang, X. J., & Rinzel, J. (1992). Alternating and synchronous rhythms in reciprocally inhibitory model neurons. *Neural computation*, *4*(1), 84-97.

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