

# Accepted Manuscript

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PII: S0304-3975(17)30907-6  
DOI: <https://doi.org/10.1016/j.tcs.2017.12.015>  
Reference: TCS 11418

To appear in: *Theoretical Computer Science*



Please cite this article in press as: T. Wu et al., Spiking neural P systems with rules on synapses and anti-spikes, *Theoret. Comput. Sci.* (2018), <https://doi.org/10.1016/j.tcs.2017.12.015>

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# Spiking neural P systems with rules on synapses and anti-spikes

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## Abstract

Spiking neural P systems with anti-spikes (in short, ASN P systems) are a variant of spiking neural P systems (in short, SN P systems), inspired by the way in which neurons process information and communicate to each other through both excitatory and inhibitory impulses. In this work, we consider ASN P systems with rules on synapses, where all neurons contain only spikes or anti-spikes, and the rules are placed on the synapses. The computational power of ASN P systems with rules on synapses is investigated with the restrictions: (1) systems are simple in the sense that each synapse has only one rule; (2) all spiking rules on synapses are bounded; (3) the delay feature and forgetting rules are not used. Specifically, we prove that ASN P systems with pure spiking rules of categories  $(a, a)$  and  $(a, \bar{a})$  on synapses are universal as number generating and accepting devices. The universality of ASN P systems with spiking rules of categories  $(a, \bar{a})$  and  $(\bar{a}, a)$  on synapses as generating and accepting devices is obtained, where synapses can change spikes to anti-spikes or change anti-spikes to spikes. We also prove that ASN P systems with inhibitory synapses using spiking rules of category  $(a, a)$  on synapses are universal as both generating and accepting devices. These results illustrate that simple form of spiking rules is enough for ASN P systems with rules on synapses to achieve Turing universality.

**Keywords:** Bio-inspired computing, Spiking neural P system, Turing universality, Anti-spike, Synapse

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