A scheme for optical reservoir computers with atomic memory

Elizabeth Robertson[1,2], Lina Jaurigue[2], Luisa Esguerra-Rodriguez[1,2], Guillermo Gallego[2], Kathy Lüdge[2], Janik Wolters[1,2]

[1] Deutsches Zentrum f ür Luft- und Raumfahrt e.V. (DLR), Rutherfordstr. 2, 12489 Berlin, Germany
[2] Technische Universit ät Berlin, Str. des 17. Juni 135, 10623 Berlin, Germany

We propose an all-optical setup with the internal states of the reservoir which are stored in an optical memory, allowing for more complex internal dynamics. We present an electro-optical implementation as first result, and outline how this can be implemented all-optically by using atomic vapor based memories [1]. Using an electro-optic modulator (EOM), we encode the internal states of a RC using pulses from an external cavity diode laser of 894nm. These pulses are then detected using an avalanche photo-diode (APD), where the internal state values are measured, the reservoir output x_{out} is calculated and then propagated through the reservoir. The reservoir outputs are used to train a classifier to learn the logical XOR gate. To train the network, we used a Ridge Regression classifier and 5-fold cross validation, on a training and test set size of 50 bits. We achieved a test accuracy of 80% without reservoir or training process optimisation. Building on this toy model we propose a re-configurable all-optical RC based on multi-cell optical memories.

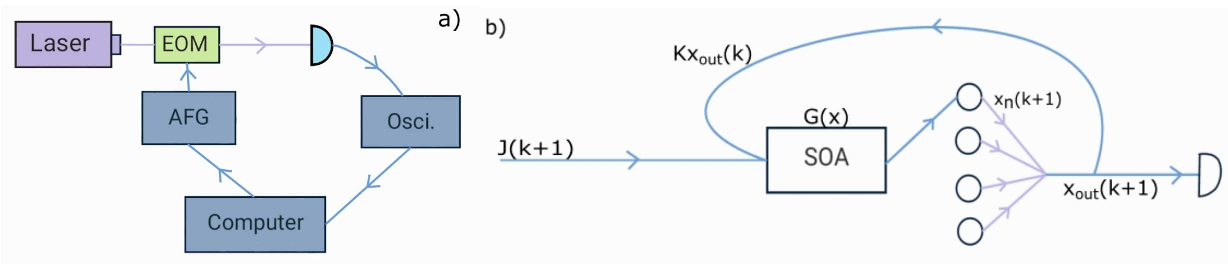

Fig. 1 a) Basic setup of the electro-optical RC, optical- and electrical connections are marked in purple, and blue respectively. The node states are encoded on to the pulse amplitude by an EOM. The pulses are detected by an APD, and the detected signal is electrically passed on to the computer for updating the memory states. b) A schematic of all-optical reservoir with optical memory. The state of the network nodes x_{n} is encoded in the amplitudes and stored in a multi-cell atomic memory. The memory cells are partially read out, and the read out inputs combined to give the output of the network $x_{\mathrm{out}}(k+1)$. One fraction of the output intensity is directed to the detector, the other fraction is combined with new input to the system J and is given as an input to a non-linear function $G(X)$, implemented by a semiconductor optical amplifier (SOA). The output from the non-linearity is then read into one of the memory cells, overwriting any information stored in the cell. By iterating the process, the RC evolves over time.

[1] Wolters J., Buser G., Horsley A., et al. 'Simple Atomic Quantum Memory Suitable for Semiconductor Quantum Dot Single Photons.' Physical Review Letters, ;119(**6**):060502. (2017)