# **Pho**tonic quantum **mem**ristor net**wor**ks


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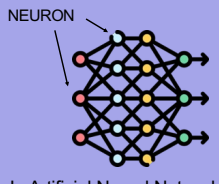
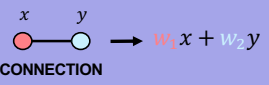
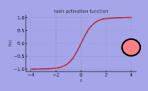
## Neuromorphic architectures are an alternative and more-efficient model for machine learning

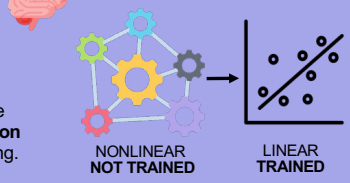



In Artificial Neural Networks both the **connection weights** and the **activation functions** are optimized during training.

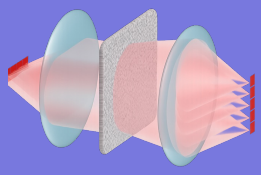



**Brain-inspired** models keep the same versatility but are **energy-efficient** (only the linear readout is trained)




## Optical-based computing is more resource efficient than standard computing



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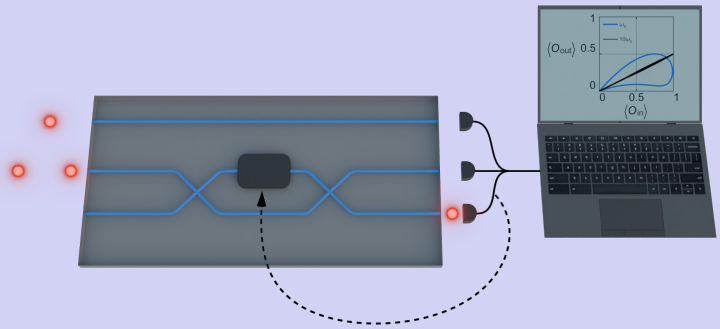
- Passive matrix multiplication
- Low dissipation
- Parallelization
- Sub-Landauer performances

Weak non-linearities!

The photonic memristor can be used to implement machine learning models in a resource efficient way.



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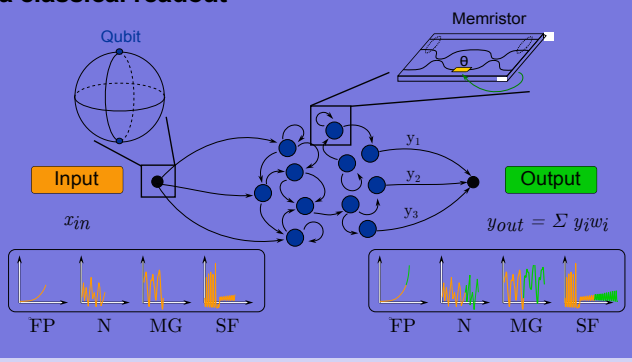
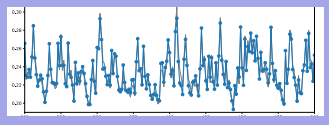
## We implemented the first neuromorphic architecture based on photonic memristor!

### Our model has a physical memristive reservoir and a classical readout



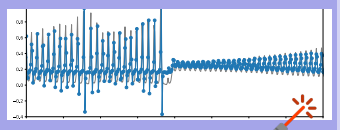

NARMA task

$y_{t+1} = 0.4y_t + 0.4y_t y_{t-1} + 0.6x_t^3 + 0.1$

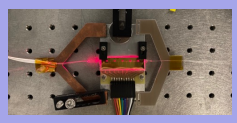


$MSE = 2.80 \times 10^{-5}$

$MSE = 1.26 \times 10^{-2}$

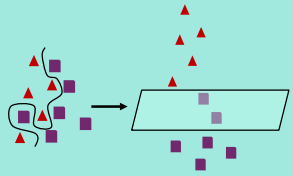


Santa-Fe task

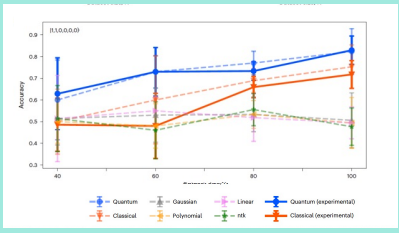


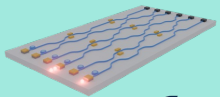
### We experimentally demonstrated it can be applied to time-series prediction tasks

## There exist problems for which quantum algorithms grant a better performance



We **map our data in a higher-dimensional space**, where they can be linearly classified, depending on their pairwise inner product (kernel method)



$x_i \to \Phi(x_i) \to U_{x_i}|\psi\rangle$

$|\psi\rangle = |1,1,0,0,0,0\rangle$

$K(x_j, x_i x) = |\Phi(x_i)\Phi(x_j)|^2 \to |\langle\psi|U_{x_j}^{+} U_{x_i}|\psi\rangle|^2$

$y \to \mathrm{sgn}(\Sigma_{i=1}^{N} \alpha_i y_i K(x, x_i))$

We perform the mapping and evaluate the inner products on a photonic platform

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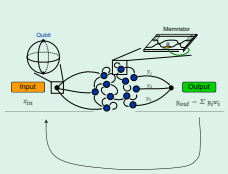
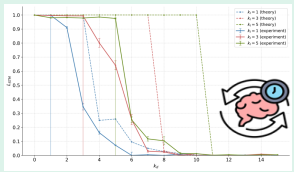
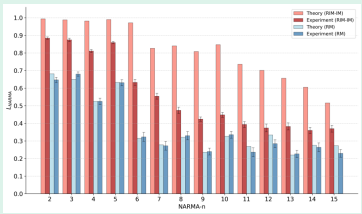
SOON ON ARXIV!!



SHORT TERM MEMORY



### Adding a loop acting on the input enhances the performance of the reservoir!