quantenphotonik

Project Seminar
Data Science and Artificial Intelligence

UNIVERSITÄT DES SAARLANDES

Intelligent AOM

Project Donor: Prof. Dr. Eschner & Team (Experimental Physics – Quantum Photonics)

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Introduction

In the experimental setup the spectrum of an incoming laser beam is changed in an **acousto-optical modulator (AOM)** by interfering with an applied radio frequency (rf) signal coming from an **arbitrary wave generator (AWG).**

We want to **predict** the required **frequency spectrum** produced by the AWG given a desired output spectrum which should then be produced by the AOM.

Experimental Setup

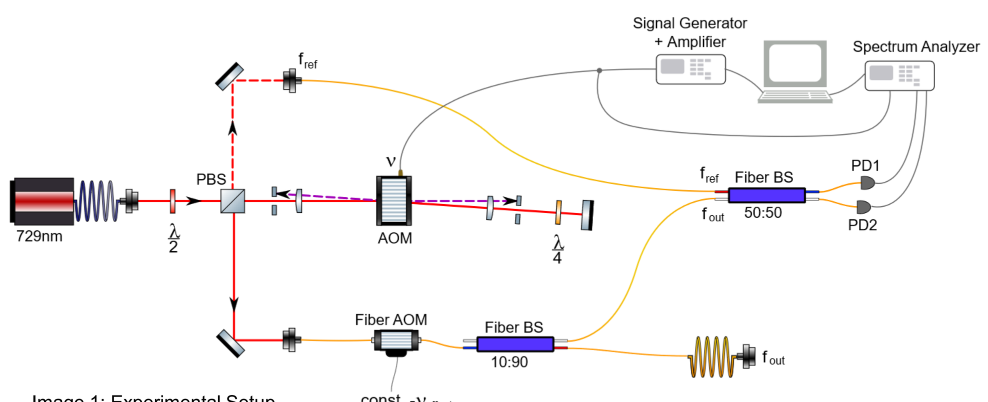
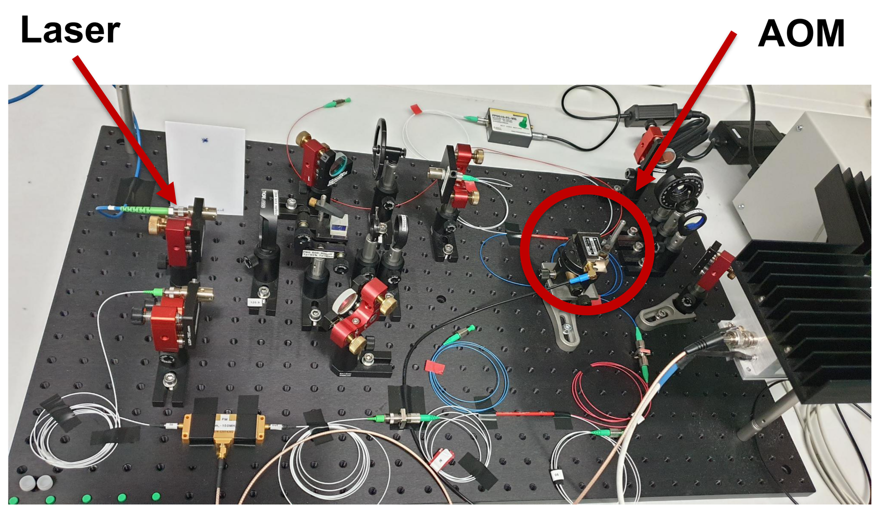


Image 1: Experimental Setup



Simplified Experimental Setup

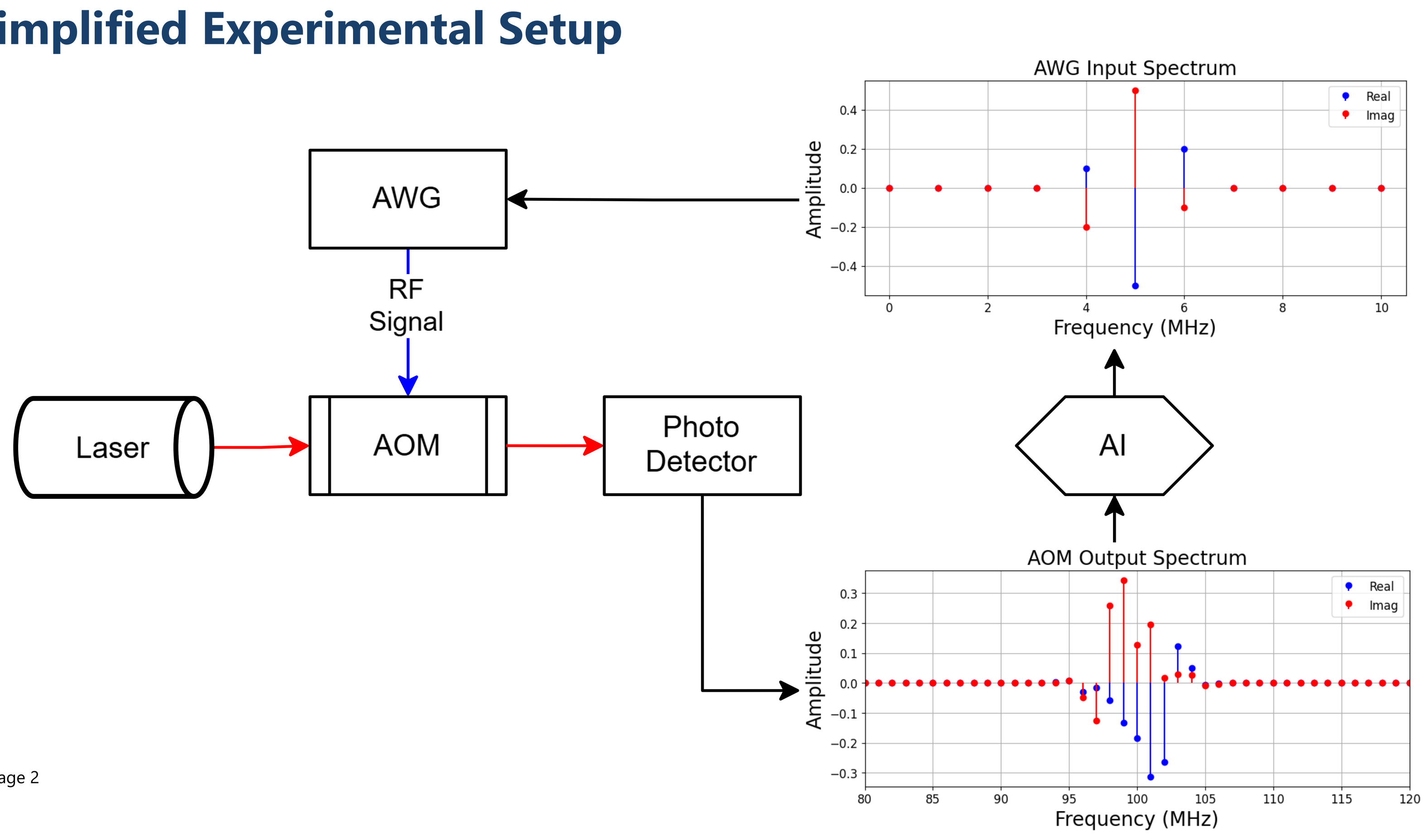


Image 2

Motivation [Image 1, Image 2]

For experiments in the field of quantum photonics **concrete laser frequency spectra** are often needed. Due to the **nonlinear** and **complex** relationship between the input and output spectra of the **AOM,** the required AWG configurations **can not be computed** easily.

But by applying **machine learning methods** we can predict them to a certain accuracy. Doing so, we achieve the **ability to control** output frequency spectra **freely**, provided by the configurations given by our model.

Objectives

Find a **suitable model** able to predict the required AWG input spectra, given the desired AOM output spectra and observe the **impact of** different **hyperparameters, changes in the simulation & non-linearity** on the **model performance**.

Visualization of Data Processing

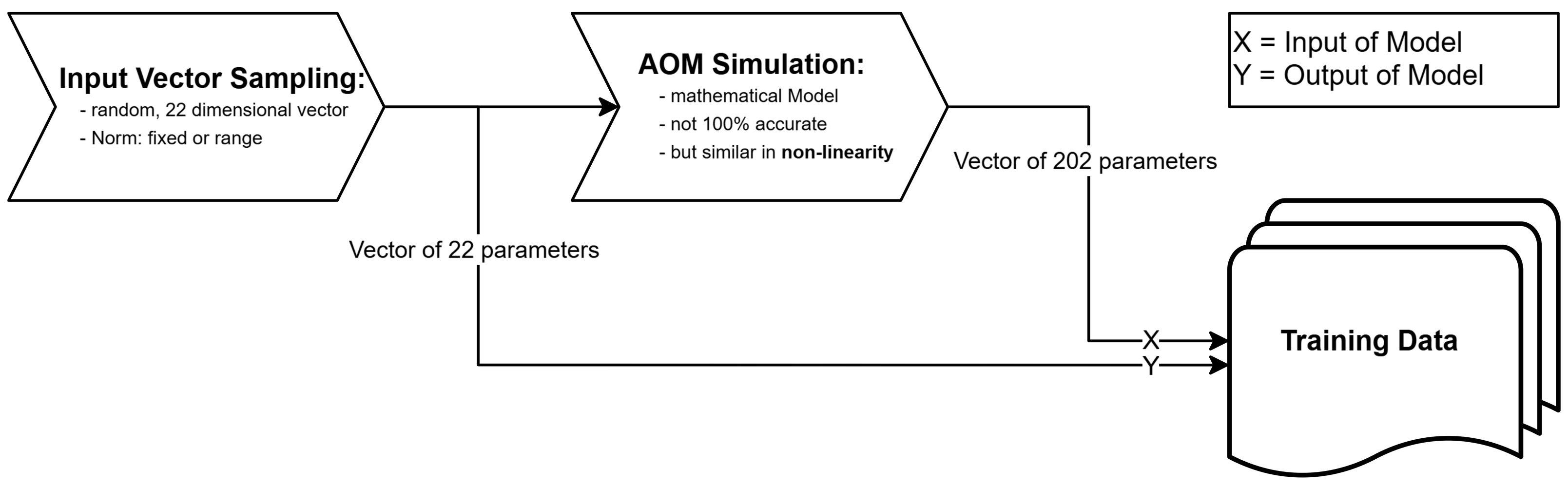


Image 3

Data Processing [Image 3]

Each AWG **input** spectrum has **11 complex valued Fourier coefficients** (22 real valued parameters) at 11 frequencies ranging from 95 to 105 MHz.

Similar, each AOM **output** spectrum has **101 complex valued Fourier coefficients** (202 real valued parameters) at 101 frequencies ranging from 50 to 150 MHz.

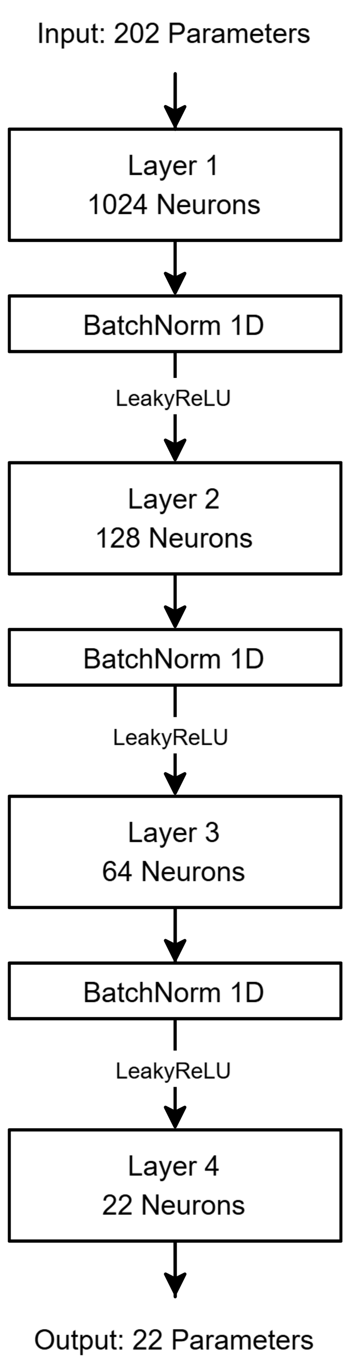
The **training data** is generated without noise and missing values. For this we **sample** the potential **AWG input** spectra by **randomly selecting points** on the surface of a 22-dimensional sphere, ensuring that the norm is constant.

The AOM output is obtained by **simulating the AOM** using a provided **mathematical model** which is physically motivated and similar in complexity.

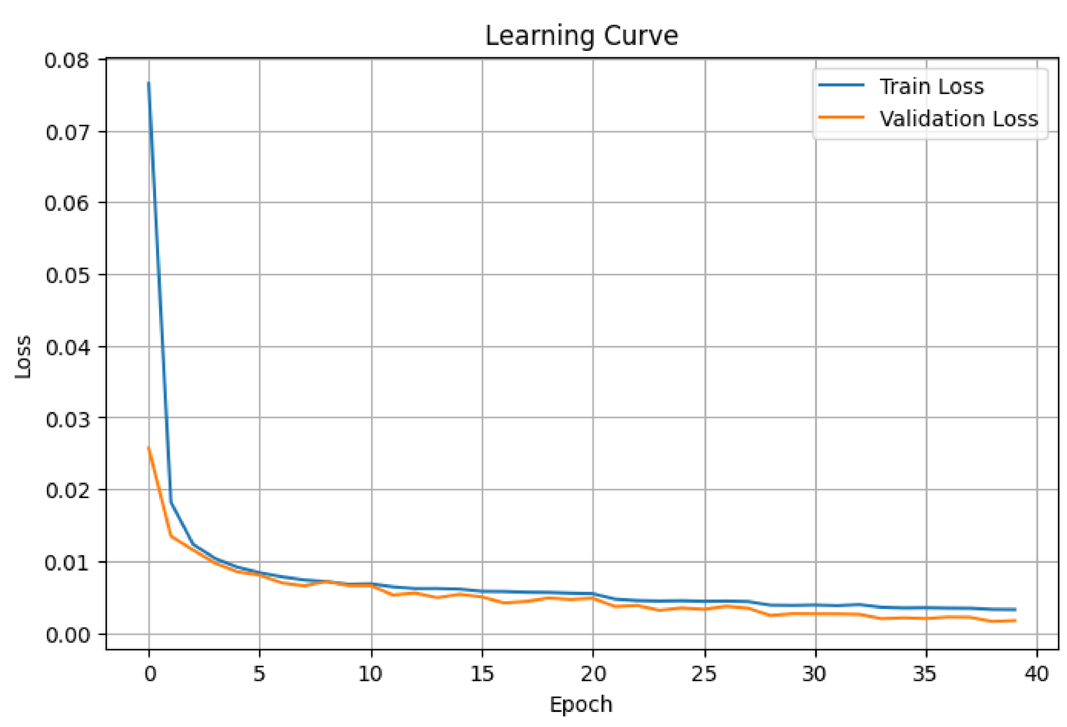
The **training data** now consists of both the **simulated AOM output spectra as input** for the model and the sampled **AWG input spectra as desired output** of the model.

We **train** the model, utilizing the mean absolute error (**MAE**) as the loss function and by gradually reducing the learning rate.

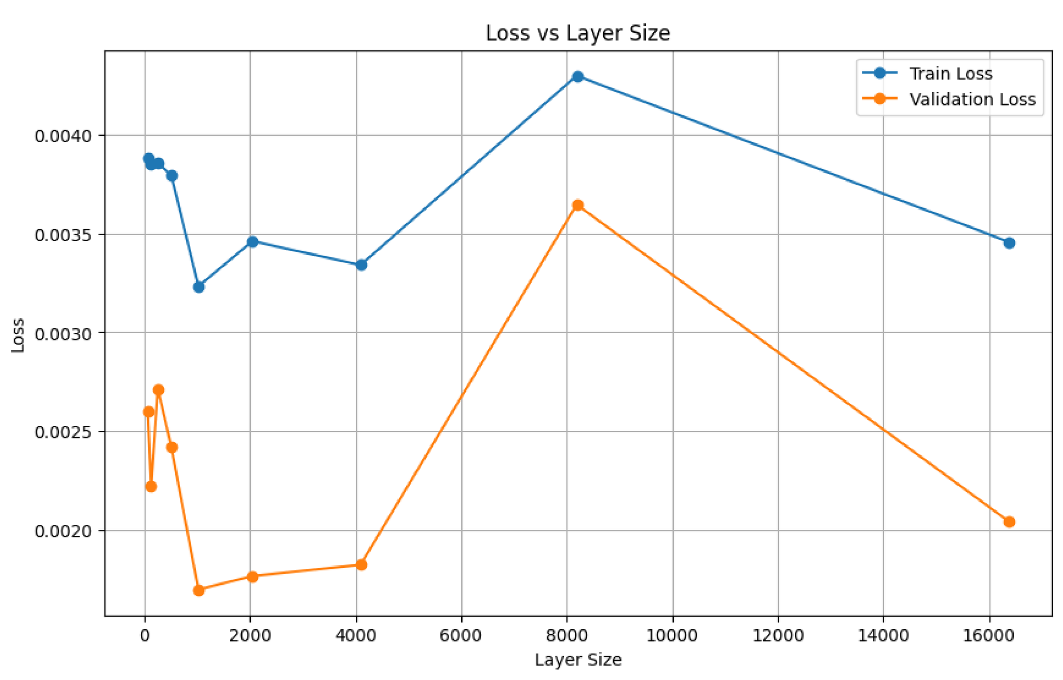
Model Architecture



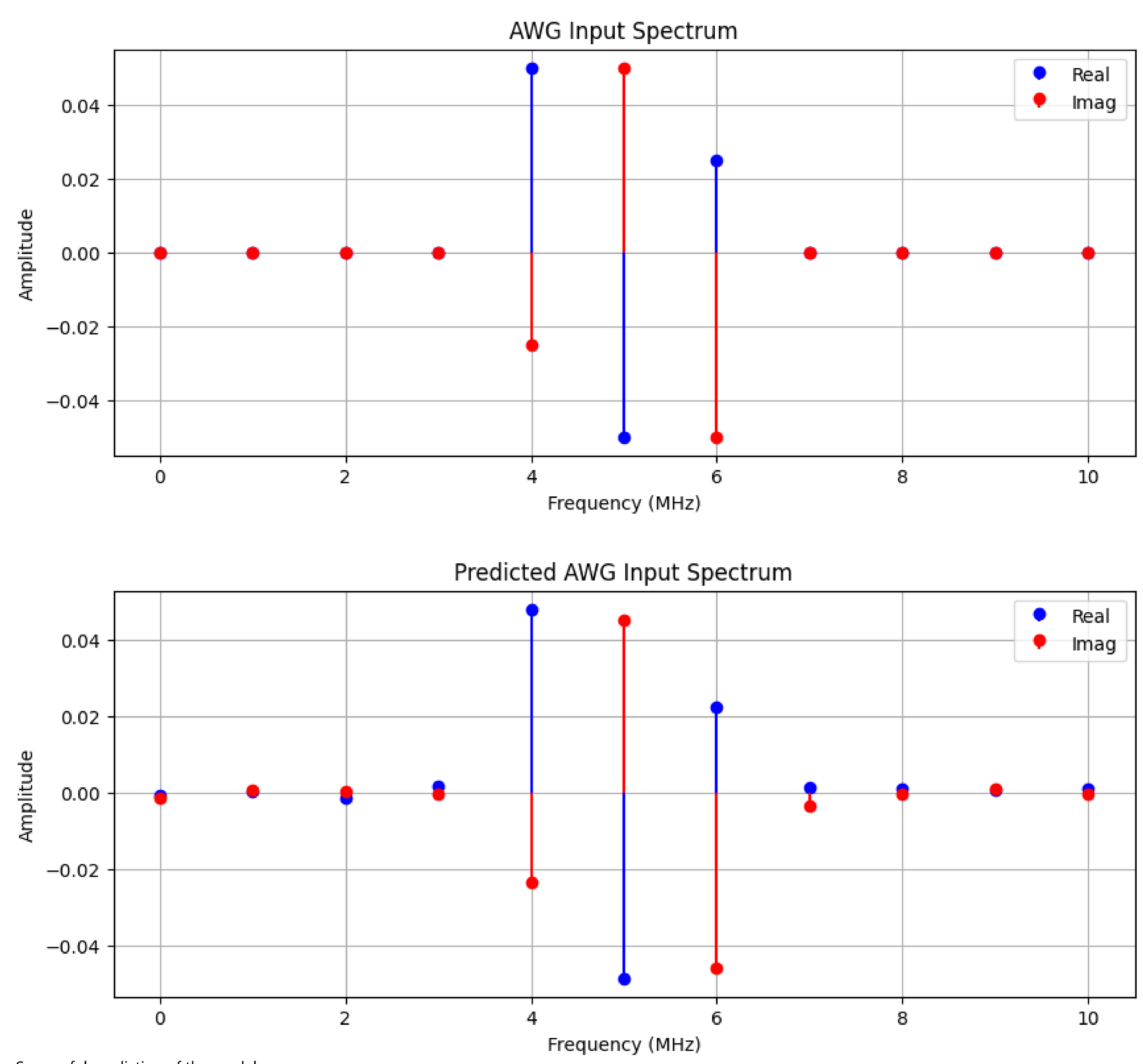
Results



Learning curve of a successful training run



Impact of the layer size on the model performance



Successful prediction of the model