Ultrafast fiber lasers have made impressive advancements in last years and they are now widely used in academic research and industrial applications replacing traditional solid-state lasers. However, there are still two main challenges with these lasers: the range of colors (or wavelengths) and the amount of power that they can produce. Researchers have tried different approaches to tackle these issues, but there is still a need for breakthrough solutions to develop fiber lasers that can generate high-power beams with a flexible range of colors. We expect that the quest for novel solutions on wavelength range and power throughput will also lead to expand significantly the panel of applications for fiber lasers.

In this project, we will focus on exploring new ways to overcome these challenges by combining consolidated techniques with novel physical approaches. We will work on creating tunable light sources commonly called fiber optical parametric oscillators. In these sources, a strong light beam, called the pump, can locally modify the material properties, such as the refractive index, leading to the conversion of one color of light into another. The conversion efficiency is improved when this action is repeated many times as in an oscillator: this solution has long been the standard workhorse for generating colors whenever standard laser sources are not available. In this project, we will develop an innovative method for adjusting the color of light by using the interactions between different types of light effects. This approach is different from the usual method which requires shifting the pump wavelength.

Another part of the project will involve studying multimode fiber lasers, which are lasers that exploit different paths for the light to travel through the fiber. Such novel types of lasers have great potential for increasing power and finding new ways to control the light. We would like to better understand how these lasers work and to explore interesting phenomena involving multiple light pulses traveling together.

A major challenge we face is figuring out how to control the lasers to produce the desired light patterns. To tackle this problem, we propose to use artificial intelligence techniques and optimization methods that will help us to find the best settings to control the lasers effectively. This is an exciting area of research, which is yet unexplored territory. It holds promise, but it is still unclear whether beam control can be extended to multimode fiber lasers.

Overall, our project aims to push the boundaries of fiber laser technology and to unlock new capabilities for “smart” lasers. We will investigate different techniques for tuning light sources and understand the physics of multimode lasers. By applying artificial intelligence, we hope to achieve better control over the lasers and open up new opportunities for their applications.