instituto de telecomunicações

IT-Aveiro

# Signal Processing for SDM Systems

## Optical Communications Systems

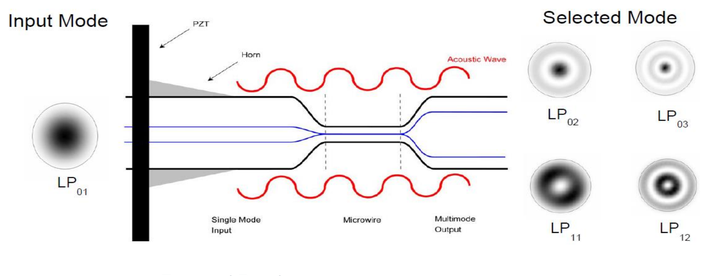
## Background and challenges

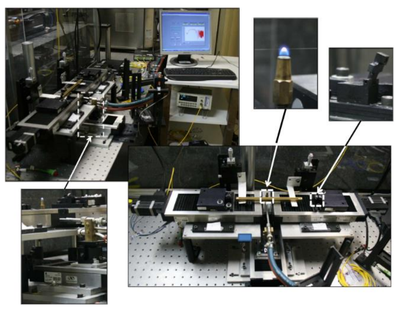
- The **exponentially growing** traffic demand in optical networks is exhausting the **standard single-mode fiber** (SSMF)-based **transmission systems**.
- **Space-division multiplexing** (SDM) systems have been recently **proposed** to increase the transmission capacity by using additional spatial channels through a single fiber.
- **New optical and digital signal processing techniques** are **required** to **support** this disruptive **technology**.

## Description and main innovation

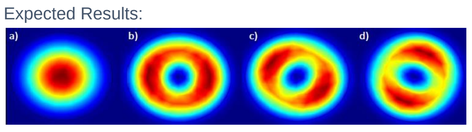
### Acousto-optic mode switch:

- The **switching** between an arbitrary pair of modes can be achieved by using **flexural** or **longitudinal acoustic waves**.
- We **demonstrate** the **switching between** the $LP_{01}$ and the $LP_{11}$.

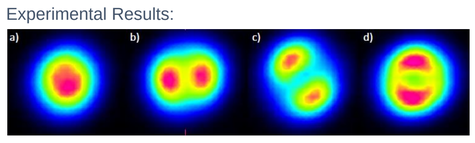


Expected Results:

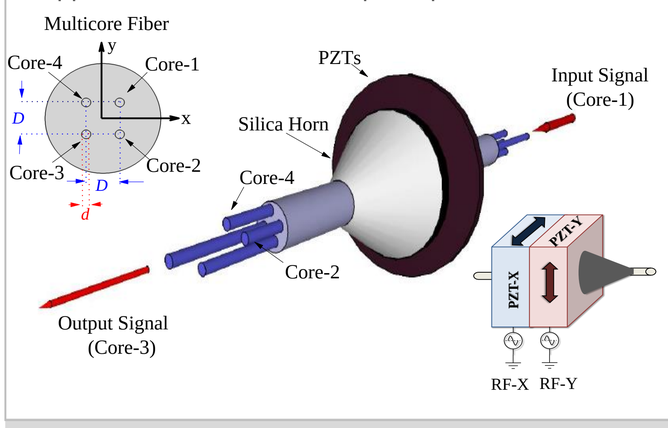


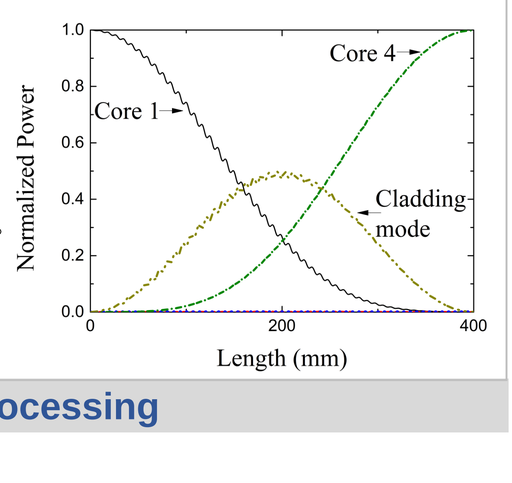

Experimental Results:




### Acousto-optic core switch:

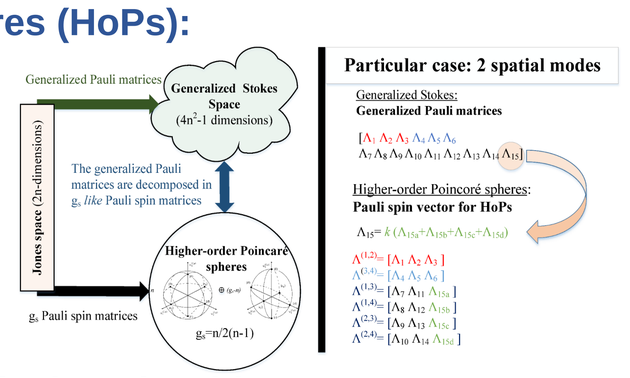
- We can **switch** a signal from a particular core to any other core in **heterogeneous** MCFs.
- In **homogeneous** MCFs, we are able to **switch** between any **two cores diametrically** opposed or **distribute** the optical power **over all** the **cores**.



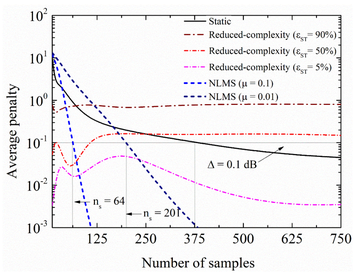

### Higher-order Poincaré spheres (HoPs):

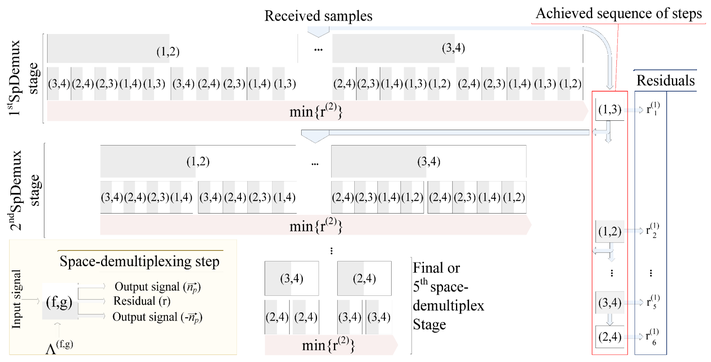
- We **propose** a novel **representation** of the multimode signal in a **Higher-Order Poincaré spheres (HoPs)**.
- Based on this representation, we have developed **novel digital techniques** for signal processing.




### HoPs-based space-demultiplexing algorithms:

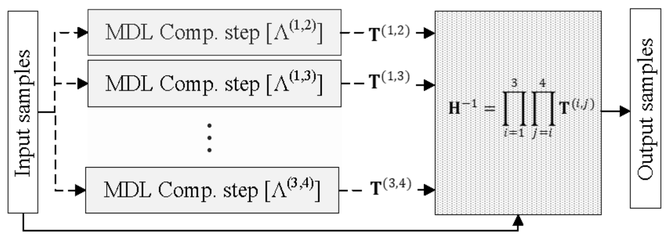
- **Modulation format agnostic.**
- **Free of training sequences.**
- **Faster convergence speed.**

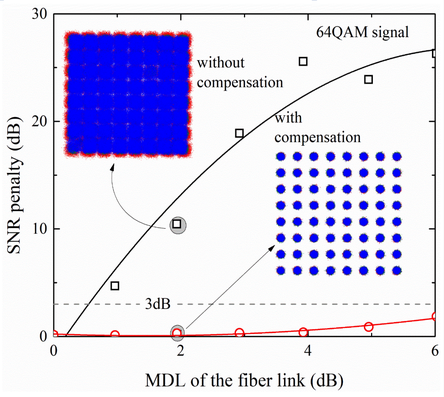



### HoPs-based MDL monitoring and compensation technique:

- **Modulation format agnostic.**
- **Free of training sequences.**
- Robust against **phase fluctuations** & **frequency offsets**.




### Optical signal processing

### Digital signal processing

## Achievements

### Scientific outputs

- Eleven papers published in international journals:
  - ✓ G. M. Fernandes, N. J. Muga, and A. N. Pinto, "Reduced-complexity algorithm for space-demultiplexing based on higher-order Poincaré spheres," Opt. Express 26, 13506-13520 (2018).
  - ✓ G. M. Fernandes, N. J. Muga, and A. N. Pinto, "Space-demultiplexing based on higher-order Poincaré spheres," Opt. Express 25, 3899-3915 (2017)
  - ✓ G. M. Fernandes, N. J. Muga, A. M. Rocha, and A. N. Pinto, "Switching in multicore fibers using flexural acoustic waves," Opt. Express 23, 26313-26325 (2015)
  - ✓ G. M. Fernandes, N. J. Muga, and A. N. Pinto, "Tunable Mode Conversion Using Acoustic Waves in Optical Microwires," J. Lightwave Technol. 32, 3257-3265 (2014)
  - ✓ G. M. Fernandes, Á. J. Almeida, M. Niehus, and A. N. Pinto, "Theoretical Analysis of Multimodal Four-Wave Mixing in Optical Microwires," J. Lightwave Technol. 31, 195-202 (2013)
- Twenty-one papers in **international conferences**.
- One **book chapter**.
- **Collaborations**: Department of Physics, University of Aveiro, Portugal.
- **Participation in National Projects** : PTDC/EEI-TEL/3283/2012, UID/EEA/50008/2013 (OPTICAL-5G/SoftTransceiver), POCI-01-0145-FEDER-029405 and MCTechs-POCI-01-0145-FEDER-029282.

### Main contributions

Optical signal processing:

- Theoretical analyses of the **multimodal four-wave mixing** process in optical microwires.
- **Mode switching** based on the acousto-optic effect.
- **Core switching** based on the acousto-optic effect.

Digital signal processing:

- Novel signal description of the multimodal signal in HoPs.
- Two **digital space-demultiplexing** techniques based on HoPs.
- Two techniques for **MDL monitoring and compensation** based on HoPs.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