Expanded Modal Capacity for OAM with Standard 2×2 MIMO

Mai Banawan[1], Satyendra K. Mishra[1], Ariane Gouin[1], Nathalie Bacon[1], Xun Guan[1,2], Lixian Wang[3], Sophie LaRochelle[1], and Leslie A. Rusch[1*]

[1]*Electrical and Computer Engineering, Center for Optics, Photonics and Lasers (COPL), Université Laval, Québec, Canada, *rusch@gel.ulaval.ca*

[2]*now with Tsinghua Shenzhen International Graduate School, Shenzhen, Guangdong, China*

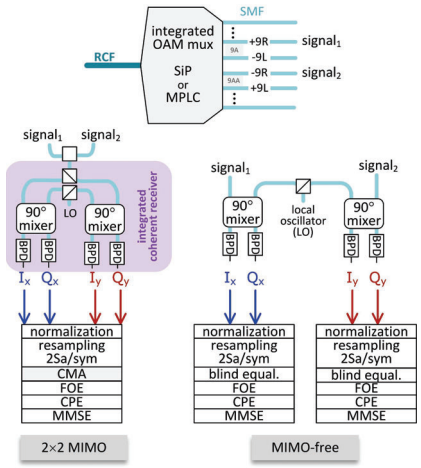
[3]*Canada Research Center, Huawei Technologies Canada, Ottawa, Ontario, Canada*

Abstract

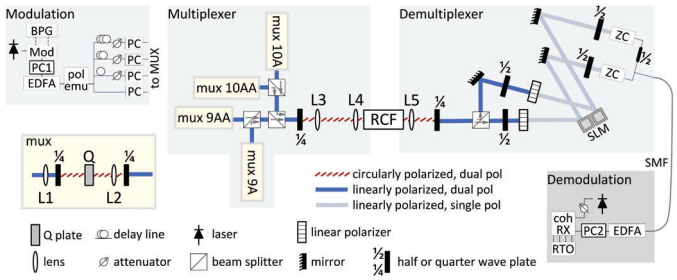
Standard commercial, electronic **2×2 MIMO** can greatly extend modal multiplexing compared to **MIMO-free** strategies. We experimentally demonstrate the highest bit rates achieved with multiplexing of orbital angular momentum (**OAM**) modes at **475 Gb/s** per wavelength. Our demultiplexing strategies are compatible with commercial solutions.

Compatibility with Commercial Receivers

- MIMO-free reception and 2×2 MIMO use similar hardware and differ in DSP
- MIMO-free reception has one equalizer per channel, 2×2 MIMO has four equalizers per two channels



Experimental Setup



- 8×32 Gbaud QPSK
- No optical MIMO, i.e., launching elliptical polarization
- PCs align signal to linear polarization of 0◦ and 90◦
- 600 m RCF, orders 9 and 10
- Demux can handle MIMO-free or 2x2 MIMO
- -3.5 dBm per pol at the coherent receiver input

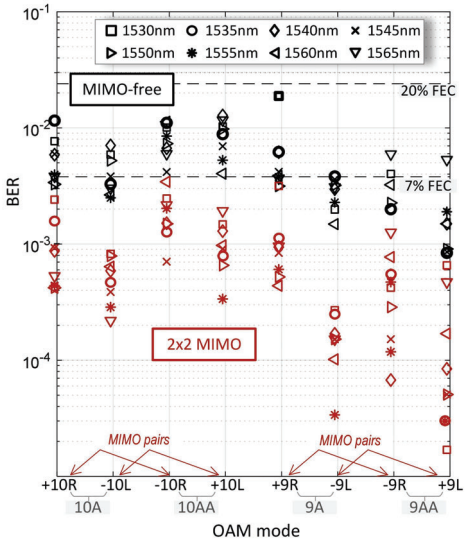
dBm	10A		10AA		9A		9AA	
	+10R	-10L	-10R	+10L	+9R	-9L	-9R	+9L
+10R	**-20.0**	-39.5	-32.5	-39.7	-37.5	-47.0	-41.1	-48.5
-10L	-40.5	**-21.0**	-38.5	-32.5	-50.0	-34.5	-49.1	-41.0
-10R	-32.9	-40.8	**-20.0**	-46.8	-40.8	-48.4	-36.0	-49.6
+10L	-42.0	-33.0	-46.9	**-21.2**	-50.0	-41.4	-50.0	-38.0
+9R	-35.7	-49.5	-41.7	-50.5	**-19.8**	-46.0	-32.7	-35.6
-9L	-48.6	-35.5	-49.7	-41.8	-46.5	**-20.3**	-37.0	-32.5
-9R	-41.0	-49.0	-36.0	-49.5	-32.4	-37.0	**-19.7**	-41.5
+9L	-47.9	-41.4	-49.0	-36.4	-39.7	-31.9	-42.6	**-19.6**

Experimental Setup

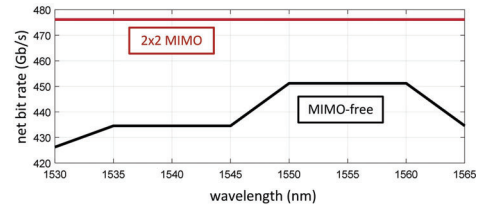
XT (dB)	10A		10AA		9A		9AA	
	+10R	-10L	-10R	+10L	+9R	-9L	-9R	+9L
worst single ch.	-12.9	-12.0	-12.5	-11.3	-12.6	-11.6	-13.0	-12.9
next worst single ch.	-15.7	-14.5	-16.0	-15.2	-17.7	-14.2	-16.3	-16.0
total	-9.8	-8.7	-9.7	-8.8	-10.3	-8.5	-9.7	-9.7

- 2×2 MIMO used to eliminate the worst-case XT
- Worst XT comes from RCF, next worst XT comes from mux/demux

MIMO-free vs. 2x2 MIMO performance



- MIMO-free falls above 7% FEC for some measurements
- All 2x2 MIMO below 7% FEC



- Net bit rate per wavelength after FEC overhead

Conclusion

- We show that two demultiplexed outputs input to 2×2 CMA can greatly reduce crosstalk.
- The added cost of 2×2 reception is negligible compared to MIMO-free reception.
- We have demonstrated 475 Gb/s per wavelength, with a margin to increase fiber reach.

References

1. N. Bozinovic, et al., *science*, vol. 340, no. 6140, pp. 1545–1548, 2013.
2. K. Ingerslev, et al., *Optics express,* vol. 26, no. 16, pp. 20 225–20 232, 2018
3. R. Ryf, et al., in *Frontiers in Optics 2012/Laser Science XXVIII, ser. OSA Technical Digest* (online), Optical Society of America, FW6C.4
4. L. A. Rusch, et al., *IEEE Communications Magazine*, vol. 56, no. 2, pp. 219–224, 2018
5. Z. Lin, et al., in 2021 *Optical Fiber Communications Conference and Exhibition* (OFC), IEEE, 2021.
6. Y. Chen, et al., *IEEE Journal of Selected Topics in Quantum Electronics*, vol. 26, no. 2, pp. 1–7, 2020
7. M. Banawan, et al., in 2022 *Optical Fiber Communications Conference and Exhibition* (OFC), IEEE, 2022.
8. M. Banawan, et al., in *Journal of Lightwave Technology*, vol. 39, no. 2, pp. 600–611, 2020.

Natural Sciences and Engineering Research Council of Canada (NSERC) Funding: CRDPJ515539