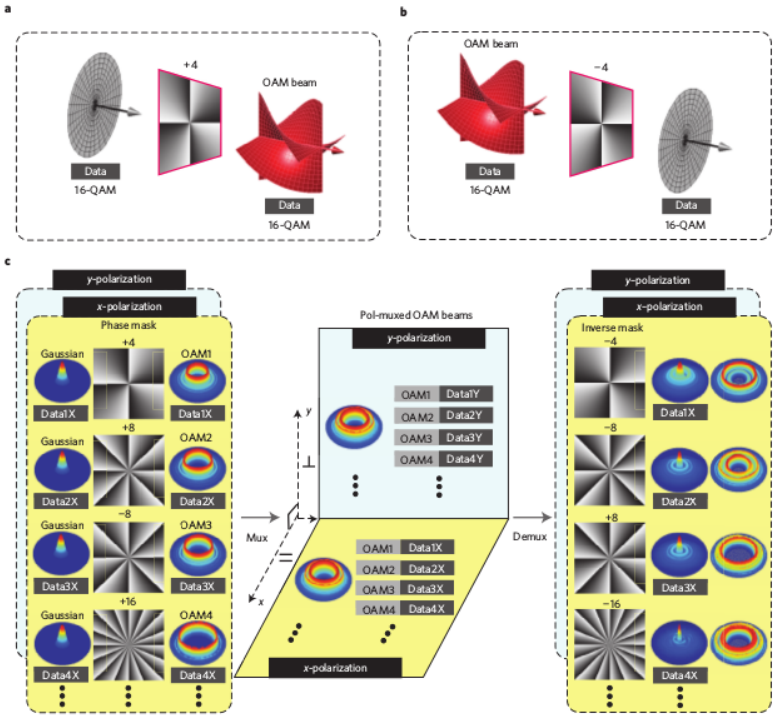

Figure 1 | Concept and principle. a, Generation of an information-carrying OAM beam with a helical phase front. **b**, Recovery of an information-carrying beam with a planar phase front. **c**, Multiplexing/demultiplexing of information-carrying OAM beams together with polarization multiplexing/demultiplexing (middle panel). For multiplexing, OAM beams with 'doughnut'-shaped intensity profiles (left panel, third column) are spatially multiplexed. For demultiplexing, one of the OAM beams is converted into a beam with a high intensity at the centre (right panel, second column), which can be separated from other updated OAM beams with 'doughnut' shapes (right panel, third column) by spatial filtering. 16-QAM, quadrature amplitude modulation; Mux, multiplexing; Demux, demultiplexing; Pol-muxed, polarization-multiplexed.

ARTICLES
PUBLISHED ONLINE: 24 JUNE 2012 | DOI: 10.1038/NPHOTON.2012.138
nature photonics

Terabit free-space data transmission employing orbital angular momentum multiplexing

Jian Wang[1,2]*, Jeng-Yuan Yang[1], Irfan M. Fazal[1], Nisar Ahmed[1], Yan Yan[1], Hao Huang[1], Yongxiong Ren[1], Yang Yue[1], Samuel Dolinar[3], Moshe Tur[4] and Alan E. Willner[1]*

The recognition in the 1990s that light beams with a helical phase front have orbital angular momentum has benefited applications ranging from optical manipulation to quantum information processing. Recently, attention has been directed towards the opportunities for harnessing such beams in communications. Here, we demonstrate that four light beams with different values of orbital angular momentum and encoded with 42.8 × 4 Gbit s^{-1} quadrature amplitude modulation (16-QAM) signals can be multiplexed and demultiplexed, allowing a 1.37 Tbit s^{-1} aggregated rate and 25.6 bit s^{-1} Hz^{-1} spectral efficiency when combined with polarization multiplexing. Moreover, we show scalability in the spatial domain using two groups of concentric rings of eight polarization-multiplexed 20 × 4 Gbit s^{-1} 16-QAM-carrying orbital angular momentum beams, achieving a capacity of 2.56 Tbit s^{-1} and spectral efficiency of 95.7 bit s^{-1} Hz^{-1}. We also report data exchange between orbital angular momentum beams encoded with 100 Gbit s^{-1} differential quadrature phase-shift keying signals. These demonstrations suggest that orbital angular momentum could be a useful degree of freedom for increasing the capacity of free-space communications.

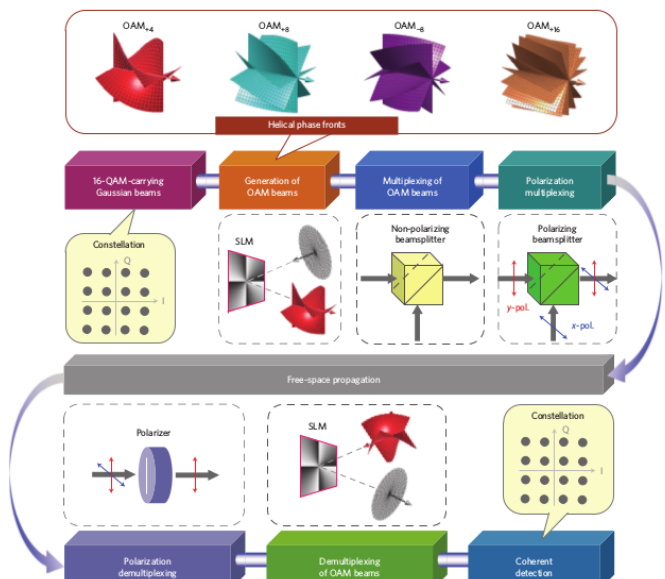

Figure 2 | Block diagram of the experimental set-up. Multiplexing/demultiplexing of information-carrying OAM beams.