Scalable Quantum Computing Over the Rainbow

OLIVIER PFISTER, University of Virginia, NICOLAS C. MENICUCCI, Perimeter Institute, Waterloo, Canada, STEVEN T. FLAMMIA, IQI, Caltech — The physical implementation of nontrivial quantum computing is an experimental challenge due to decoherence and the need for scalability. Recently we proved a novel theoretical scheme for realizing a scalable quantum register of very large size, entangled in a cluster state, in the optical frequency comb (OFC) defined by the eigenmodes of a single optical parametric oscillator (OPO). The classical OFC is well known as implemented by the femtosecond, carrier-envelope-phase- and mode-locked lasers which have redefined frequency metrology in recent years. The quantum OFC is a set of harmonic oscillators, or Qmodes, whose amplitude and phase quadratures are continuous variables, the manipulation of which is a mature field for one or two Qmodes. We have shown that the nonlinear optical medium of a single OPO can be engineered, in a sophisticated but already demonstrated manner, so as to entangle in constant time the OPO’s OFC into a finitely squeezed, Gaussian cluster state suitable for universal quantum computing over continuous variables. Here we summarize our theoretical result and survey the ongoing experimental efforts in this direction.