Contribution ID: **384** Type: **Poster Presentation**

Engineering Exotic Hybrid States

Entangled quantum states find themselves in many active fields, such as cryptography and information transfer. High dimensional states are highly sought after as they can carry large amounts of information. One method used to scale the amount of information carried by these states is to use higher dimensional degrees of freedom (DOFs). However, these states are fragile, easily disturbed by noise, and difficult to measure. Luckily, one can create a hybrid entangled state, where we entangle higher dimensional DOFs with robust, 2D DOFs. This shifts us from one high dimensional fragile entangled state to multiple robust 2D entangled states, allowing us to leverage the advantages of both DOFs. Using a novel interferometric device, hybrid states were generated using a spin to orbit conversion technique implemented on photons produced from a spontaneous parametric down conversion process. This compactly designed interferometer was used to generate arbitrary hybrid states entangled in orbital angular momentum and polarisation. Several hybrid states of high purity were generated using this interferometer and Bells inequalities were violated with high visibilities. The high visibilities and purities indicate that high quality states with high fidelities can be produced by our interferometer. Our approach allows for a wide variety of hybrid states packed with a large amount of easily measurable information. These hybrid states have great potential for use in real world information transfer.

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Session Classification: Poster Session

Track Classification: Track C - Photonics