

## Description of Additional Supplementary Files

File name: Supplementary Movie 1

Description: The time-variant amplitude and phase profiles of the rotating-revolving  $LG_{\bar{\ell},0}$  beams with the value of  $\bar{\ell}$  varied from -1 to +3.  $\bar{\ell}$  represents the number of  $2\pi$  phase changes along the azimuthal direction around the beam center.