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Bessel beam array generation using an axicon lens and gratings

Prasenjit Praharaj, Manoj Kumar Bhuyan

CSIR – Central Scientific Instruments Organisation, Sector 30C, Chandigarh 160030, India

Academy of Scientific and Innovative Research (AcSIR), Ghaziabad 201002, India

INTRODUCTION & AIM

Arrays of non-diffractive beams, such as Bessel beams [1], are important for applications in emerging fields of microscopy, photonics, nonlinear optics, optical trapping, beam shaping, laser fabrication, etc.

Researchers have demonstrated array of Bessel beam generation using Spatial light modulator (SLM), Dammann grating [2], metasurfaces [3], and lenslets array. However, the poor resolution of SLM restricts the generation of high cone angle Bessel beams. Also, the fabrication process of metasurfaces are complex. In addition to this, passive optical elements-based array generation have advantages over active optical elements due to high damage threshold, as often required for high power laser applications.

Our study [4] focused on the generation of an array of zero-order Bessel beams, primarily using passive optical elements, i.e., an axicon lens, telescope, and laser-fabricated gratings.

METHOD

- **Grating fabrication:** one-dimensional (1D) and two-dimensional (2D) gratings of various periods and a fill factor of 0.5 were fabricated using nanosecond pulsed laser micromachining technique.
- **Bessel beam generation:** A Gaussian laser beam with a central wavelength of 532 nm was incident on an axicon lens and a telescope, to generate a micro-Bessel beam [Fig. 1(a)].
- **Bessel beam array generation:** The laser fabricated grating was placed before the axicon lens to generate an array of micro-Bessel beams.
- **Bessel beam characterization:** The generated Bessel beam array was then imaged by a 4f imaging system. The radial beam profiles of micro-Bessel beams were recorded all along the beam propagation direction and were subsequently processed using MATLAB software.

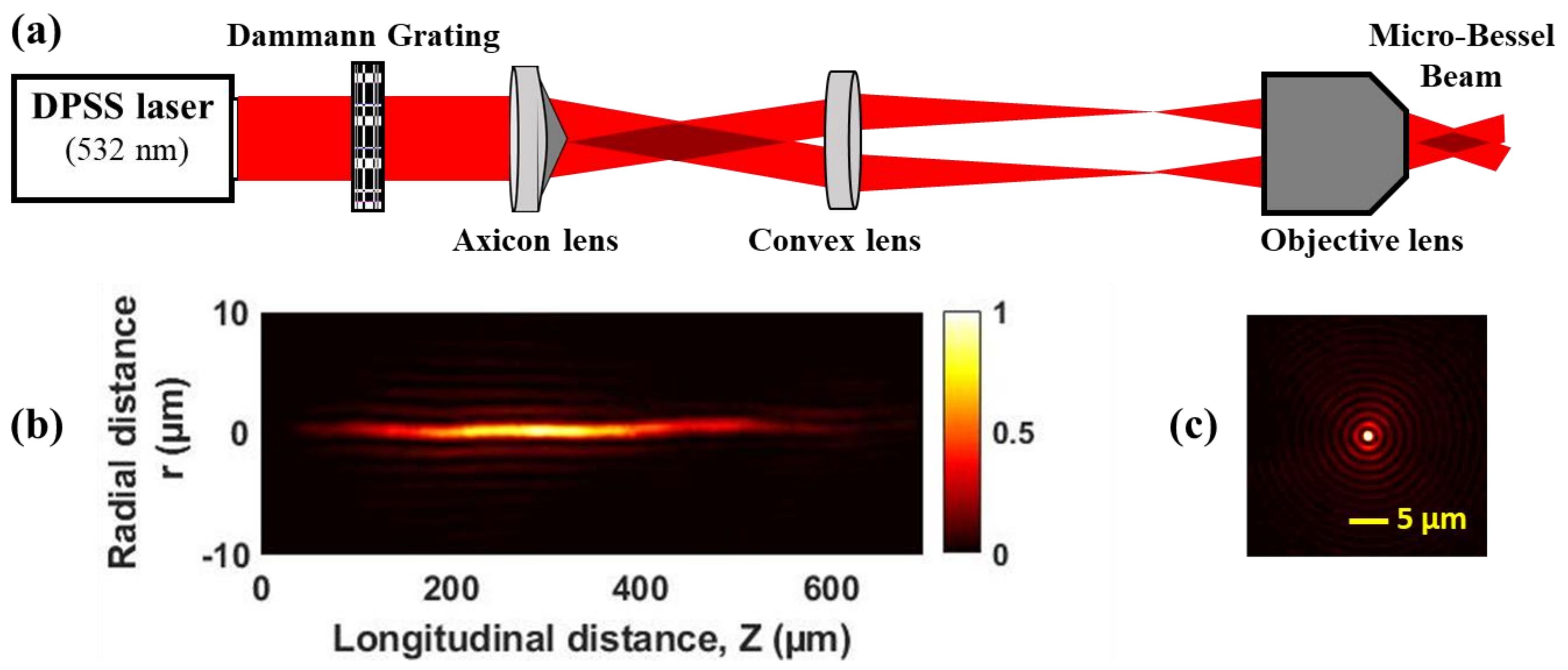

Figure 1. (a) Schematic of the experimental setup; (b) longitudinal profile and (c) radial profile of generated Bessel Beams.

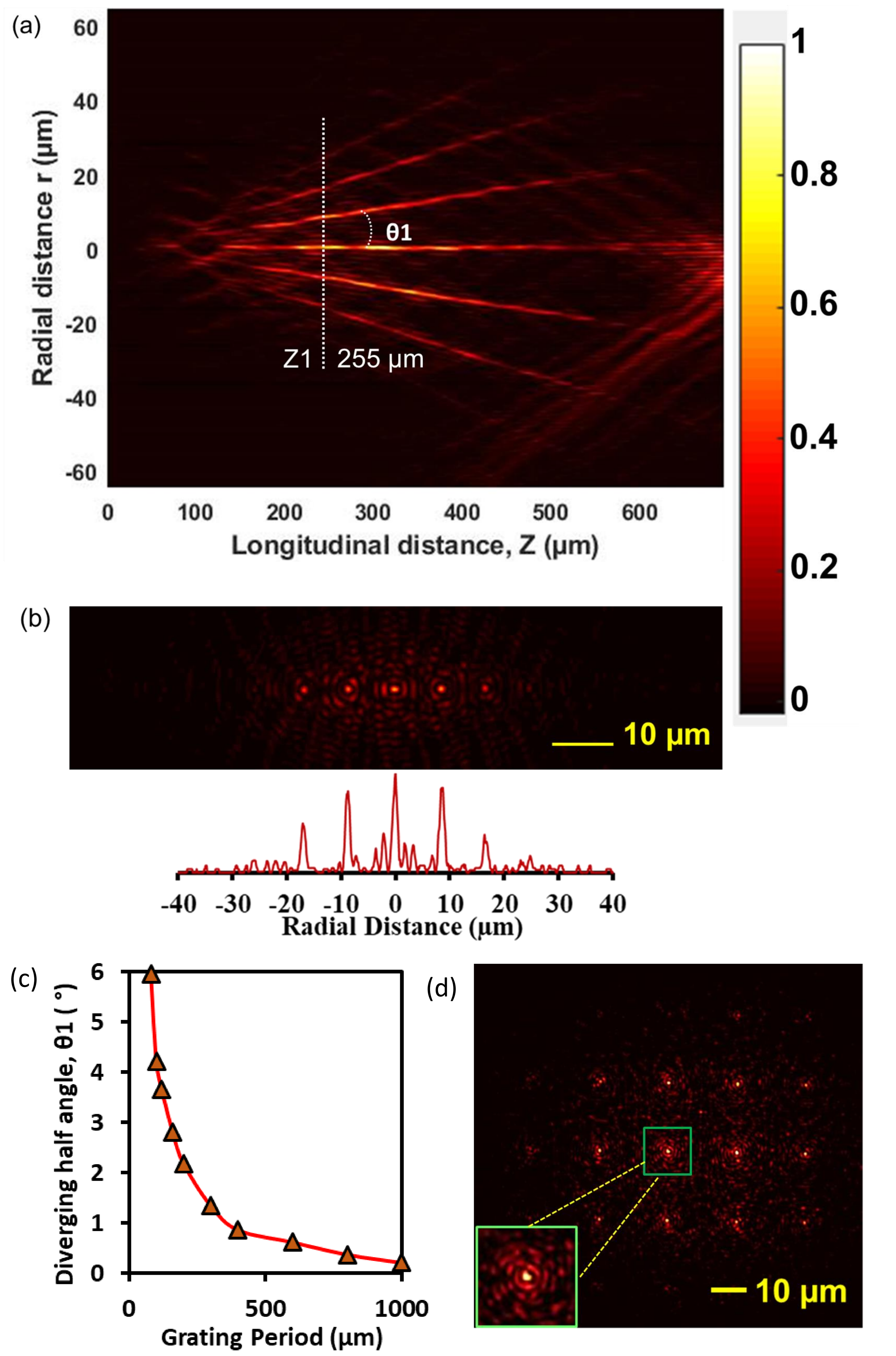

Figure 2. (a) Longitudinal profile and (b) radial profile at Z1=255 μm distance of [1x5] array of Bessel beam. (c) Variation of beamlet divergence w.r.t grating period. (d) Radial profile of [5x5] array of Bessel beams.

RESULTS & DISCUSSION

- **Isolated Bessel beams:** The physical characteristics of Bessel beams generated with an axicon only (i.e., without grating) are as follows:
  - Bessel conical half angle: 12°
  - Bessel beam central core size (FWHM): 0.9 μm
  - Bessel longitudinal extent (FWHM): 220 μm
- **Array of Bessel beams:** Diverging Bessel beam arrays in 1D [Fig. 2(a, b)] and 2D [Fig. 2(d)] configuration were obtained using axicon - grating combination.
  - The diverging half angle of Bessel beam in array format dependent on grating period is shown in Fig 2.(c).
  - [5x5] array of Bessel beams were obtained using a 200 μm period grating.
  - The characteristics of Bessel beams in an array format remained invariant from isolated Bessel beams [Fig.2(b)].
  - The diverging angle of Bessel beams in the array format depends on the grating period as shown in Fig. 2(c).

CONCLUSION

In summary, we have generated high cone angle micro-Bessel beam array in 1D and 2D geometry with Bessel conical half angle of 12° using passive optical elements such as axicon lens, gratings and suitable magnification system. The Bessel beams in the array retain the characteristics of isolated Bessel beam.

REFERENCES

1. Durnin, J.; Miceli, J.; Eberly, J.H. Diffraction-Free Beams. Phys. Rev. Lett. 1987, 58, 1499–1501.
2. García-Martínez, P.; Sánchez-López, M.M.; Davis, J.A.; Cottrell, D.M.; Sand, D.; Moreno, I. Generation of Bessel Beam Arrays through Dammann Gratings. Appl. Opt. 2012, 51, 1375–1381.
3. Chen, L.; Kanwal, S.; Yu, B.; Feng, J.; Tao, C.; Wen, J.; Zhang, D. Generation of High-Uniformity and High-Resolution Bessel Beam Arrays through All-Dielectric Metasurfaces. Nanophotonics 2022, 11, 967–977.
4. Praharaj, P.; Bhuyan, M.K. Nanosecond Laser Fabrication of Dammann Grating-like Structure on Glass for Bessel-Beam Array Generation. Photonics 2024, 11, 473.

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