RX16-8

1. **Research Title:** ***Photorefractive Beam Coupling for Agile Filter Applications***

2. **Individual Sponsor:** *List the AFRL research topic sponsor's contact information:*

Dr. Dean R. Evans, AFRL/RXAP
AFRL/RXAP Bldg 651
3005 Hobson Way
WPAFB, OH 45433
dean.evans@us.af.mil

3. **Academic Area/Field and Education Level:** Electro-Optics; Ph.D. level

4. **Objectives:** *Describe the overall objectives for the proposed research.*

To construct and test hybrid photorefractive (PR) devices, comprising liquid crystals (LCs) between two space-charge field generating windows, and design novel integrated structures with ferroelectric PR nanoparticle dispersed LCs. To develop a mathematical model based on the transfer matrix method/Berreman's method for space-charge dynamics in PR materials, and apply it to analyze PR beam coupling in hybrid PR devices. To conduct a theoretical investigation the effects of coherent and partially coherent beam combination.

Description: It has been shown that by manipulating the molecular reorientation in LCs through electrostatic fields which are spatially periodic along the surface of the liquid crystal layer, a strong periodic induced refractive index can be achieved in the liquid crystal which can enable efficient two-beam coupling with extremely high gain coefficients. These electrostatic fields can be generated during two-beam interaction with space-charge field generating enclosing the liquid crystal. The purpose of this proposed research is to model and test this effect, and explore novel designs for integrated hybrid liquid crystal devices with ferroic nanoparticles.

Experimental: The experimental work will comprise testing of hybrid PR devices, comprising LCs between two space-charge field generating windows. This will be extended to integrated hybrid structures where ferroelectric PR nanoparticles will be incorporated into the liquid crystal layer to improve electric torque for enhanced two-beam coupling efficiency. Characterization techniques such as Raman and FTIR will be used to determine the best mixture of nanoparticles and LCs which can provide the strongest interaction between the organic liquid crystal molecules and the inorganic nanoparticles.

Theoretical: A steady state transfer matrix method/ Berreman's method based approach to two-wave mixing in PR materials will be first reproduced and tested against existing results. A heuristically developed time-dependent model for PR grating formation will then be used to analyze the evolution of the space charge field within, and in the vicinity of, the PR materials. This will then be used in conjunction with developed models for molecular reorientation of LCs under external electrostatic fields to determine the magnitude and phase of the induced refractive index grating in the liquid crystal. Knowledge of the induced refractive index will then be used to determine two-beam coupling in the liquid crystal layer sandwiched between PR windows.

5. **Research Classification/Restrictions:** This research has no ITAR restrictions.

6. **Eligible Research Institutions:** Place an X in all that apply.

   ☒ Universities (DAGSI) ☐ AFIT (only) ☐ USAFA

7. **Interest in Summer USAFA Cadet:** No

PA Release #88ABW-2015-3722