



AFRL-AFOSR-JP-TR-2024-0015

Soft-Colloids on Plasmonic Surfaces: Optothermal Trapping and Assembly

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**12/11/2023
Final Technical Report**

DISTRIBUTION A: Distribution approved for public release.

Air Force Research Laboratory
Air Force Office of Scientific Research
Asian Office of Aerospace Research and Development
Unit 45002, APO AP 96338-5002

REPORT DOCUMENTATION PAGE

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1. REPORT DATE 20231211	2. REPORT TYPE Final	3. DATES COVERED	
		START DATE 20220428	END DATE 20230727
4. TITLE AND SUBTITLE Soft-Colloids on Plasmonic Surfaces: Optothermal Trapping and Assembly			
5a. CONTRACT NUMBER	5b. GRANT NUMBER FA2386-22-1-4017	5c. PROGRAM ELEMENT NUMBER	
5d. PROJECT NUMBER	5e. TASK NUMBER	5f. WORK UNIT NUMBER	
6. AUTHOR(S) G.V. Pavan Kumar			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) INDIAN INSTITUTE OF SCIENCE EDUCATION AND RESEARCH 900, NCL INNOVATION PARK., DR HOMI BHABHA ROAD, PASHAN, PUNE, MAHARASHTRA 411008 IND			8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) AOARD UNIT 45002 APO AP 96338-5002		10. SPONSOR/MONITOR'S ACRONYM(S) AFRL/AFOSR IOA	11. SPONSOR/MONITOR'S REPORT NUMBER(S) AFRL-AFOSR-JP-TR-2024-0015
12. DISTRIBUTION/AVAILABILITY STATEMENT A Distribution Unlimited: PB Public Release			
13. SUPPLEMENTARY NOTES			
14. ABSTRACT <p>The proposed objective was to study optothermal trapping, assembly and scattering from individual dielectric soft-matter based micro-colloidal architectures placed on a variety of plasmonic platforms. In this project, we utilized optical tweezers to study the optical interaction between an isolated colloid that harbours whispering gallery modes, and a plasmonic thin film which facilitates plasmons.</p> <p>We explored mirror-coupled microsphere and showed that it can narrow the angular distribution of photoluminescence from WS₂ monolayers [1]. I have summarized some new opportunities of performing optical trapping of plasmonic colloids with beams carrying orbital angular momentum of light [2]. We published a couple of collaborative papers [3,4] on interaction between two dimensional materials with substrates using dielectric engineering. The tools that we had developed to perform optothermal trapping has turned out to be very versatile and useful for the characterization.</p> <p>Of prominent importance to the project were the publications related to optothermal evolution of active colloids in a structured optical trap [5] and simultaneous detection of spin and orbital angular momentum of light via coherent light scattering from a single plasmonic nanowire [6]. These papers showed experimental aspect of utilizing soft colloidal platforms to trap and interrogate both structured light and soft matter.</p> <p>In a recent paper titled "Emergence of Directional Rotation in an Optothermally Activated Colloidal System" [7] we demonstrate the experimental emergence of directional rotation in thermally active-passive colloidal structures under optical confinement. The observed handedness of the rotation can be controlled by changing the relative positions of the constituent colloids. The angular velocity of rotation is sensitive to the intensity of the incident optical fields and the size of the constituent colloidal entities. The emergence of rotational dynamics can be understood in the context of the asymmetric temperature distribution in the system and the relative location of the active colloid, which creates a local imbalance of optothermal torques in the confined system. The paper discusses how localized optothermal fields lead to directional rotational dynamics without explicitly utilizing the spin or orbital angular momentum of light. The findings have potential implications in realizing Brownian engines and can directly relate to rotational dynamics in biological and ecological system</p> <p>Following research papers were published from this project:</p> <ol style="list-style-type: none"> 1. Chaubey, S. K., Tiwari, S., M. A., G., Paul, D., Rahman, A., & Pavan Kumar, G. V. (2022). Mirror-coupled microsphere can narrow the angular distribution of photoluminescence from WS₂ monolayers. <i>Applied Physics Letters</i>, 120(26), 261109. https://doi.org/10.1063/5.0089863 2. Kumar, G. V. P. (2023). When Plasmonic Colloids Meet Optical Vortices—A Brief Review. <i>Indian Journal of Pure & Applied Physics (IJPAP)</i>, 61(7), Article 7. https://doi.org/10.56042/ijpap.v61i7.107 3. Narayanan, V., Majumder, S., M. A., G., Taneja, C., Kumar, G. V. P., & Rahman, A. (2023). Improving the optoelectronic properties of monolayer MoS₂ field effect transistor through dielectric engineering. <i>Nanotechnology</i>. https://doi.org/10.1088/1361-6528/acf9aa 4. Nechiyil, D., Gokul, M. A., Shukla, A., Kumar, G. V. P., & Rahman, A. (2023). Strain-enabled defect migration and defect activation in monolayer MoS₂. <i>2D Materials</i>, 10(4), 045009. https://doi.org/10.1088/2053-1583/aceb74 5. Paul, D., Chand, R., & Kumar, G. V. P. (2022). Optothermal Evolution of Active Colloidal Matter in a Defocused Laser Trap. <i>ACS Photonics</i>, 9(10), 3440–3449. https://doi.org/10.1021/acsp Photonics.2c01083 6. Paul, D., Sharma, D. K., & Kumar, G. V. P. (2022). Simultaneous Detection of Spin and Orbital Angular Momentum of Light through Scattering from a Single Silver Nanowire. <i>Laser & Photonics Reviews</i>, n/a(n/a), 2200049. https://doi.org/10.1002/lpor.202200049 7. Chand, R., Rani, C. E., Paul, D., & Kumar, G. V. P. (2023). Emergence of Directional Rotation in an Optothermally Activated Colloidal System. <i>ACS Photonics</i>, 10(11), 4006–4013. https://doi.org/10.1021/acsp Photonics.3c00890 			
15. SUBJECT TERMS			

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES
a. REPORT U	b. ABSTRACT U	c. THIS PAGE U	SAR	3
19a. NAME OF RESPONSIBLE PERSON TODD RUSHING			19b. PHONE NUMBER (Include area code) 315-227-7003	

Standard Form 298 (Rev.5/2020)
Prescribed by ANSI Std. Z39.18

Grant No. FA2386-22-1-4017, R&D 22IOA017
Soft-Colloids on Plasmonic Surfaces: Optothermal Trapping
and Assembly,
PI: Prof. G V Pavan Kumar

Final Report:

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