A Spectrally and Temporally Resolved Optical Pyrometer for Measurements of Optical Self-Emission and Reflectometry on OMEGA EP



APS DPP 2022 Spokane Washington 10/17/2022

University of Rochester Laboratory for Laser Energetics



The Streaked Optical Spectrometer with spectral resolution (SOP-spec) will unlock a new class of investigations into laser compressed HED materials

- The current SOP system measures a single intensity value for the 590-700 nm band, used to infer the temporally and spatially resolved gray body temperature*.
- SOP-spec is being designed to capture the time-resolved emission spectrum, or reflectivity in the 450-800 nm band
- Self-emission spectroscopy will be used for temperature measurements of materials with emissivities
 that are non-constant or have unknown spectral dependencies
- Reflectivity measurements will provide a probe into the electronic structure of HED materials
- Final design work is currently underway with first expected usage on 6/22/2023 with many exciting
 experiments to follow





Collaborators

B. Henderson*, M. Marshall, A. Sorce, J. Katz, S. Ivancic, K. Vencatasamy, T. Boehly, D. Polsin, X. Gong, M. Huff, M. K. Ginnane, S. Regan, J. R. Rygg, and G. Collins

University of Rochester Laboratory for Laser Energetics

P. M. Celliers

Lawrence Livermore National Laboratory

* Now at L3Harris Technologies



Funding for this research was provided by the National Science Foundation under Award PHY-2020249 and by the NNSA DOE through the Laboratory for Laser Energetics Cooperative Agreement.

SOP is regularly fielded with the velocity interferometer system for any reflector (VISAR) to constrain the equation of state variables of HED materials



VISAR and SOP share a line of sight and are used to infer surface velocity and temperature respectively.



SOP is regularly fielded with the velocity interferometer system for any reflector (VISAR) to constrain the equation of state variables of HED materials



VISAR and SOP share a line of sight and are used to infer surface velocity and temperature respectively.



SOP is regularly fielded with the velocity interferometer system for any reflector (VISAR) to constrain the equation of state variables of HED materials



VISAR and SOP share a line of sight and are used to infer surface velocity and temperature respectively.



With SOP the gray body temperature is inferred from the absolute emission measured within the 590-700 nm band with 1-D spatial resolution





SOP-spec will be capable of measuring the time-resolved optical emission spectrum in the 450-800 nm wavelength band, enabling new experiments





^{*} S. V. Raju et. al. Journal of Applied Physics 110, 023521 (2011) ** P. M. Celliers et. al. Science, 361, 6403 (2018)

SOP-spec will be capable of measuring the time-resolved optical emission spectrum in the 450-800 nm wavelength band, enabling new experiments



* S. V. Raju et. al. Journal of Applied Physics 110, 023521 (2011) ** P. M. Celliers et. al. Science, 361, 6403 (2018)



SOP-spec will be capable of measuring the time-resolved optical emission spectrum in the 450-800 nm wavelength band, enabling new experiments



In addition, SOP-spec will be capable of measuring low temperature (<0.5 eV) gray body spectra

* S. V. Raju et. al. Journal of Applied Physics 110, 023521 (2011) ** P. M. Celliers et. al. Science, 361, 6403 (2018)



A prototype SOP-spec was previously implemented and used to collect time resolved optical spectra





Time

This first prototype does not meet all physics requirements, but provides critical data for the final design process.



A synthetic diagnostic has been created and benchmarked against the prototype





Based on a synthetic data study, the diagnostic's throughput must be increased by 3X to measure the temperature of a 0.5 eV gray body with 10% uncertainty



Uncertainty on the inferred temperature for 0.5 eV gray body

This increase is achievable through a redesign of the spectrometer components without effecting those shared with SOP and VISAR.





- Different detector options are being investigated including a ROSS streak camera with a new streak tube and photocathode and multi-anode MCP-PMT arrays
- Different custom vs off-the-shelf spectrometer options are being explored
- Most optical components in the current SOP relay have been identified, but there are still some "mystery mirrors" which we would like to characterize
- Investigating options for a new dichroic beam splitter between VISAR and SOP to narrow the data loss region
- Redesign of the reflectivity measurement platform to reduce preheat and background.



The Streaked Optical Spectrometer with spectral resolution (SOP-spec) will unlock a new class of investigations into laser compressed HED materials

- The current SOP system measures a single intensity value for the 590-700 nm band, used to infer the gray body temperature*.
- SOP-spec is being designed to capture the time-resolved emission spectrum, or reflectivity in the 450-800 nm band
- Self-emission spectroscopy will be used for temperature measurements of materials with emissivities
 that are non-constant or have unknown spectral dependencies
- Reflectivity measurements will provide a probe into the electronic structure of HED materials as they
 undergo transitions
- Final design work is currently underway with first expected usage on 6/22/2023



UR IIF

Questions/comments



neelkabadi@lle.rochester.edu



Backup slides





The reflectivity platform will require some redesign to reduce pre-heat and background, but signal statistics are sufficient



Shielding will be added between the sample and backlighter on future shots



The current prototype can measure ~450-700 nm based on calibration with a NIST standard tungsten lamp



