Modeling and simulation of a solar simulator with multi-wavelength high-power LEDs

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As solar power becomes a more important energy resource, the ability to test and accurately verify the efficiency of solar cells in a lab setting becomes more and more important. The problem is that most high power solar simulators, or lighting rigs that simulate the wavelength spectrum of the sun, use lights that don't match the solar spectrum well. Light Emitting Diodes (LEDs) provide a solution to that problem. By combining eighteen different LEDs, the solar spectrum can be more accurately simulated, create a more precise simulator.

To model these LEDs, we started by modeling the system in MatLab. Essentially, each LED has a short wavelength spectrum, and by adjusting a scaling factor, each LEDs' spectrum can be combined in such a way to make a spectrum the same length as the sun's. This spectrum was then compared to the sun's, and using that comparison, we tweaked the values of the scaling factor until the spectrum of the LEDs was close to the sun's. Once we had the optimal spectrum, we modeled the simulator part using a tool called LightTools. This involved moving model LEDs around a space the size of the part we are planning to make, adjusting the positions and intensities to match the spectrum found in MatLab. We then did color measurements and analysis to see how closely our part would match color-wise to the sun.

The results we found were impressive. Our spectrum matched the sun's incredibly well. Our color measurements showed that our configuration matched the sun's color closely, measuring among the top of similar LED lights for color quality. These results are great, showing that this tool could be revolutionary in the solar simulator industry. This research can also be applied to other industries, such as interior lighting to combat SADs or natural lighting for photoshoots and movies.

It was a pleasure to work on this research. To be able to work with a professor, getting to know them and their work better was awesome. Not only that, but this research allowed me to pursue a passion of mine. I am interested in smart lighting and using LEDs in modern lighting and design, and this project let me explore how LEDs can be used and combined to create new and better designs. It is also cool to work on research that is ground breaking. Being able to submit a paper that presents impressive results to a huge international conference was an amazing experience. Overall, I had a lot of fun working on this project, and am so glad to be able to work on it.