

Solar and stellar measurements using accurate spectroscopic techniques

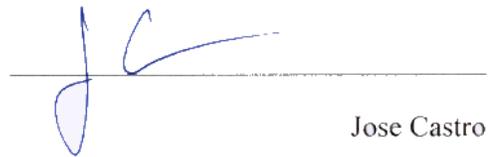
Department of Physics, Lamar University, Beaumont, Texas

November 30, 2012

Requested Budget: \$2000.00

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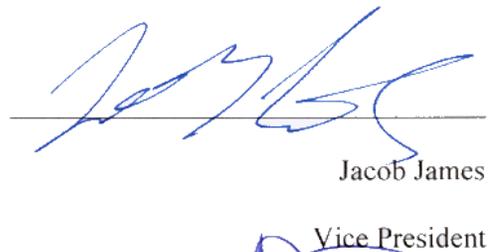

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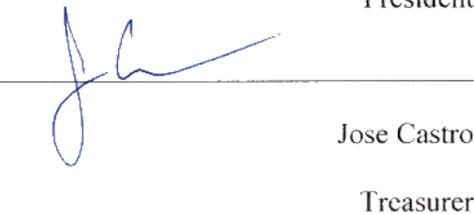
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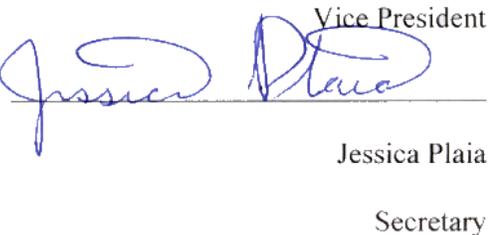

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Abstract

We propose to use low-cost optics equipment in order to (1) generate a Hertzsprung-Russell diagram for the 24 brightest stars visible in Beaumont, (2) analyze the polarization of stellar and solar light and the effect a telescope's optics have on these measurements, and (3) analyze the absorption spectrum due to Earth's atmosphere on the Sun's blackbody radiation spectrum.

Purpose

Several SPS members at LU have a strong interest in astronomy. Because astronomical research is often too expensive for an undergraduate physics program, we are eager to apply our knowledge in using spectroscopic techniques acquired in a general optics course [1] to analyze light from bright stars and the Sun. The research proposed will improve the existing optical methods for quantitative analysis of light sources using low-cost equipment with the purpose of running accurate stellar measurements in our geographic area, despite the adverse conditions such as local gaseous and light pollution from chemical plants and urban activity.

We propose three experimental projects using equipment which can be purchased within the budget of the present grant solicitation. The equipment will be dedicated to this research project for the duration of the grant, and later it will be incorporated into astronomy and optics labs in order to generate other research opportunities for undergraduate students at Lamar. Also, due to the "astronomical" expenses usually associated with astronomical research, our low-cost equipment can be appealing to similar undergraduate labs.

Proposed Activities

The scope of the first experiment is to generate an accurate Hertzsprung-Russell Diagram (HRD) for the 24 brightest stars visible in Beaumont by precisely measuring their surface temperature from the peak of radiancy using Wien's displacement Law and generating a curve of radiancy to determine their luminosity. These 24 stars (Sirius, Vega, Capella, Arcturus, Rigel, Procyon, Betelgeuse, Altair, Aldebaran, Spica, Antares, Pollux, Fomalhaut, Deneb, Regulus, Adhara, Bellatrix, Alnath, Alioth, Mirphak, Alkaid, Castor, Alhena, and Polaris) were selected for the likelihood to observe and measure the peak of radiancy with our 14" Meade reflector telescope and optics equipment for the blackbody radiation, and because of the need to align our telescope using the Polaris star (which is the 24th brightest star in a standard astronomical chart for this latitude). This experiment will primarily use a high sensitivity VIZ light sensor.

The second experiment, APSL, will involve the Analysis of Polarized Stellar Light at different degrees of polarization and will use solar light as a benchmark. The influence of the optical components of a telescope on the degree of polarization of light will be assessed by comparing the effects of placing a polarizer before and after the light enters the telescope and using a control setting which consists of a non-reflective tube and a polarizer. Our experiment will use UVA, high sensitivity VIZ, and IR light sensors to determine if light from the

first five brightest stars has been polarized before reaching us. Studies of polarized light have recently been published as able to reveal the shape of a supernova's core [2].

Our third project intends to identify Pollutants in Earth's Atmosphere (PEA). Toward this end we will record the absorption spectrum of the Earth's atmosphere superimposed on the Sun's blackbody spectrum using UVA, high sensitivity VIZ, and IR light sensors, and spectroscopic charts available online from NIST databases [3]. This method can be used as a model to determine the composition of stellar or planetary nebula located between us and distant stars. These readings will be used to generate a complete blackbody curve of radiancy similar with the one published by Martin Greens [4]. We will compare this data with the data of the emission spectra of atoms and molecules, typically present in the atmosphere, superimposed on a blackbody radiation background spectrum, as shown in Figure 1b.

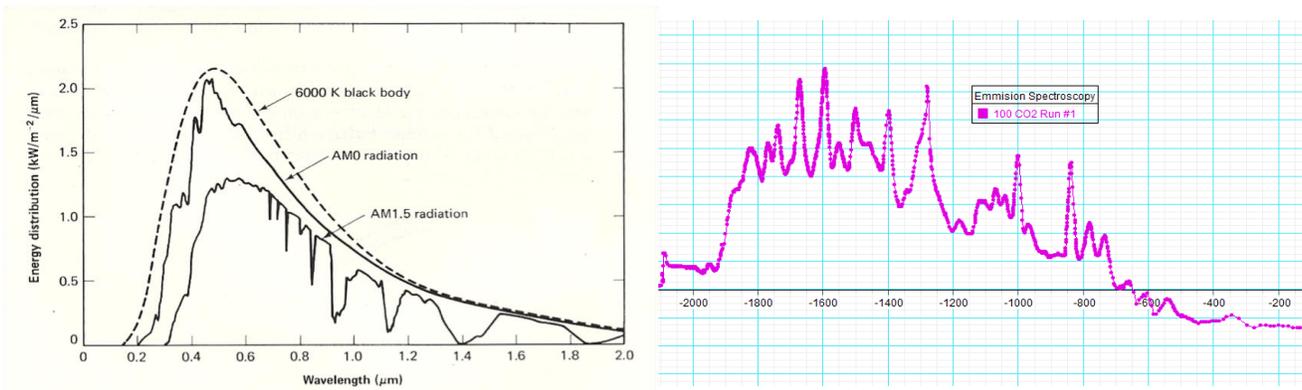


Figure 1a: Left: The figure shows the difference between a blackbody curve measured from above (AM0) and below (AM1.5) the Earth's atmosphere as report in [4]. Figure 1b: Right: The figure shows the emission spectrum of CO₂ superimposed upon a typical blackbody radiation spectrum and measured with similar equipment as the one included in this proposal.

Technical Details and Timeline

The three experiments (HRD, APSL, and PEA) are related because they will be using similar experimental optical techniques and arrangements (as shown in Figure 2) with only minor adjustments for allowing specific measurements. The confidence we have in using optical equipment and methodologies is grounded in the knowledge acquired from our optics course [5].

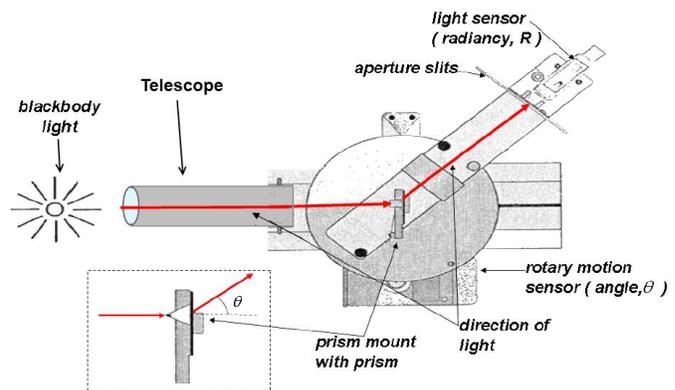


Figure 2: A setup for the study of the blackbody radiation spectrum. The path of the light is shown by two red arrows.

All three experiments will use basic PASCO equipment (<http://www.pasco.com/home.cfm>) attached to our two telescopes. A 14" Meade LX200GPS-SMT Schmidt-Cassegrain telescope will be used for stellar observations and measurements, while a smaller 50 mm aperture Bushnell 340x60 telescope will only be used for solar measurements.

The month of January will be spent acquiring and calibrating the new equipment required for the three projects (HRD, APSL, and PEA). The months of February through November will be spent collecting and analyzing data in order to generate a final report in December.

Expected Conclusions

We expect our HRD to provide a reference for comparison to the standard Hertzsprung-Russell diagram that southeast Texas astronomers can use. APSL should increase our knowledge in the blossoming field of studying polarization of light in astronomy. It should also provide better understanding for the professional community with regard to polarizer placement during data acquisition. PEA will provide insight regarding the magnitude of corruption in astronomical data collection due to pollutants.

The projects are also expected to produce accurate measurements able to instruct students in freshmen astronomy courses all the way to senior optics courses with open-ended potential for future research. Our efforts might even ignite greater student interest in experimental research, which is a goal of our SPS chapter and the science community at large.

References

- [1] Bahrim, Cristian, ed. W. Aung, et al. "A modern optics laboratory for undergraduate students." *Innovations 2006: World Innovations in Engineering Education and Research*. Potomac, MD: iNEER, 2006. 207-215. ISBN: 0974125253.
- [2] Cowen, Ron. "Astronomy Gets Polarized." *Science News*. Vol. 170, No. 2, July 8, 2006, p. 24.
- [3] NIST Database. <http://www.nist.gov/physics-portal.cfm>
- [4] Green, Martin A. *Solar Cells: Operating Principles, Technology, and System Applications*. Englewood Cliffs: Prentice-Hall, Inc., 1982. ISBN: 9780138222703.
- [5] Bahrim, Cristian. "Blackbody radiation." *Optics - PHYS 4480/5480 Laboratory Activities*. Online resource. http://sethi.lamar.edu/bahrim-cristian/Courses/PHYS4480/4480-LABS/4480_lab_2.pdf.

Budget

Basic Optics Spectrophotometer Accessory (OS-8537)	\$599.00
Spectrophotometer Base	
Rotating Arm	
Collimation Slits and Lens	
Focusing Lens	
Diffraction Grating and holder	
Rod Stand and Mounting Brackets	
Optics Bench Rod Clamp - set of 2 (OS-8479) x2	\$58.00
Rotary Motion Sensor (CI-6538)	\$179.00
High Sensitivity Light Sensor (CI-6604)	\$139.00
Aperture Bracket (OS-8534A)	\$89.00
UVA Light Sensor (CI-9784)	\$165.00
Infrared Sensor (CI-6628)	\$219.00
Basic Optics Prism Mount (OS-8543)	\$198.00
Basic Optics Polarizer Set (OS-8473)	\$59.00
Two Polarizer Disks	
Optics Holder	
120 cm Stainless Steel Rod (ME-8741) x4	\$124.00
Small "A" Base (ME-8976) x4	\$156.00
Light Shielding Fabric	\$15.00
Total	\$2000.00
