SOCIETY OF PHYSICS STUDENTS

An organization of the American Institute of Physics

SPS Chapter Research Award Proposal

Project Proposal Title	***SPS***@UCA: ***S***mall ***P***arallel ***S***upercomputer at UCA
Name of School	University of Central Arkansas
SPS Chapter Number	Zone 10, Chapter 1059
Total Amount Requested	$1,997.73

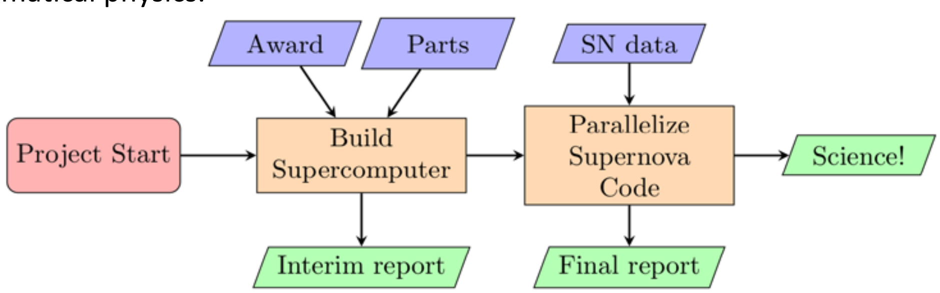
Abstract

The Society of Physics Students at the University of Central Arkansas plans to build a small parallel supercomputer. We will use it to get hands-on experience with the tools and techniques of computational physics research. We will expand our astrophysics research, attract new SPS student research, and foster educational outreach.

Proposal Statement

Overview of Proposed Project

This project started as an outgrowth of two students' independent research with university physics faculty in both parallel computing and astrophysics. When the idea of building a supercomputer arose, we quickly became organized and put the call out for additional SPS students to help with this project. Four more students joined our project. Currently we consist of two freshmen, one freshman-level post baccalaureate, a sophomore and two seniors. We worked under the supervision of our faculty advisor and researched the idea of a low cost, yet powerful computer. Our research led us to the LittleFe project (Peck, 2010) that has been discontinued. We pursued their previous efforts and realized that for approximately $2000 we could build our own small parallel supercomputer. This, in turn, spurred further dreams of particular research that we could undertake. With the full complement of students, the project developed into two main thrusts. The first is to research, build, and deploy an operational small parallel supercomputer, and then develop the Python language control program to maximize parallel processing. The second main thrust will be to use this computer to process large amounts of astrophysical data. Specifically, we will attempt to measure the bolometric luminosity of supernova using astrophysical data from model simulations. Our faculty advisor published his dissertation on this topic and can guide and mentor the SPS students as we attempt to reproduce his results. This will directly contribute to SPS students' increased exposure to astrophysics research. We envision a future and third main thrust of continuing research in acoustical physics, biological physics, and mathematical physics.



Background for Proposed Project

College campuses, generally, lack a dedicated supercomputer server (Adams, 2015). Those that have them are usually very large schools in a region or state. This limits supercomputing time available for universities without their own supercomputer. Building a small supercomputer that is portable will allow a much broader range of undergraduate research opportunities by permitting the parallel processing of large data sets previously unavailable. The types of research data we plan to use this for include astrophysics data, acoustical data, and particle and fields data; all of which are of high interest on UCA's campus.

The inspiration for this project came from the LittleFe project (Image shown from Babic, 2014), an NSF grant awardee that aimed to build small, portable supercomputers capable of effectively showing the power of parallel computing. We hope to mimic this design, adding our own modifications and using campus resources along the way, in order to show students in many different research areas how beneficial supercomputing can prove to be.

Expected Results

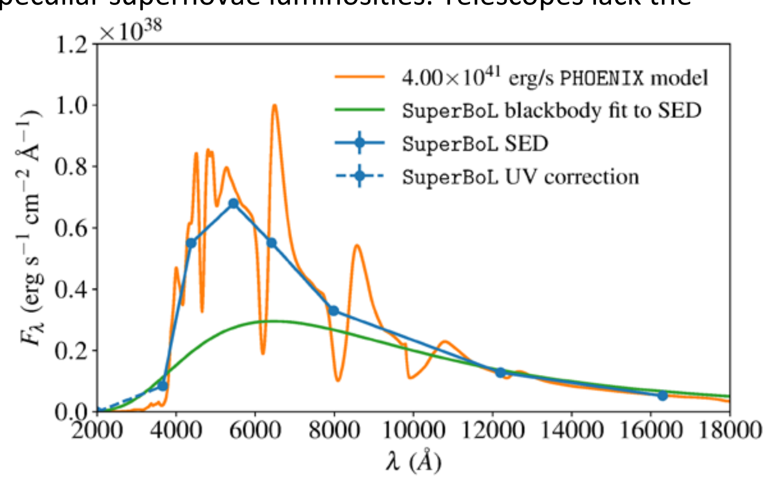
This project will expose SPS students to the entire life cycle of both theoretical and experimental physics. From the theoretical side, we highlighted the need for a supercomputer to access and process large amounts of data. Specifically, much of the research in astrophysics occurs with requirements for large amounts of data processing. With access to large amounts of astrophysical data and our supercomputer, continuing undergraduate research will flourish. Much of today's astrophysics research involves modeling behavior of stellar events, because of the difficulty of observing specific required astrophysical phenomena. Our supercomputer will model these physical phenomena, such as supernovae data, and enable their study. From the experimental side, we will build the supercomputer for the data access and processing needed. The final result will be an operational supercomputer, capable of gathering and processing data that can jumpstart our SPS students' knowledge of both theoretical and experimental physics, and serve as a hands-on introduction to high-performance computing, data-enabled science, and computational science (Babic, 2014).

Overall, we hope to achieve the following goals:

- Teach SPS students basic computational physics skills, computer engineering and how to build a supercomputer
- Show SPS students how supercomputing can apply to real world projects in a multitude of fields (gene sequencing, supernova research, computer science applications such as parallelization)
- Transport the supercomputer for SPS meetings, local school demonstrations and community events to generate interest in the STEM fields, specifically physics
- Facilitate research environment for SPS students, enabling leadership, cooperation, and teamwork occasions
- Expose SPS students to new ways of coding, specifically in Python, that will serve well in post graduate opportunities
- Presentation opportunities to present results at both the university and professional levels
- Learn prioritization, delegation and project management skills while completing the project

Description of Proposed Research - Methods, Design, and Procedures

Though significant emphasis will undoubtedly be placed upon making sure this supercomputer is available for a plethora of research projects, the main physics research we hope to accomplish by building this machine is to utilize the parallelization of a supercomputer to run a Python-coded package, known as SuperBoL. This code carries the ability to perform calculations regarding peculiar supernovae luminosities. Telescopes lack the ability to directly observe the bolometric luminosity of a supernova due to much of the emitted radiation falling outside of its observable wavelength range (Lusk & Baron 2017).



To remedy this, SuperBoL plays a key role to simulate what the actual luminosity might be by interpolating between observed photometric magnitudes using a variety of techniques. The figure, previous, shows one process: observed magnitudes are converted to fluxes (blue points) then interpolated (blue line), and the resulting integrated flux is augmented by a blackbody fit at wavelengths both longer and shorter than observed. The orange line is a simulated spectrum used to generate the observed magnitudes. It is also important to note that this code includes error propagation which serves to show, essentially, how accurate this simulated luminosity is. Using the computer, we will explore different ways to process the data and perform the calculations in parallel, and measure execution time to determine how effective the parallel routines are at speeding up the code.

Our results could be disseminated at local meetings such as the College of Natural Sciences and Mathematics Poster Symposium at UCA and the Arkansas Academy of Science meeting; and at national meetings such as the American Astronomical Society and SPS PhysCon. The AAS also accepts submissions of papers describing research software and techniques to the Astronomical Journal.

Plan for Carrying Out Proposed Project

As with any task, a concrete plan of action is of utmost necessity if it is going to be accomplished in an elegant, efficient manner. Our plan, if awarded this grant, is to purchase the necessary components to build a parallel computing machine as outlined in our proposed budget. The engineering lab in which we would assemble the supercomputer also contains a laser-cutter, 3D printer, as well as a PCB printer, an intricate machine that allows for the printing of custom circuit boards tailored to any project. After assembly, the supercomputer would have more than adequate space to stay in the engineering lab, but could be easily stored almost anywhere due to its compact size. In essence, we aim to make this lab the local “hub” around campus where research students in any field, although students in STEM would likely have more applications, can come to have an array of resources at their disposal; this, of course, includes the supercomputer as the centerpiece. Armed with numerous faculty members that genuinely care about their student’s creative endeavors, research students that have a working knowledge of PC building, and students fluent in numerous programming languages, it is our hope that this grant can benefit not only the research community around campus, but also serve to capture the interest of local high school students that share our same passion for science and mathematics.

Project Timeline

Below, we have listed our major milestone points with leeway built in for the unexpected events that always occur in an imperfect world. Two of the students are continuing their independent research, which will involve weekly individual participation, one on one, with our faculty advisor. We will also hold weekly progress and action meetings with all students involved in the research.

Milestones:
January 2019 - start of project, receive grant money, determine final parts list/price
February 2019 - order/receive parts, consider Python program design
March 2019 - finalize build, operational test of build
April 2019 - begin Python controller program, test software, presentations at UCA College of Natural Science and Mathematics (CNSM) Poster Symposium, and Arkansas Academy of Science annual meeting
May 2019 - complete interim report
Summer 2019 - continue implementation Python control program, operational test, internal data
September 2019 - optimize software for parallel speeds
October 2019 - operational test of hardware/software on external (to UCA) data
November 2019 - start final report, presentations to UCA physics department, and SPS PhysCon 2019

December 2019 - present final report to UCA CNSM and submit to SPS Journal of Undergraduate Reports in Physics

Budget Justification

See attached and filled in Proposal Budget Template. All of the items listed are required parts to build the supercomputer. University resources will include laboratory space, storage space, and the use of university equipment required for the build. Most notably, we will use the laser cutter to form the framework and housing of the supercomputer. We have included a budget item to cover the cost of materials and supplies used in the construction and design of this frame. The exact costs of the frame are uncertain, since the team will have to design the shape from scratch, and might need to test multiple materials. The biggest budget item, but lowest fiscal item, will be all of the required uncompensated time the SPS students will put into this project along with consultation of our faculty advisors.

Because the award comes in two halves, we have discussed two different strategies for purchasing all the parts we need. One would be to build the computer in stages - using the initial award to build the first two motherboards, power supply, and network switch to get a parallel system up-and-running. The rest of the award could then be used to purchase the remaining four motherboards and memory. Our second strategy would be to use funds from the physics department or the UCA Foundation to match the initial award, build the entire computer, and then use the final award to reimburse the matched funds.

Bibliography

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