Draft version February 16, 2021
Typeset using LaTeX default style in AASTeX62

Plan Of Study

Sean C. Lewis[1]

[1] *Drexel University Department of Physics*
Philadelphia, Pennsylvania

(Received February, 16 2021)

1. TIMELINE

1.1. *2019*

In the last year, I have made significant progress towards my first publication as well as in my understanding and usage of Torch. In attempts to supplement my allotted computation time on Cartesius and funding from Drexel, I have applied to the Frontera Fellowship grant and an internship position at Los Alamos National Lab. Though both were declined, I will reapply this coming Fall. In addition, I have become increasingly involved in the upkeep and progression of Torch. Most recently, I successfully ported Torch's FLASH to the latest released version (4.5 to 4.6.2; regression tests pending) and am confident in my ability to continue software updates of Torch components.

1.2. *2020*

Priority one of the remaining half of the year is completion of my 3 runs in preparation for Paper 1. A run "completing" means pushing the simulation until the stars I have forced to form go supernova. The main obstacle is a matter of computation time. As of June 2020, FLASH4.5 is used in Torch. Commonly, FLASH will hang while passing around MPI buffers to fill grid guard cells after 9-12 hours of wall-clock run time. While this does not prevent runs from progressing (a simple restart from the last checkpoint output will continue past the stall point) it is preferred to be able to run simulations on Cartesius for the maximum time allotment of 120 wall-clock hours. Updating FLASH

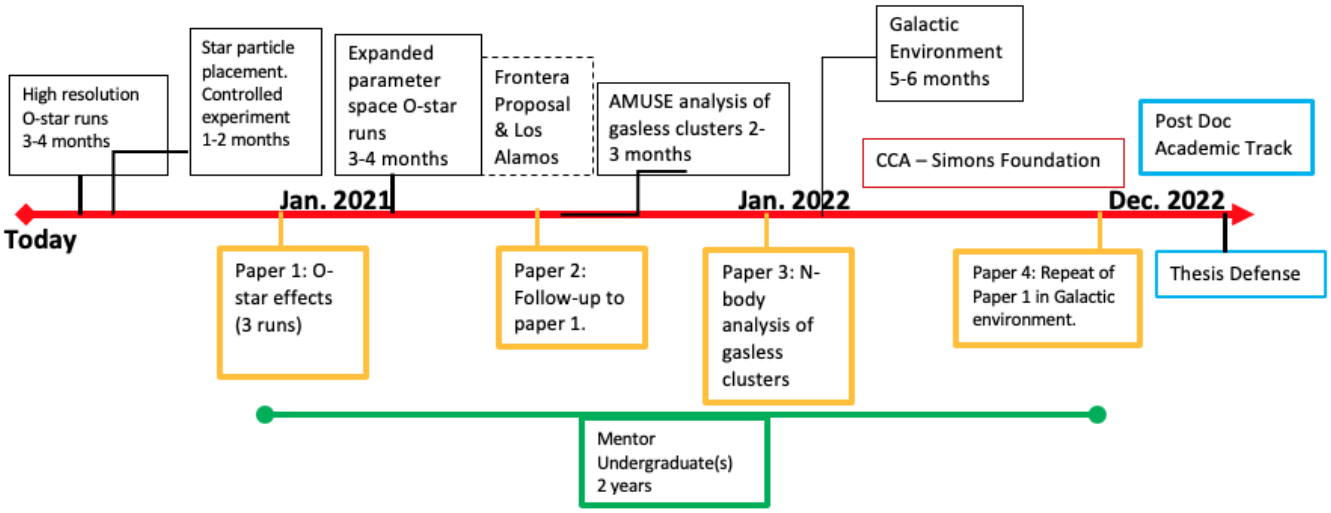

Figure 9. *Timeline.* The boxes in black are long-term items of work along with estimated completion times. The orange are the papers I will publish, other colors are for decoration. I will publish 4 papers, mentor one or more graduate students and continue to work in collaboration with national and international Torch users as well as continue the upkeep and development of Torch software and methods. In addition, I will reapply to the Frontera Fellowship and Los Alamos National Lab internship. I will also complete the PROFESS program at Drexel. Ultimately, my efforts will be to best prepare me for applications to post doctoral positions at Universities. The timeline begins "Today" (Summer 2020) and ends Winter 2022 constituting 2.5 years of work.

to the latest 4.6.2 version will potentially fix this issue (word of mouth suggests so) but at the very least allows myself to productively communicate with the FLASH development team rather than trying to debug an out of date version.

Once the 3 runs detailed in this proposal reach the first supernova detonation, the runs in their entirety can then be analyzed and reported in Paper I. Which I will complete and submit in late Fall of this year. I expect the analysis and writing process to take at least two months. I have allotted more time to provide room for inevitable revisions.

While the 8, 20, 50 $M_\odot$ runs progress, I will design a simple recipe for testing different possible star particle initial position and velocity prescriptions. As discussed, this is an active conversation among Torch users and deserves investigation. This investigation would not constitute a paper in itself (although it could be twisted into a stand-alone technical paper) but instead be an appendix addition to Paper 2 (since any changes to the star particle placement methods would not be present in the Paper 1 runs.

1.3. *2021 - 2022*

After Paper I is submitted, I will begin expanding the parameter space of star masses forced to form to include 40, 75, and 100 $M_\odot$ stars. In addition, these three new runs will be at a level of refinement higher than the Paper I runs and include the results of the previously mentioned star particle placement method improvements. The ambition is to submit Paper II my mid-year 2021, I anticipate the analysis to take less time as Paper I as analysis methods will have already been developed.

In early Winter quarter, I will also reapply to both the Frontera Fellowship and Los Alamos Graduate Research opportunities, both of which include travel to sites on location (of course the pandemic may force significant changes to this) and offer extensive interaction with HPC experts and other scientists.

After Paper II is submitted, I will begin to analyze the stellar dynamics of my half-dozen runs as unembedded clusters. By initializing the same star cluster in AMUSE only and evolving the system for a timescale on the order of Gigayears, we will be able to compare aged cluster dynamics and mass distributions with observations of clusters in the Milky Way. The computational requirements would be significantly less than the prior runs as FLASH MHD methods are not needed here. This work will constitute Paper III to be submitted in late Fall 2021.

1.4. *2022 - 2023*

In my fifth year, I will again expand upon Papers I, and II. Here, I will embed my simulations in a larger galactic context. This may be something like including a background galactic potential to analyze the effects of gravitational shear on the GMC and embedded star cluster. Or, by placing a star cluster that is about to have its first supernova into a galactic simulation, the larger scale effects can be monitored such as champagne flows. This would constitute Paper IV.

This effort may require significant collaboration amongst Torch users (collaborative efforts with Torch already exist and I address this in the final section), or outside experts. I hope to use the necessity for a larger-scale cooperative effort to establish a well-founded application to the Simons Foundation Center for Computation Astrophysics.

I will defend my thesis with the inclusion of four papers in late Fall 2022.