*Torch* provides a stable, portable, and modular computational software suite used to simulate star cluster formation from initial conditions and using physics that are easily controllable by the user. *Torch’s* method of bridging the AMR Eulerian grid magnetohydrodynamics code FLASH with the n-body dynamics software engine AMUSE provides a novel computational structure on which the feedback and dynamical effects of individual stars can be followed. This uniquely detailed and controlled modeling of the physical processes that govern star cluster formation will allow the exploration of the specific dynamic and energetic effects of early massive O-type star formation. *Torch* is no longer in the development phase and such simulations are currently possible and are being conducted given enough computing power and time.

When a star forming region is detected in *Torch*, the region is assigned a list of stars that are to be produced there as mass is accreted into the region. By manipulating this list, we are able to control in what order stars form and what mass (and therefore feedback properties) a star has. At TACC, Sean will conduct a series of controlled experiments of a self-gravitating 10,000 solar mass gas cloud. The 24 simulations (twelve pairs) will be used to specifically investigate the effects on star formation and giant molecular cloud structure by manipulating when and where O-star formation occurs. To do this, each simulation pair will have identical initial conditions (thereby ensuring a star forming region will occur in the same location) and once a star forming region is identified, one simulation will be set to produce an O-type star right away, while the other will be manipulated to avoid O-star formation. The other simulation pairs will perform the same task but will have different initial conditions (randomized gas velocity field) to promote star formation in a different location within the natal cloud. Ultimately, Sean will examine any resulting patterns in star formation location, and cloud/star cluster disruptions to determine if the patterns are largely stochastic or if they are driven by the specific event of an O-type star forming. And, more broadly, Sean will use the produced dataset to answer: what patterns do massive star feedback consistently lead to? To eventually answer this, a significantly larger set of simulations must be produced, the computational requirements of which exceeds the time allotted by the Frontera Fellowship. On an important note; *Torch* simulations are designed such that a checkpoint file is written to disk at a user-defined frequency. A checkpoint contains all simulation data and state information and so can be restarted from that point without consequence or loss of information. In addition, such a restart can be performed on a computing system separate from the one used to begin the simulation. Therefore, we will be able to continue simulations at TACC as well as continue the simulations initiated at TACC.

A typical simulation will begin forming stars at 600-1000 hours of computation time, using 25-40 processors. To begin resolving the effects of star formation, 2000 hours of computation time is the target for each simulation. The data output at this point averages 100 Gigabytes per simulation. As such, the majority of TACC’s allotted 50k computational hours will be devoted towards processing the twenty-four simulations, 2000 computer hours each. The remaining computation time will be devoted to the data reduction and analysis of each simulation. Using the yt-project python package, the physical data within *Torch’s* output files may be processed and converted into visual representations of the star forming regions where the dynamics and energy budget of the molecular gas as well as the dynamics and feedback of the individual stars can be examined. Such images/movies are critical to understanding the accuracy of the simulations as simple visual comparisons to observational data is a powerful tool. Sean has already written some rudimentary versions of *Torch* image processing and data analysis algorithms and has generalized and parallelized them such that any set of *Torch* data files can be processed across any number of processors. As further optimizations and development is needed here, the computationally focused environment at TACC will lend valuable assistance on this front.

Overall, Sean’s current work with *Torch* will be amplified by the computational opportunity provided by the Frontera Fellowship and the innovative and passionate environment fostered at the Texas Advanced Computing Center.